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Emotions and Emotional Appeals in Science Communication

Editors

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Emotions and Emotional Appeals in Science Communication

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Table of Contents

COGITATIO

Media and Communication (ISSN: 2183–2439)
2020, Volume 8, Issue 1, Pages 101–106
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Editorial

Between Evidence and Emotions: Emotional Appeals in Science Communication

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Abstract
In the field of science communication, there is currently a great deal of discussion on how individuals can be reached, not only through fact-oriented communication, but also through emotional appeals and 'edutainment' approaches. This discussion has been further intensified by the changing conditions of new media environments. From an academic viewpoint, the discussion is often met with scepticism. However, categorical statements about a supposed dichotomy of emotion and rationality are misleading. What is needed are differentiated arguments and analyses. Nevertheless, emotions in science communication are an often overseen research field. With this thematic issue, we seek to enrich the scientific discourse by providing research from authors coming from different perspectives using different concepts, methods, and cases. In this editorial, we summarise the contribution of ten different articles on three levels: (1) emotions of science communicators, (2) emotional(ised) content, and (3) emotions of science communication audiences.

Keywords
audiences; communicators; content; emotions; entertainment; rationality; science communication

Issue
This editorial is part of the issue "Emotions and Emotional Appeals in Science Communication" edited by Monika Taddicken (Technische Universität Braunschweig, Germany) and Anne Reif (Technische Universität Braunschweig, Germany).

1. The Relevance of Studying Emotions in Science Communication

In 1985, the Royal Society of London declared that a better public understanding of science (about results as well as methods) is necessary for individual citizens to make reasoned, personal decisions in most aspects of daily life (Royal Society of London, 1985). Scientists, scientific institutions, and the media were asked to encourage this public understanding of science by communicating more information to the public. Empirical research, however, could not prove a positive correlation between the amount of information and knowledge of science the public has and its positive attitude towards scientific topics. As a result, the assumption of a knowledge deficit that can be addressed through better information distribution has been criticised. It was said that the narrow emphasis of the deficit approach does not recognise that knowledge is only one factor among many influences that are likely to guide how individuals reach judgments (Bubela et al., 2009; Sturgis & Allum, 2004).

This has led to a general shift in focus towards a new 'public engagement' or interactive model that emphasises deliberative contexts, the relevance of participation (Bubela et al., 2009), and emotions in the communication process. In particular, new media environments, in the form of digital communication and social media, create a low-threshold participation opportunity with the potential to encourage citizens' participation in science (Stilgoe, Lock, & Wilsdon, 2014). Many innovative public engagement formats have been developed, such as science slams, hackday formats or science cafés, which have the potential to not only enhance audiences' scientific knowledge but also arouse positive emotions. So far,

entertainment has been acknowledged as important for science communication perceptions and effects in particular (Nisbet & Goidel, 2007). An 'edutainment' approach focusing on the emotional experience of the audience has been indicated (Gerber, 2011) in the emerged 'experimental field' of practical science communication.

From an academic viewpoint, emotionalised science communication is often regarded as trivial and met with scepticism. However, little empirical research has been carried out relating to usage, reception, and the effect of these new formats. There are scarcely any scientific findings concerning participation, as well as the motivation for and the emotional appeal of it. The academic debate stays on normative grounds (Fähnrich, 2017; Stilgoe et al., 2014), and in particular the relevance of emotions has been neglected this far—although urgently needed more than ever.

Public discussions around so-called 'alternative facts' and 'fake news' direct further towards the negative aspects of emotional appeals and debate. Seen as contrary to the Habermasian ideal of public communication, the discourse on social media is not only positively discussed—it is attributed to trolls and bots, potential echo chambers and paradoxes of participation (Schmidt, 2018), which also influences (somehow) the public discourse on topics such as science. Social media are called 'emotion media' because of their basic functional logic of communication (Eisenegger, 2017). Against the backdrop of 'hate speech' in social media and the allegedly linked verbal coarsening in the debating culture, so-called 'sensitivity communication' (in German, *Befindlichkeitskommunikation*; Barth & Wagner, 2016) is commonly seen in negative light. Here, emotions are often explicitly associated with an overarching trend of disaffection with elites and (possibly) a loss of trust in societal authorities and systems, particularly against the background of leading politicians who publicly question the truth of scientific results and thus contest fundamental epistemological criteria.

However, what is the role of emotions in the scientific discourse? Does an 'absolute dichotomy of ratio and emotion' (Neverla, 2017) even exist? Clearly, the relationship between affective and cognitive engagement with issues needs to be rethought and reinterpreted. For communication on scientific topics in particular—that are characterised by a high degree of complexity and uncertainty—it is necessary to question the extent to which evidence and emotion can actually be understood as opposites. Emotions may affect communication as well as reasoning processes, but may also promote social and moral behaviour. Thus, categorical statements on emotions and rationality would be considered misleading (Pham, 2007), which is why this thematic issue helps to close the research gap about emotions in the relationship between science and the public.

In sum, we identified three reasons and perspectives why it seems more important than ever to bring research on emotion, in the context of science communication, into focus: (a) practical science communication and (b) scientists and researchers debate the necessity and potential effects of new science communication paradigms. Furthermore, the relevance also derives from (c) recent developments of the public debate connected to the use of online media and phenomena, such as disinformation and so-called 'fake news.'

This essay will introduce different research perspectives regarding emotions and emotional appeals in science communication, and summarise the contribution of the articles published in this thematic issue. Different concepts of emotions exist, which can be researched and discussed in various contexts and from different angles. This diversity is reflected by the articles of this thematic issue.

2. Different Perspectives of Emotions and Emotional Appeals in Science Communication

The starting point of the idea for this thematic issue was the annual conference of the Science Communication Division of the German Communication Association (DGPuK), in February 2019 in Braunschweig, Germany. Many of the authors presented their research projects at the conference before writing their articles. The conference welcomed more than 70 participants coming from different disciplines and perspectives, including practical science communicators. We then called on the international scientific community.

Accordingly, the articles of this thematic issue reflect the scientific discourse on emotions and emotional appeals in science communication from diverse angles. Different emotions and emotional aspects are studied with various methodological and disciplinary approaches using several science communication formats or science topics as examples. Furthermore, we consider the diversity of concepts and definitions of emotions that can be found in the academic discourse. Thus, the readers will find variations across the articles. We are convinced that the multidisciplinary and multiperspective view of this issue has the potential to enrich the scientific discourse.

Following a common structure of communication research, we will differentiate between three levels in which emotions are relevant in the science communication process: (1) the communicators; (2) the content; and (3) the audience. This differentiation helps to structure the articles published in this thematic issue (see Figure 1).

2.1. Emotions of Science Communicators

There is a tension between emotion and rationality in science, which results from the methodological principle of 'objectivity.' Science should be individual-independent, but, naturally, scientists themselves are confronted with emotions during the research process—as well as science communicators (including science communicating scientists) during the communication process. In his

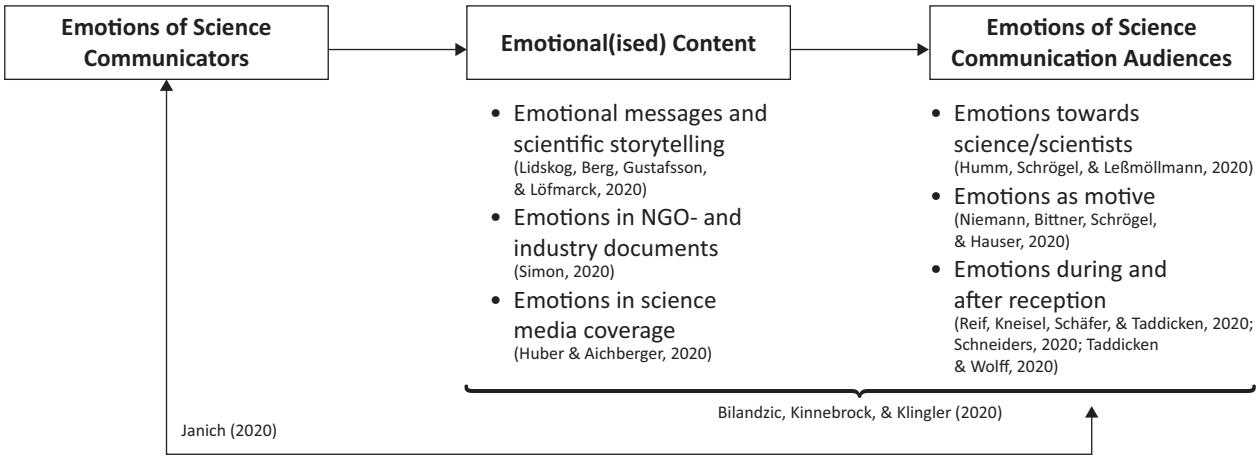

Figure 1. Overview of articles in this issue.

conference keynote in Braunschweig, Rainer Bromme (University of Münster) recommended scientists to show their emotions and to make them reflexively a topic. He argued that emotions are indicators of social values: What feels good is valuable and worth striving for (see also Pham, 2007). In addition, because individuals know that their emotions are strongly correlated with their values, they assume this is also the case with other people (Bromme & Gierth, in press).

However, other studies find cues that emotional language can harm the trustworthiness of scientists as well as the credibility of their arguments (König & Jucks, 2019a, 2019b). This is somehow confirmed by the first article in this thematic issue by Janich (2020) and by Humm, Schrögel, and Leßmöllmann (2020), who focus more strongly on the audience perspective (see Section 2.3). Humm et al. (2020) and Janich (2020) indicate that science communication audiences, as well as audiences excluded by science communication in general, expect scientific experts to be objective and to objectively report on scientific issues. However, both articles argue that science that does not permit emotions seems culturally distant or even contradictory to the emotional(ised) daily lives that audiences experience. Having these stereotypes of science and scientists in mind, one asks what happens if scientific experts are not objective but openly express emotional reactions in the public discourse? Analysing the comments in science blogs, Janich (2020, p. 116) observes in the first article that:

> When the experts become impatient or respond with irony, and when they do not (want to) live up to these expectations due to a lack of empathy or due to, at best, egocentric empathy, the interaction quickly becomes emotionally charged.

In the centre of this article are emotions expressed in the textual dialogue between scientific experts and the public. From her linguistic research perspective on the dialogue between science and the public in a new media environment, the author calls for more reciprocal empathy.

2.2. Emotional(ised) Content

It is often asked how science and scientific results should be presented to 'successfully' reach a wider public (usually without clarifying what 'successful' means). With regard to emotions: Can or should the rational position of science and the presentation of abstract results be abandoned in favour of more emotional narratives? Or, does this approach undermine the neutrality and thereby the credibility of science? So far, there has been little research on the level of emotionality within science communication, and whether or not science communication varies when it comes to different times, communicators or formats. The second thematic area of this thematic issue aims to discuss questions about professional emotional science communication content. Three articles in this thematic issue analyse texts by different science communicators on the topics of climate change (Lidskog, Berg, Gustafsson, & Löfmarck, 2020), possible risks of neonicotinoid pesticides (Simon, 2020) and—related—honey bee colony losses (Huber & Aichberger, 2020).

By comparing two different storylines as a case study (dystopic story vs. optimistic story) about environmental and climatic change, Lidskog et al. (2020) show that scientific storytelling does not only present 'cold facts' and provide normative orientation, but it also reflects emotional appeals such as fear or hope. The combination of both is assumed to facilitate climate friendly actions. Emotions in this article refer to the process to produce (scientists' perspective) and receive (audiences' perspective) knowledge, and are understood as an instrument to facilitate actions.

Similar results are revealed by Simon's (2020) linguistic analysis of different knowledge claims of possible risks of neonicotinoid pesticides, which are published in documents by the agricultural industry compared to environmental organisations. The author approaches emotions from a rhetorical perspective by distinguishing between ethos (measured as trustworthiness: expertise, integrity, and benevolence) and pathos. Ethos and pathos

are both reflected by the texts but different rhetoric patterns are detected. While texts by the agricultural industry strongly focus on demonstrating their scientific ethos, environmental organisations highlight concerns about the use of neonicotinoid pesticides.

As most people receive their information about science from media content, examining emotions in the media coverage about science and scientific issues is of high relevance. Huber and Aichberger (2020) refer to this perspective with a quantitative content analysis—a commonly used method in communication research. They find that media coverage about honey bee colony losses in Austrian newspapers not only refers to scientific expertise, but is highly emotionalised—especially in tabloid papers. Emotionalisation is expressed more frequently through the use of rhetorical devices than by explicit references to negative or positive emotions.

2.3. Emotions of Science Communication Audiences

Bearing in mind that, within a public discourse, scientific facts are understood and interpreted individually, it becomes significant to look closely at the recipients' perspective. The question is how (emotional) content is emotionally processed by the audience.

In the fifth article, Bilandzic, Kinnebrock, and Klingler (2020) present a theoretical model that combines the emotional content and its emotional processing and effects on users' emotions by focusing on emotional potentials of science stories. The authors include a theoretical classification of different patterns in science narratives, as well as a typology of emotions (discrete and complex) that can be evoked by different narratives.

One of the prime issues of practitioners is: (1) why science communication often reaches highly educated and science-literate audiences; and (2) how underserved audiences can be reached and engaged. To help answer these questions, Humm et al. (2020) investigate the reasons why underserved audiences feel excluded by science communication. They use a qualitative approach by conducting (group) interviews with different minorities in Germany and refer to negative emotions such as fear of being left out, as well as negative self-perception and emotional barriers. Besides material exclusion factors, the authors highlight how underserved audiences sense an emotional distance to science.

In contrast, Niemann, Bittner, Schrögel, and Hauser (2020) study the audiences and their motivations to attend the innovative science communication format of science slams that combine scientific content and entertainment. Applying a mixed-methods approach, entertainment is understood here as hedonic emotion that motivates individuals to attend science slams. Although people's primary motive to attend a science slam is the need to be entertained, through the use of eye-tracking methodology the authors reveal that the audience focuses longer on the scientific aspects than the entertaining elements of the presentations. Thus, the data indicate a good compatibility of scientific content and entertainment.

One different science communication format that emphasises users' (emotional) engagement is the online explainer video. Reif, Kneisel, Schäfer, and Taddicken (2020) highlight the importance of YouTube videos and sciencetubers as science communicators, as well as the necessity to examine viewers' emotional assessment of scientific experts for the evaluation of their trustworthiness. Thus, emotions are understood in connection to trustworthiness and refer to three types of emotional assessment of scientific experts. While the findings of the experimental online survey also suggests that scientific experts who appear in a TV interview setting are perceived as more competent and regarded as typical scientists, sciencetubers are evaluated as entertaining and explaining comprehensibly.

Online environments comprise very heterogeneous contents communicated by different agents; many are non-compliant, dissonant, but also false information can be found online (Pfetsch, Löblich, & Eilders, 2018). With that in mind, Taddicken and Wolff (2020) examine how people react to online 'fake news' about climate change and how they try to resolve the cognitive dissonance evoked. Using mixed-methods, the article provides insight into the individual affective arousal and coping strategies after being confronted with opinion-challenging disinformation. If dissonance can be dissolved, individuals feel relieved and satisfied. Otherwise they state dissatisfaction and frustration.

Building on the idea of feelings of cognitive dissonance in connection with information processing, Schneiders (2020) presents results of an experimental study. He demonstrates that feelings of cognitive dissonance do not affect people's recall of information. Against the bad reputation of explainer videos, the results indicate that videos and the so-called 'scrollytelling' are most effective, whereas text is most efficient regarding the recall of information.

3. Conclusion

This issue offers numerous opportunities for further thoughts, research, and discussions. We believe that the multidisciplinary and multiperspective view in this thematic issue, which also takes practical aspects into account, allows a more comprehensive examination of emotions in the supposedly rational field of science and science communication.

Apparently, this issue provides some answers regarding emotionalised communication content as well as answering the question about how the audience is affected, particularly regarding the manifold different science communication formats, but also within the new media environments. However, the variety of different theoretical concepts and perspectives on emotions reflected in this issue underlines the difficulty of giving a simple answer to the question where science communi-

cation is to be located between evidence and emotions.

What is striking is the small number of contributions in the area of 'emotions of science communicators.' This research gap should be filled in the future. It includes the questions of emotions in scientific processes, next to the science communication processes, and, with this, of the underlying values and norms of scientists. In the field of science of science communication, it is often asked how science can best be communicated and what makes science communication effective. Here, emotions are understood as a functional means of disseminating knowledge and an instrumental perspective is applied. Beyond that, however, research can focus more on the relationship of science and the public. Emotional processes in science communication should be investigated more closely in the future—not only at the micro, but also at the meso and macro levels of society. The mutual processes should be investigated, i.e., the emotional effects on scientists and science communicators. In this issue, concepts like sympathy, empathy, and ethos/pathos were identified as relevant. However, research has to acknowledge that nowadays many more stakeholders than just science and the public (thus, the audience) come into play, such as political stakeholders, NGOs—with their own goals and strategies, but also with their own emotions and values.

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Conflict of Interests

The authors declare no conflicts of interest.

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Article

What Do You Expect? Linguistic Reflections on Empathy in Science Communication

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Abstract
This linguistics article, which draws additionally on interdisciplinary insights, discusses whether and to what extent more empathy could facilitate and promote the exchange of knowledge between science and society. The existence of the Internet as a knowledge resource has made it necessary, especially in online communication, to renegotiate (scientific) expertise and roles such as 'expert' and 'layperson.' A discourse linguistics case study of a science blog shows that these negotiations quickly take on the character of an emotionally charged relationship between writer and respondent and are by no means limited to the level of fact or disinterested scholarly debate. The reason for this—so this article argues—is that reciprocal expectations and expectations of expectations play an essential role in science communication, as in any social communication. This hypothesis is supported by an analysis of interviews with scientists about their expectations of the public's understanding of science. Against this background, empathy seems to be a suitable means to better meet the expectations of one's interlocuter (or at least to avoid disappointed expectations) and to move from a more emotional level back to a more rational one. Empathy and its role in science communication should therefore be investigated more closely—on an interdisciplinary basis.

Keywords
discourse linguistics; emotionality; empathy; expectations of expectations; science communication

Issue
This article is part of the issue "Emotions and Emotional Appeals in Science Communication" edited by Monika Taddicken (Technische Universität Braunschweig, Germany) and Anne Reif (Technische Universität Braunschweig, Germany).

1. Introduction

In 1996, Jäger identified a crisis of expert culture, which he traced back primarily to an increasing compartmentalization and specialization in science and technology, but also to a lack of transparency in expert knowledge. In 2012, Beckers postulated a stronger cooperative construction of knowledge, calling for the participation of both 'patient experts' and 'knowledgeable laypersons' alike. Both postulates are based on the classic deficit model of expertise which "is traditionally thought of as a social practice consisting of an asymmetrical, hierarchical relationship between at least two participants: the knowledgeable expert and the less knowledgeable advisee" (Eriksson & Thornborrow, 2016, p. 1; see also Weingart, 2003). The large number of online resources and social media platforms (especially blogs, Twitter, etc.) has since become an important resource, freely available, of different kinds of knowledge and expertise, one that also influences the relationship between science and the public and between experts and laypersons in general (e.g., Brossard & Scheufele, 2013; Dudo, 2013; Weingart & Guenther, 2016). The classical understanding of expertise should accordingly be subjected to critical reflection and be understood as a "highly complex phenomenon" (Eriksson & Thornborrow, 2016, p. 1). Those who claim expertise must also renegotiate their identity as an expert in a—possibly unexpected—linguistic-discursive way, because scientific writing in fora other than the traditional scientific ones is not endowed with the same authority found there (Hyland, 2009):

> A scientist speaking at a public forum, for example, might shift in and out of speaking as an expert. Expertise discourse then becomes a communicative ability as a marker of expert behaviour, which could be locally marked by level of knowledge, professional experience, firsthand experience, or professional judgment. (Sprain & Reinig, 2017, p. 3)

In this context, then, it is also a matter of the construction and acceptance of social identities:

> Presenting oneself as a particular kind of person therefore involves making rhetorical choices which meet a particular community's assumptions, bodies of knowledge, and ways of seeing. So, we embed our writing in a particular social world which we reflect and conjure up through approved discourses….This means that identity involves both shared norms and personal traits….For academics, it is how we achieve credibility as insiders and reputations as individuals. (Hyland, 2009, pp. 26–27; see also Motta-Roth & Scotti Scherer, 2016)

If we examine science blogs and the comments written by the blogs' readers, for example, we quickly notice that the discussion here is characterized by different types of expertise (Sprain & Reinig, 2017) and has long left the level of facts and content (Kuteeva, 2016). The participants' roles—by no means free of conflicting affiliations in other ways as well (Maillé, Saint-Charles, & Lucotte, 2010)—are therefore much less clear, with communication quickly changing from the objective to the personal level: Expert and lay roles are then renegotiated, and the right to speak as well as communication styles become a subject of heated dispute.

Against this background, the present article argues for and discusses from a linguistic point of view the hypothesis, first, that greater empathy among all participants could facilitate the negotiation of social identities in (online) science communication and could thus bring about a quicker and smoother return to the issue—or to participants not leaving the scientific, objective level in the first place. This is because—to introduce the second hypothesis—more empathy could lead to fewer expectations being disappointed: be it because they are already empathically anticipated or because, in the event of conflict, an effort to empathize renders them clearer. The article suggests that an examination of empathy in scholarly communication would be a worthwhile field of interdisciplinary research (Schneider, 2019); it would be fruitful to focus on the specific expectations of empathy, the different possible forms in which empathy can be generated, and the signs of a willingness to empathize on the part of the various actors (Bender & Janich, 2020).

The theoretical background of the article is briefly outlined below. First and foremost, the sociological concept of 'expectation' (and its reciprocal extension, the 'expectation of expectation') is examined in relation to the philosophical and psychological concept of 'empathy' and to a linguistics approach to 'emotion' (Section 2). We then explain how the research proceeded and how the database was assembled (Section 3): Interviews with scientists who possess many years of experience in communicating science to broader publics are used as an initial empirical source to determine which public expectations scientists usually assume, i.e., around which expectations they usually focus their communication, for example when blogging (Section 4). Finally, some examples of comments left on a science blog are analysed linguistically to show in concrete terms which expectations actually play a role among readers and commentators, how their possible disappointment affects communication, and to what extent empathy may contribute to resolving the ensuing communicative conflicts (Section 5).

2. The Theoretical Background: Expectations, Empathy, and Emotion

2.1. Expectations and Expectations of Expectations

Interaction is the condition on which the possibility of society depends. If groups of people are to manage to live together, there is a certain need for communication and thus for cooperative action more generally. This common action is coordinated and made possible by what are termed expectations. Drawing on Luhman (1976), Klenk outlines the relevant aspects of this concept:

> a) expectations, in this context, must not be understood as expectations of human minds; the expectations are realized as forms of communication in the medium of meaning…; b) expectations, as communication itself, become observable only in retrospect; expectations are bound to their response, particularly their disappointment. Only by the reply it becomes observable what has been expected….And, c) the selection and stabilization of expectations as structures of social systems can only be constituted on the level of expectations of expectations (German: *Erwartungserwartungen*, cf. Luhmann, 1976, 63f), which means that expectations only gain structural relevance for social systems, if they are themselves expected, which in turn means that they must be observed. (Klenk, 2013, p. 177)

According to this theory, in our actions we learn to expect the expectations of the other individual and to act accordingly. Further, we assume that the other person is competent and willing to expect our expectations and to act accordingly him- or herself. This postulate of reciprocal expectations of expectations explains how social and rhetorical norms develop from it. It also directs our attention to the consequences of disappointed expectations for communication (here: communicating science) and the potential that empathy may offer for resolving communicative conflicts.

2.2. Empathy

Empathy is conceived as the fundamental prerequisite for all understanding, and thus also for the possibility of anticipating expectations (Hermanns, 2007b). Philosophical approaches see empathy more precisely as a phenomenon that can be understood multidimensionally and in the sense of a stage model. In this multidimensionality, the concept of empathy becomes closely related to the concept of the reciprocal and observable expectation: Empathy is viewed on the one hand as existing in the inner world of the subject (as a situation-specific sympathetic understanding), and on the other hand as a form of negotiation and recognition within a community with shared norms (and thus also across situations; Breyer, 2013). Additionally, empathy can also mean 'taking sides in a scene of three,' in other words, when a third party mentally takes sides with one of the other two parties involved (Breithaupt, 2009). For science communication, this third aspect is an important extension of the originally dyadic model of empathy. Empathy as a stage model means that different degrees of empathy can be assumed: from basic forms such as perceiving another's emotions and being moved by them to putting oneself in the place of the other person and imagining how one would act if one were that person (Breyer, 2013). To summarize dimensions and stages, the following types of empathy can be identified (Breyer, 2013; Hoffman, 2000; for more detailed discussion see Bender & Janich, 2020)—set here in relation to the concepts of expectation vs. expectation of expectations:

1) Global empathy: Meaning only a general acceptance of the condition of the other in a vague and general way, without anticipation of possible specific expectations (i.e., formation of expectation only, not of differentiated expectations of expectations);

2) Egocentric empathy: Such empathy is based on a clear awareness of difference (me/the other person), one's assessment of the other person is based on one's own standards, an expectation of expectations is based only on one's own horizon of expectations as shaped by the situation;

3) Allocentric empathy: This concerns a genuine attempt to empathize with the other person (in light of his/her background, according to his/her standards) and thus entails, among other things, an attempt to actually anticipate, as far as possible, the expectations of the other person from his/her perspective and to take them seriously as expectations of expectations in one's own communicative actions;

4) Symbolically mediated empathy: This does not take place in one's own immediate experience, but arises on the basis of reports and judgements, i.e., for example on the basis of explicit and formulated expectations, reports of disappointed expectations, etc., in the sense of positive recognition of these expectations;

5) Empathy with groups: This special form, which extends to more than one counterpart, is based on a medialization and collectivization of the aforementioned symbolically mediated empathy.

In addition to this distinction concerning with whom one feels empathy and why, we must identify three dimensions which are analytically relevant for our evaluation of the blog and interview material, because a clearer distinction can be made here between the normative and the descriptive level: on the descriptive level it can be shown who actually shows empathy towards whom and with what linguistic means they do so (dimension of empathy generation). For the hypotheses to be tested here, however, the normative level seems particularly important, i.e., the question of where empathy is explicitly formulated as an expectation of the counterpart and where the attempt is actually made to meet this expectation by making concessions and offering options (dimensions of empathy expectation or empathy readiness).

2.3. Emotion

The concept of empathy is linked to the concept of emotion in classical dyadic models of empathy by placing it between mind and sensuality. Breyer points out, however, that such dualistic tendencies neglect the complex interactions of empathy with emotional, affective, and rational factors against the background of observations, memory, and knowledge (Breyer, 2013). Linguistically, it is of particular interest how emotion affects the negotiation of roles and the discussion of expectations and disappointments, i.e., when (and how and why), for example, a change from the factual level to the relationship level takes place. Emotionality is reflected linguistically either in the use of explicitly descriptive expressions for emotions (such as "annoy," "disturb," "rejoice") or in expressive speech acts (such as praise, scolding, consolation, but also, for example, in the use of irony or the offer of personal insights). One of the hypotheses of this article concerns the rationality of empathy to cope with this emotional level within science communication without losing credibility and trustworthiness (Schneider, 2019).

3. Data and Methods

The following is a two-step procedure: First, using interview material (1), I examine the expectations that scientists have about the public's expectations when they are dealing with the possibilities and limitations of external science communication (in other words, the expectations of expectations beyond their own expectations and attitudes towards science communication, as explored by, e.g., Herrmann-Giovanelli, 2013). In this way, I reconstruct the fundamental orientations that guide scientists'

communication (Section 4). Against the background of these reconstructions, I examine a case of external science communication in the form of a science blog and the discussion triggered by it (2) to see how this interplay of expectations and language action works in direct contact with the public—and what conflicts arise (Section 5).

3.1. Step 1 (Data)

In Section 4 below, interview statements are evaluated in order to identify the expectations of expectations on the part of scientists that might serve as a practical orientation for them in external science communication. The interviews with scientists that form the basis of this study were conducted in 2018 and 2019 as part of a project (2018–2022) funded by the Klaus Tschira Foundation entitled "Textual Competence of Young Researchers in Science." The aim of the evaluation within the framework of the project is to reconstruct critical communication situations in order to develop hypotheses regarding the nature of science communication among young scholars in the natural sciences. The database consists of transcripts from 17 structured narrative interviews, each of which lasted about 40–90 minutes. Since the interviews were conducted in German, the spoken text was transcribed and then carefully edited for an intelligible translation into English. The interview questions concerned good and bad experiences in communication between scientists and the public and, in particular, the question of whether and how scientific uncertainties should be addressed in science communication. All the scientists who were interviewed have several years of experience in communicating science to journalists and the wider public.

3.2. Step 1 (Methods)

For the present article, the interviews were evaluated selectively with regard to whether the expectations of certain actors are explicitly mentioned and reflected on by the scientists and, if so, which ones. To this end, all the interviews were searched for word tokens of "expect-" (German original: "erwart-"), and the corresponding passages and their co-text were evaluated with regard to forms of argumentation. The corresponding code units are derived from the syntactic valency of the verb to expect ('who expects what of whom when/in which context'): whose expectations—expectations with regard to what and how/when—and, to take account of the reciprocal character of expectations and the dyadic character of communication, the speaker's/writer's own attitude toward those expectations. Passages in which the scientists expressed expectations concerning future research results were not taken into account. Since the aim is to make only an initial inventory of the connection between expectations of expectations and their influence on science communication, passages on expectations of expectations only expressed implicitly were ignored in this first evaluation.

3.3. Step 2 (Data)

On the portal *Scilogs—Tagebücher der Wissenschaft* (offered by the German publishing house *Spektrum der Wissenschaft*), science journalists maintain a blog along with several prominent German scientists. In the column Climate Lounge, a blog about an expert hearing in the Environment Committee of the Lower Saxony regional parliament on global warming in June 2014 contains a statement by a climate scientist concerning an expert opinion heard by the committee in question. In Section 5, the comments posted on this science blog will be used to examine linguistically which expectations are prompted and which ones influence communication when scientists and the public communicate directly with one another, without professional mediators (see blog and comments in Rahmstorf, 2014). The blog was chosen for analysis because: (1) it refers to a topic that has been the subject of heated debate in recent years (greenhouse effect/global warming); and (2) because it deals specifically with the people involved in the controversy in the science-policy nexus. These two factors serve to generate a debate on the role of scientists and of policy makers that is both intense and explicit, which is why the example is particularly well suited to show in a nutshell which expectations can collide in science communication and to explore the role that (more) empathy can or might play in resolving conflicts. The results are suited merely to highlighting some phenomena which should be examined more closely and with regard to the different kinds of science blogs (including different audiences and commentators) and social media formats (e.g., Kuteeva, 2016; Schäfer, 2017; Sprain & Reinig, 2017). The aim of the case study is thus to identify issues of interest search instructions for later, more detailed investigation.

3.4. Step 2 (Methods)

The German excerpts from the comments section of this blog concerning the criticism of one of the experts heard by the committee were translated into English and were used to illustrate how quickly the communication and negotiation of assigned or claimed roles (e.g., expert vs. layperson) and associated role expectations (e.g., concerning both the comprehensibility of the expert's explanations and his expertise in the subject matter) (can) become emotionally charged. The approach chosen here is a discourse hermeneutic interpretation (Hermanns, 2007a) of linguistic keywords and discourse patterns which indicate emotions (expressive speech acts or affective formulations; see Section 2.3), role assessments (explicit role descriptions/names or legitimizing references to training, knowledge, etc.; see Section 1) and the implicit or explicit mention of expectations—for more empathy, for example (see Sections 2.1 and 2.2).

Since I am dealing with a normative question, namely, whether empathy is a relevant dimension in science communication and should thus receive greater at-

tention in the future, this study takes an exploratory and hermeneutic approach. The aim is to achieve the highest possible plausibility with regard to the above hypotheses by linking an analysis of scientists' reflections on the meta-level about the expectations they encounter or assume (interviews) with an analysis of actual communication (blog comments).

4. Scientists' Expectations of Expectations with Regard to the General Public

Based on their experiences when communicating science to a wider public, the scientists interviewed are aware that people outside science have certain perceptions and expectations of science. The scientists address these expectations in a very concrete and differentiated way, often immediately reflecting upon them in a normative, differentiated, and empathic manner. Therefore, the following section will first present the expectations of expectations of the scientists interviewed reconstructed from interview excerpts (passages in the co-text of word tokens of "expect-"/German: "erwart-"; Subsections 4.1–4.4), followed by the scientists' reflections on the exchange. A few quotations from the interviews are provided (samples 1–10) to show how close reading and hermeneutic interpretation led to the reconstructions offered. A few brief comments shall indicate some of the conclusions that can be drawn from the analysis.

Below I identify the expectations of expectations on the part of the scientists from the interviews I analysed.

4.1. Expectation of the Expectation that 'Science is Complex'

Scientists' reflections in a nutshell: 'Science should communicate not only results, but also methods and cognitive processes to enable a better understanding of science and its findings.'

> Sample quotation 1: But people should see, wow, that's really complex, that's always bound up with it. That's what people expect from science somehow, but certain things that might be important for the interpretation you try to explain….I've noticed that people are really into that….And this is not to demand that people understand that, but that they are at least taken along with you a little, taken briefly into science or into the laboratory.

> Sample quotation 2: The second point is that I think it is important that everyone understands how science works. Somehow, you have to understand it. It's not just the result that's important, it's the story, how do I arrive at a result?

> Sample quotation 3: People ask a lot more about the animals or the results themselves, that's quite obvious, that's what it's about, but people do also ask about methodological backgrounds….It's noticeable that people are pleased to be involved in this scientific process a little bit.

The quotations show that scientists see the benefit of the mediation of scientific knowledge and work processes, for three reasons: (1) because they can remain more authentic themselves; (2) because their audience feels that they are being taken more seriously; and (3) because they hope that the results, which are usually the main reason for and the subject of communication, can be better understood and evaluated. This leads us directly to the expectation regarding the certainty/uncertainty of scientific findings.

4.2. Expectation of the Expectation that 'Scientific Knowledge Is Certain Knowledge'

Scientists' reflections in a nutshell: 'Omnipresent uncertainties should be communicated honestly and as transparently as possible in order to counter this false expectation/change this expectation in the long term.'

> Sample quotation 4: I believe that it is important for a scientist to talk about the uncertainties, because of course otherwise he is committing himself to a certain version. However, I think this is fairly difficult to communicate to the public, because…they always expect scientists to be able to state clearly what the situation is, indeed, what the definite facts are. Scientists certainly can say what the situation is, but you just have to see the whole picture, how this knowledge was arrived at. And that, I think, is a bit difficult for the public to judge.

> Sample quotation 5: Well, if I were to claim that there are no uncertainties, that would be a lie. And in the sense that we say we try to generate true insights with science, and we try to reach an agreement on this, you have to somehow communicate the uncertainty too. You would also create false expectations if you said that something is one hundred percent certain if it's not one hundred percent certain. So I think that's the normal way of dealing with scientific findings, that you know you can call them uncertain and then you deal with them.

The two quotations show how important it is for scientists to counter the often false public expectation of scientific certainty (especially in the case of complex topics) through honesty and transparency when dealing with their findings—not least in order to achieve a better understanding of science itself. There are, however, rather varying attitudes concerning the extent to which scientists actually react appropriately to this issue or whether the way they do so does not rather contribute toward affirming these expectations:

> Sample quotation 6: In my opinion, the [scientific uncertainties] are barely presented. Because it would simply take far too long in these fast-moving times to clarify these uncertainties, and nobody wants to listen anymore….And maybe that's the reason why people don't want to take science so seriously anymore, because they like to expect definitive statements….But there are many things science cannot speak about definitively. I think there's a complete lack of awareness in the public sphere….Somehow one expects that these are data, firm data, and that is the wrong expectation. And of course, the natural sciences work out data, not opinions, but the data, they are just interpreted, and then I have opinions.

4.3. Expectation of the Expectation that 'Science Should Provide Diagnosis and Problem Solving, Responsible Expertise Knowledge and Recommendations for Action'

Scientists' reflections in a nutshell: 'Science communication should not only impart knowledge, but also present this as a central task of science.'

Here too the scientists interviewed discuss the public's expectations, of which they are critical and which they wish to correct. From their perspective, empathy can only involve responding to this expectation while at the same time showing that it is everyone's responsibility, and not just the task of scientists, to draw the corresponding conclusions from scientific findings. In other words, it is everyone's responsibility to decide which conclusions are to be drawn for oneself and for collective action:

> Sample quotation 7: There will be more frequent enquiries [concerning the research topic], but then the question immediately following that will usually be 'what should I do now if it's so uncertain?' And then there's the debate, people again expect that scientists or science should say what every one of us should do now, that would be the most convenient thing. And then we have the role science can play in democracy, and well, then you can say what you yourself would do now or what you consider ethically justifiable….Well, then I try to communicate that everything, our whole life, is just constantly uncertain and we constantly make decisions nevertheless and have actually got quite used to it and don't always want to ask or shouldn't always ask experts either. I think I always try to put the responsibility back on every one of us.

In this context, communication problems are discussed in relation to the extent to which science communication is useful or suited to changing attitudes and ways of behaving—e.g., in view of selective perception and the use of information:

> Sample quotation 8: People's expectations of what they want to hear are much stronger than they used to be….And the masses go in with certain expectations of what they actually want to hear. That is, there are people who want to hear about catastrophes, that humans are so bad, and they just want to hear that humans have ruined everything. And then there is another group, they just want to hear that everything is not so bad…but they just come along with a certain hope, 'I hope he says what I actually want to hear.' But you can have good discussions with them. They are happy to argue with you and you can put them on a scientific track. These ideological people, it's not worth it, with them you can break off the discussion after two minutes.

The public expectation that science also makes key decisions for society and politics is ultimately rejected by all the scientists we interviewed, usually by referring to their different roles in society (e.g., 'as a scientist' vs. 'as a citizen')—and clearly this stance has not caused them any difficulty:

> Sample quotation 9: And then I am also completely honest at this point, because I also think I don't want to be the better fellow citizen here. I am just—in a way I have access to knowledge that others don't have, and I like to try to make it available, without dogmatically coming along and saying what you have to do. And that, I have noticed, is very well received.

4.4. Expectation of the Expectation that '(Every) Science Communicates its Findings'

Scientists' reflections in a nutshell: 'Science should carry information outwards in various ways, but also make clear where there is a specialization/division of labour and that this poses limitations.'

> Sample quotation 10: But of course this allows us to take the liberty of maintaining a broad research portfolio and keeping experts on hand: some do one thing, others do another, others do another thing altogether. But in communication, it's expected of the other person, and also of society, that you talk about things in depth, which is always very exciting, because it's kind of great and fascinating—you can generate a sense of the fascination of research with really weird, specialist topics that everyone just thinks are great. But if you have a question where you want to have orientational knowledge, like how you should behave…then what you want is more reflective, more balanced, more broadly supported knowledge, and in the German science system this is not so easy to get. You'll find a lot of experts on something, but they'll all be stuck for answers pretty quickly, because it's a very differentiated system.

While none of the interviewees denied that scientists have a basic duty to communicate scientific knowledge, some of them immediately respond by discussing the different opportunities, media, and channels for doing so

and the differing extent to which these are able to fulfill said expectations (including the broad understanding that even a conversation with a neighbour about one's own work is also a—by no means negligible—form of science communication). With the scientists' reflections on the expectation that the public desires orientational knowledge, we once again come full circle to expectations of expectations and scientists' own aspiration that, despite the complexity of its problems, it should contribute as much as possible to the public's understanding of its findings.

All in all, the interviews show that the scientists interviewed explicitly formulate expectations with regard to the public. However, they do not anticipate or address the expectations that science journalists and communicators may have of scientists in the same way. These actors are obviously considered not so much addressees as cooperation partners in communicating science to the wider public. This can be seen from the fact that the interviewees focus more on the expectations they have of these partners (e.g., good research, a minimum of prior knowledge, correct representation, support in formulating findings in an understandable way).

5. Expectations, Emotionality, and Empathy in the Science Blog

5.1. The Core Conflict: Disputed Expertise and Disappointed Expectations

The quotations presented below are taken from the science blog's comments section, a prototypical example of science blog communication (Kuteeva, 2016) containing well over 100 comments in this case (Rahmstorf, 2014). The quotations show the core conflict that runs parallel to the factual and technical discussion about (inter alia physical) causes, processes, and degrees of global warming, namely, that one of the experts invited to give evidence is a controversial figure, both with regard to his claimed expertise and to the statements he made to the Environment Committee. The scientist who writes the blog discusses in his post both the position taken by this invited expert and the scientific context, his aim being to provide correction and clarification.

The italics in the following quotations denote *assigned or claimed roles* while underscoring denotes a judgement about a role (and thus implicitly fulfilled or unfulfilled role expectations). The original blog and comments are in German and are translated here into English. Bracketed omissions refer to omissions within a comment, not to unquoted comments. The following explanation points out the linguistic keywords, discourse patterns, and arguments which underlie the hermeneutic interpretations of this case study example.

Example Sequence 1:

1) Commentator nickname A (23 June 2014 11:31): How can it be that "*experts*'' like Mr. [criticized expert] are invited to an "*expert hearing by the Environment Committee*''? Of course I understand that *as a politician* you can't know about everything, but you should be able to distinguish between *a competent advisor* and *a charlatan* with completely obvious pied piper arguments! If this is what realpolitik looks like, then good night.

2) Expert criticized in the blog (23 June 2014 15:25): Another *one calling for censorship*! And he throws insults but doesn't mention his name. My topic, for the sake of clarification, dear "[A]," is "thinking on behalf of Germany as a competitive location." I can assure you that there are now *a lot of politicians* who do not consider my remarks on this to be "charlatanry" at all. Perhaps you could join *the more than 220,000 people* who have downloaded our latest basic report "Energiepolitik im Konzeptnebel" published in late January ([Link]). Mr. [Blogger] correctly pointed out that *I am not a physicist*. But complex questions are necessarily always interdisciplinary. In *my company* we work with *networks of consultants* which include *physicists* as well as *theoretical and synoptic meteorologists, physical chemists, biologists* and *other experts on the issues at stake here*. Other people invited to the committee were *agricultural scientists, political scientists, government bureaucrats* and *a churchman*. But because, in [Blogger's] and your opinion, they represented the True Teaching, THEY were of course allowed to be heard by the Landtag [= regional parliament] without objection.

3) Commentator nickname B (24 June 2014 10:25): Where did [A] call for censorship? He rather called for reasonable classification: a disproved and untenable marginal opinion on physics *by a non-specialist* should rightly not be presented as an "*expert opinion*'' in an expert hearing. Of course you may express your opinion freely—but if you spread rubbish, you must also respect the right of *all others* to call this rubbish rubbish….

4) Commentator real name C (24 June 2014 3:17): @[criticized expert]: So as not to lay myself open to the cheap accusation of being *an anonymous sniper*, I made an exception and used my name. But the validity of arguments depends just as little on whether someone reveals his real name as it depends on *his professional-scientific qualifications*.

5) Expert criticized in the blog (28 June 2014 18:11): Dear @[nickname B], you too may express your opinion freely. But if you had *expert ARGUMENTS* in addition to your opinion—then it might also be interesting. *And a name*.

6) Commentator nickname D (29.06.2014, 18:11): Mr [criticized expert], there are enough arguments here

> and elsewhere. To remind you:…It remains completely unclear to me what drives you to adhere to a hypothesis that has crumbled into dust both experimentally and theoretically. As *an economist without a scientific education*, you don't seem to have any knowledge of Karl Popper and the falsification of hypotheses. Your "cooling" is done. Period.

This short dialogue between four people, including the criticized expert, already reveals a great deal: The role of the expert, assigned to the latter externally by his invitation to the regional parliament's committee, is questioned by readers and commentators alike, but defended by the expert himself.

The commentators who call into question the expert status of the individual criticized explicitly and in detail by the blog do so against the background of the various expectations they obviously have of experts and which they do not consider fulfilled here: (1) the expectation of education relevant to the field ("charlatan," "by a non-specialist," "economist without a scientific education"); and (2) the expectation of a scientific mindset and corresponding argumentation ("completely obvious pied piper arguments," "disproved untenable marginal opinion on physics," "spreading rubbish," "adhere to a hypothesis that has crumbled to dust both experimentally and theoretically," "don't seem to have any knowledge of…"). The fact that this discourse participant is perceived by politicians as an expert and, given his invitation to advise the regional parliament, is taken seriously by them, clearly disappoints the other participants' expectations to such an extent that it leads to emotionally laden language, including strongly evaluative expressions ("pied piper arguments," "crumbled to dust," "rubbish," "adhere") and speech acts signalling impatience and frustration ("If this is what realpolitik looks like, then good night"). In this excerpt the expert defends himself against these accusations not with factual arguments but with (repeated) criticism of the communicative behaviour of his opponents ("calling for censorship," "doesn't mention his name") and of the discourse itself ("But because, in [Blogger's] and your opinion, they represented the True Teaching, THEY were of course allowed to be heard…without objection"). He thus formulates expectations that are rather unusual for communication on social media, but are quite common in science communication (e.g., use of clear names instead of nicknames). These expectations are understandable in view of the fact that, as a person already named in the blog's title, he finds himself in an asymmetrical situation vis-à-vis the other commentators with regard to the possibility of anonymity and data protection. At the same time, they are surprising because he argues politically rather than scientifically. Since he is not able to justify his right to speak (disputed by all participants in the communication) by referring to his education and thus cannot fulfil expectation (1) ("that I am not a physicist"), he seeks to ground his expertise in an interdisciplinary background ("in my company we work with networks of consultants") and to back it up using a relatively weak form of majority argumentation ("there are now a lot of politicians who…," "Perhaps you could join the more than 220,000 people who…").

Interestingly, both camps agree that the issue to be negotiated must be primarily about the validity of factual arguments and not mere opinions. Both camps also point out that these arguments can be supported by consensus, i.e., by the consent of others. However, the positions differ in the extent to which a relevant specialist education—in this case in the natural sciences and physics—is a prerequisite for the quality of the argumentation. Possibly, these expectations differ so sharply because the commentators have a stronger perception of the discourse as scientific, despite the media environment, while the expert, as already mentioned, argues strongly from a political perspective.

5.2. Ways to Rationality via Promoting and Offering Empathy

There now follow two sequences in which expectations are also disappointed, but in which the resulting emotionality is countered in a de-escalating and objectifying fashion through expectations of or readiness to display empathy. Interestingly, it is the commentators rather than the two experts (the science blogger and the criticized expert) who in an objective tone demand empathy, serious responses, understandable explanations, and well-founded justifications. This in turn suggests some very specific expectations of scientists who communicate with the public: namely that they are patient and reasonable, that they remain objective and communicate comprehensibly. Thus, these expectations match the expectations of the scientists and their willingness to empathize as outlined in Section 4 (4.1 and 4.2): appropriate handling of the complexity of the topic, insights into cognitive processes, and transparency with regard to the validity of the statements made.

Italics (*role assignment*), underlining (action evaluation) and upper case (FORMULATION OF EXPECTATIONS REGARDING EMPATHY) have been used to emphasize how the statements are argued.

Example Sequence 2:

1) Commentator nickname E (24 June 2014 13:03): *An amateur like me* sees the greenhouse discussion as follows:…as I said, that's how I see it *as a non-expert*.

2) Blogger (Scientist) (24 June 2014 17:49): How nice that *you as a non-expert* know what *the experts* are doing wrong….

3) Commentator nickname E (25 June 2014 14:21): Dear Mr. [Blogger], this kind of reaction will bring you exactly THE OPPOSITION THAT YOU…COMPLAIN

ABOUT. It's really not necessary. IN ORDER TO ACHIEVE THE ACCEPTANCE THAT YOU WOULD LIKE, I THINK IT WOULD MAKE SENSE FOR YOU TO BROADEN YOUR HORIZONS AND PAY MORE ATTENTION TO THE GENERAL PUBLIC. FOR EXAMPLE, IT WOULD BE HELPFUL—AND WOULD CLEAR UP MISUNDERSTANDINGS—if you could tell me whether and, if so, *why I am mistaken*….I WOULD ASK YOU TO EXPLAIN to me (and possibly to *one or two interested readers*) WHY YOU (OBVIOUSLY) THINK THAT IS WRONG. PERHAPS YOU COULD ALSO CITE VARIOUS SOURCES….Thank you very much.

4) Blogger (Scientist) (26 June 2014 16:31): Dear Mr. [E], I *don't always have time* TO REPLY TO ALL THE THESES THAT APPEAR HERE. Very briefly:…Incidentally, I have nothing against discussing such questions with *laymen* (that is the purpose of this blog), but I'm surprised when *laymen* claim full of conviction that *all experts* have been committing a "terrible blunder" in their basic understanding of the greenhouse effect for more than a century. BEAR IN MIND that every semester *thousands of physics students* gain an understanding of these things from scratch, *including undoubtedly many highly intelligent and critical minds*. HOW LIKELY IS IT that such a terrible blunder exists that *no one* has ever noticed?

The request of the self-confessed layman ("an amateur like me," "as a non-expert") that the scientist demonstrate more empathy towards the public ("broaden your horizon," "pay more attention to the general public") is connected to expectations as to how this empathy can be fulfilled ("clear up misunderstandings," "explain," "cite various sources"). These correspond essentially to the expectations towards experts elaborated in example sequence 1 (see Section 5.1). The scientist complies with these expectations, but only from a perspective of egocentric (and not allocentric) empathy ("I don't always have time," "very briefly," "I'm surprised") while demanding empathy in return in the form of prompts and prompting questions ("Remember", "How likely is it…?"). The layman's attempt to achieve more objectivity with his demand for empathy in response to the scientist's ironic reaction (2) ("It's really not necessary") is ultimately successful, because the requested explanation follows—and possibly also because the layman shows that he too is capable of allocentric empathy on the basis of expectations of expectations ("In order to achieve the acceptance you would like").

Example Sequence 3:

1) Commentator nickname G (24 June 2014 00:08): Dear Mr [criticized expert], it is actually part and parcel of *general education* that the air temperatures reach their daily maximum some hours after the sun has reached its zenith (given stable weather conditions).

2) Expert criticized in the blog (28 June 2014 18:03): Mr. [G], before you boast of your general education, YOU SHOULD PAUSE FOR A MOMENT AND ASK YOURSELF IF YOU HAVE CORRECTLY UNDERSTOOD THE PROBLEM AND IF YOU HAVE THE SAME VIEW OF THE PROBLEM AS THE PARTICIPANT YOU HAVE CRITICIZED. Otherwise we get the proverbial comparison of apples and pears.

3) Commentator nickname G (29 June 2014 18:01): Dear Mr [criticized expert], first and foremost, I THINK IT IS IMPORTANT TO POINT OUT the differences…which unfortunately is often neglected in such discussions…BUT YOU ARE RIGHT, IN A DISCUSSION YOU SHOULD ALREADY SEE WHETHER YOU HAVE UNDERSTOOD YOUR COUNTERPART'S PERCEPTION OF THE PROBLEM AND WHETHER YOU CAN REPRESENT IT CORRECTLY. IF I HAVE SOMEHOW MISREPRESENTED ANY OF YOUR STATEMENTS, JUST SAY SO. I HAVE NO PROBLEM CORRECTING MYSELF.

The example sequence follows a pattern that is repeated several times in the comments section: A commentator approaches the criticized expert directly with a question or statement (certainly not without provocative elements: "it is…part and parcel of general education"), to which the expert replies in a manner ranging from the sharp-tongued to the aggressive. The commentator reacts with pronounced objectivity, expressed in both polite salutation and self-revelation ("I have no problem correcting myself"). In response to the expert's appeal for empathy, which is purely rhetorical, since it is phrased aggressively ("before you boast of your general education, you should…ask yourself"), the commentator accepts and confirms the necessity for empathy and thus shifts the discussion by his contribution from the emotional back to the objective level ("But you are right, in a discussion you should already see whether you have understood your counterpart's perception of the problem….If I have somehow misrepresented any of your statements, just say so").

6. Synthesis and Conclusion

The following conclusions are based on an exploratory approach, as already mentioned, both with regard to the expectations held by the scientists and to the analysis of the blog comments. They represent an attempt to demonstrate the relevance of empathy in science communication (especially regarding the conflict-laden negotiation of social identities) and to stimulate empirical research on it.

Scientists who are willing to communicate their findings to the public actively engage with the public's expectations. They thus demonstrate both experience- and judgement-based empathy with groups. In part, these are expectations of expectations to which they are prepared to respond with allocentric empathy. However,

they also adjust their communicative attitude, on the basis of egocentric empathy, in order to correct individual and, in their view, inappropriate public expectations of science.

In the science blog we observe that, in the context of science communication, readers actually expect not only that the experts are qualified and competent, but also that they are prepared to report objectively on science, to substantiate findings, to explain complex issues in greater detail, and to deal openly with uncertainties. When the experts become impatient or respond with irony, and when they do not (want to) live up to these expectations due to a lack of empathy or due to, at best, egocentric empathy, the interaction quickly becomes emotionally charged. This, in turn, can be mitigated by the explicit articulation of an expectation of or a willingness to display empathy as a means of returning to the substantive issue as quickly as possible. However, this pattern of action may well be a feature specific to science blogs, forums, etc. and will hardly apply to all blogs and forums on social media, since those who read and leave comments on science blogs can already be expected to have a specific interest and prior knowledge and be willing to communicate constructively (e.g., Schäfer, 2017; Sprain & Reinig, 2017).

Despite their provisional nature, the evaluation of the interviews and analysis of the comments demonstrate that emotionality is almost inevitable when people with different, hierarchically perceived roles meet, and the scientific content of their communication is complex, socially relevant, and possibly also characterized by uncertainties on both the cognitive and decision-making levels (e.g., Kuteeva, 2016). This is also because in such communicative contexts the most diverse expectations collide, heavily influencing direct communicative action in the form of reciprocal expectations of expectations. Empathy appears to be a possible way to resolve or even avoid the resulting communicative conflicts (instead of engaging in more emotional communication, e.g., Schneider, 2019). It would therefore be worthwhile taking a closer look at empathy in science communication not only by means of linguistic methods but also using interdisciplinary approaches in communication science, other social sciences, and the humanities (Bender & Janich, 2020).

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Conflict of Interests

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Article

Cold Science Meets Hot Weather: Environmental Threats, Emotional Messages and Scientific Storytelling

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Abstract
Science is frequently called upon to provide guidance in the work towards sustainable development. However, for science to promote action, it is not sufficient that scientific advice is seen as competent and trustworthy. Such advice must also be perceived as meaningful and important, showing the need and urgency of taking action. This article discusses how science tries to facilitate action. It claims that the use of scientific storytelling—coherent stories told by scientists about environmental trajectories—are central in this; these stories provide meaning and motivate and guide action. To do this, the storylines need to include both a normative orientation and emotional appeals. Two different cases of scientific storytelling are analyzed: one is a dystopic story about a world rushing towards ecological catastrophe, and the other is an optimistic story about a world making dramatic progress. These macrosocial stories offer science-based ways to see the world and aim to foster and guide action. The article concludes by stating that using storylines in scientific storytelling can elicit fear, inspire hope, and guide action. The storylines connect cold and distant scientific findings to passionate imperatives about the need for social transformation. However, this attachment to emotions and values needs to be done reflexively, not only in order to create engagement with an issue but also to counteract a post-truth society where passionate imperatives go against scientific knowledge.

Keywords
Anthropocene; emotions; Factfulness; narratives; science communication; scientific storytelling; The Great Acceleration

Issue
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1. Introduction: Constructing Knowledge that Matters

Across diverse issues and domains, a new form of expertise has emerged with the task of synthesizing, translating, and communicating scientific knowledge to decision-makers, stakeholders, and the general public (Beck et al., 2014; Esguerra, Beck, & Lidskog, 2017; Lidskog & Sundqvist, 2015; Turnhout, Dewulf, & Hulme, 2016). This expertise aims to guide and motivate action. A particular challenge for this kind of expertise is to synthesize and package knowledge in a way that makes it useful, credible, and meaningful for decision-makers (Gustafsson & Lidskog, 2018; Heink et al., 2015). In this process, there is always a risk that the reduction of complexity—in order to make it a clear message that is understandable for nonexperts—will lead to criticism and a loss of credibility (Lidskog, Mol, & Oosterveer, 2015). The scientific community may consider the simplifications to have gone too far and the public and stakeholders may express distrust and even use the reduction of complexity and uncertainty as a means for questioning the status of the knowledge claims, a strategy that the climate denialism movement has made ample use of (Dunlap & McCright, 2015).

The tension between being understandable and relevant without losing scientific credibility is further fueled by a current trend where science, apart from providing knowledge about an issue, is requested to assess possible solutions to that problem (Beck & Mahony, 2018; Haas, 2017; Jabbour & Flachsland, 2017). For a long time, the social sciences have stressed that messages need to be meaningful in order to influence an actor's thoughts and actions. Risk psychology stresses that cognitions and feelings affect the public's perception of risks (Slovic, 2010), risk sociology stresses that risks are always staged to conceal normative and epistemic assumptions (Hilgartner, 2000; Lidskog & Sundqvist, 2013), and strands within policy studies and communication studies stress that meaning-making in public policy is done in the form of narratives and storylines (Bevir, 2011; Fairclough, 2013; Persson, 2015; Yanow, 2007). In different ways, the majority of this research address how organizations, such as media, policymakers, and corporate industry, frame and distribute messages and how different social segments appropriate these messages (Arnold, 2018). This article focuses on another kind of actor: that of scientific expertise. The reason for this focus is that despite much talk about a post-truth society and science skepticism, science still holds epistemic authority (Jasanoff, 2018; Lidskog & Sundqvist, 2018). Scientists are often recognized as authoritative storytellers and legitimate constructors and disseminators of science-based stories. Thus, through their role as scientists, they give credibility to the storylines they spread. While most scientific advice tends to have a "rational bias" in the sense of paying limited attention to the importance of norms and emotions, the aim of this article is to show that there is an inevitable normative and emotive base in science-based narratives that aims to transform thoughts and initiate actions. This, we will argue, is the case even when the narratives state the ambition to create transformations and actions by "simply stating the facts," and it follows from the need to tell a compelling story in order to be heard and make an impression. By including not only factual information but also normative orientations and emotional appeals, scientific storytelling relates cold and distant scientific findings to passionate imperatives about the need for social transformation. At the same time, developing and communicating storylines is a complex task that puts the trustworthiness needed to make a story compelling at risk (Arnold, 2018). If the voice of expertise is deemed too normative and emotional, it may lose its epistemic authority—and the narrative may be reduced to an expression of opinion.

This article discusses a particular form of scientific communication: scientific storytelling aimed to facilitate action. By analyzing two different cases of scientific storytelling we will explore how scientists create storylines with the aim of disseminating a science-based worldview to a wider audience. What we are particularly interested in is how scientific storytelling connects to normative imperatives and emotional appeals. To examine this, we have chosen two different cases of successful outreach. The cases represent opposite views on the direction of current global development. Consequently, they also provide diverging guidance on how to act. The two cases are mainly used to explore how scientific storytelling relates to norms and emotions. The empirical material consists of original texts (including graphs and illustrations) that develop these storylines.

The article comprises six sections, including this introduction. The second section outlines the point of departure: the role of narratives and scientific storytelling in creating a public understanding of environmental issues. The third section presents the selection of cases and empirical materials. The fourth section describes the two selected cases of scientific storytelling, and the fifth section makes use of these cases to discuss the normative and emotive aspects of these storylines. The sixth and concluding section discusses the role of emotions in scientific storylines. The article concludes by stressing the importance of attaching to norms and emotions in a reflexive way in order to create engagement with an issue while at the same time avoiding a post-truth development in which passionate imperatives go against scientific knowledge.

2. Narratives, Storylines, and Scientific Storytelling

Storytelling is a fundamental element of all cultures, and human sciences (not least literature studies and religious studies) have analyzed the role and construction of stories in detail (Ricœur, 1995). The analysis of stories and narratives has also gradually been included in other disciplinary fields. In policy analysis, interpretative approaches (Bacchi, 1999; Fischer & Forester, 1993; Yanow, 1996) and narrative approaches (Roe, 1994) have developed methods for analyzing how meaning is created in policy formation. Narrative policy analysts (Jones, McBeth, & Shanahan, 2014) have developed a structured way to analyze policies and policy debates by stressing generalizable and context-independent elements of narratives, such as the setting, characters, plot, and moral of a story. Other policy analysts stress the important role of stories, metaphors, and symbols in the struggle over how a situation or a problem should be understood (Hajer, 1995). By means of how the problem is framed, stories, metaphors, and symbols serve to explain how the world works and to affect how actors relate to the world (Stone, 2012).

Interpretive policy studies focus on policy storylines and the function that scientific facts may play in them. These analyses have shown that scientific findings and facts often play an important role in the storylines that gain political influence, not least by lending them legitimacy (Fischer, 2003; Hajer, 1995; Lee, 2007; Stone, 2012). While the scientific communication that feeds into this process is not part of the analysis, the function of scientific components (such as causalities, concepts, or figures) in the policy narratives suggest that

they are associated with neutrality and objectivity (see e.g., Stone, 2012). This view seems to be encompassed by some advocators of scientific storytelling, seeing it as a particular narrative form that serves the function of transferring scientific truths to nonscientific contexts (see e.g., Bickmore, Thompson, Grandy, & Tomlin, 2009; Dahlstrom & Scheufele, 2018). In this study, we focus on this scientific storytelling. That is, the communication of scientific knowledge and results that may then feed into policy storylines in different ways.

Science and technology studies (STS) has, for a long time, focused on the relation between science and policy in a more general way. STS stresses the fundamental role of co-production and that the epistemic and normative understandings of the world are intertwined in such a way that both representations of the world and normative ideals about how this world should be are constructed (Jasanoff, 2004; Wynne, 2005). In other words, STS scholars argue that fact-finding and meaning-making are intertwined and that scientific beliefs often are distributed widely in society, providing meanings for ideas and objects (Jasanoff, 2012, 2018). The implication is that science never merely describes the world but also tells what the right questions about this world are, e.g., which questions need to be raised to identify potential risks. However, how issues are (scientifically and technically) framed and what epistemic and normative assumptions lie behind this framing are often invisible to the public and taken for granted by scientists (Wynne, 2005). An implication of this is that many scientists tend to interpret diverging views between science and the public as caused by the public misunderstanding science; this is called "the deficit model," where the solution is to inform or even educate the public about scientific literacy (Irwin & Wynne, 1996). Contrary to this, STS argues for greater reflexivity on the side of science about its own epistemic and normative underpinnings and an opening up of room for knowledge input from the public, which is called "the dialogical model." This contribution, with its stress on how science implicitly frames issues and influences public meanings, is very relevant for our study. However, what the discussion within STS is missing is, according to our view, a stronger focus on the role of emotions (Engdahl & Lidskog, 2014). Risk psychology has stressed for a long time that feelings are a constitutive part of human judgment and decision-making and that feelings and cognition are interrelated (Finucane, 2013). Thus, focusing only on epistemic and normative issues in scientific storytelling gives a one-sided view of how science matters in framing issues and spreading them in society.

Scientific storytelling—which is the topic of this article—is the creation and sharing of science-based storylines that are told by scientists and aimed at influencing a wider audience and guiding action (Dahlstrom & Scheufele, 2018; Kosara & Mackinlay, 2013). In scientific storytelling, scientific concepts and measures are translated in order to be meaningful for people outside a particular scientific community (Latour, 1987; Lidskog, 2014). These kinds of storylines are often based on symbols, analogies, and emblematic issues in, for example, the form of formative events or indexes and graphs that summarize complex and broad processes of change (Stone, 2012). Typically, a storyline gives a historical account of the problem and its causes and consequences, which motivates, guides, and legitimizes decisions and actions. By telling not only what has happened and why but also what to do about the issue (explicitly or implicitly), scientific storytelling combines factual statements and a normative orientation in order to facilitate action. Successful storytelling not only explains the world but also motivates action, and a central means for this is emotionally engaging the listener (Arnold, 2018). As has long been stressed by rhetoric, an orator should include not only ethos and logos but also pathos (appeals to emotions); this is done in order to not only teach the public but also engage it.

3. Case Selection and Empirical Material

We selected two different cases of scientific storytelling to explore how scientists create storylines with the aim of disseminating a science-based worldview to a wider audience, thereby hoping to transform thoughts and initiate action. *The Great Acceleration* is part of the broader Anthropocene-narrative and is a largely dystopic story of a world rushing towards a global ecological catastrophe. In contrast, the narrative of *Factfulness* is substantially more optimistic, highlighting how the world is on the right track with dramatic global progress in many areas. These stories are told by scientists and other actors using wide brushstrokes, with the aim of changing worldviews, mindsets, and beliefs about what is desirable as well as possible to achieve. Thus, the cases are: 1) macrosocial stories about the trajectory of current society; 2) told by scientists; 3) claimed to be scientifically authoritative ways to understand the world; 4) aimed at changing worldviews and fostering action; and 5) distributed broadly in society.

These cases were also selected because they represent diametrically opposite views of the direction on current global development. Consequently, they also provide diverging normative guidance and evoke different emotional appeals, which make them of great interest to analyze together. They also differ in origin and in how the stories have been disseminated. Originally, *The Great Acceleration* was presented in a scientific context, and it has gradually been spread in different settings, reaching different groups. In contrast to this, *Factfulness* has directly targeted a wider audience through a broadly spread and popular scientific book, TED Talks, and a website with interactive materials.

The empirical material consists of primary sources such as written documents, including the graphs that illustrates these texts. The analysis of *The Great Acceleration* is based on the work of Steffen, Grinevald,

Crutzen, and McNeill (2011) and Steffen, Broadgate, Deutsch, Gaffney, and Ludwig (2015). We also made a review of the broader Anthropocene narrative, which provided an interpretative frame for our understanding of *The Great Acceleration* (Lidskog & Waterton, 2016, 2018). The analysis of *Factfulness* is based on a book of the same title (Rosling, Rosling, & Rosling-Rönnlund, 2018). We also analyzed the biography *How I Learned to Understand the World* (Rosling, 2017), in which Hans Rosling describes how he developed the perspective of *Factfulness* and how he, together with his colleagues, established the Gapminder Foundation, which works to globally disseminate *Factfulness*.

The analysis of the two storylines began by mapping the two cases in terms of their problem descriptions, suggested solutions, and concept of role of the public, etc. (see also Table 1). In the next section, we specifically analyze how these two cases of scientific storytelling relate to norms and emotions.

4. The Cases: Environmental Destruction versus Human Progress

The storylines of *The Great Acceleration* and *Factfulness* construct stories about global development, distribute them to the public and stakeholders and, thereby, create incentives for action.

4.1. Anthropocene and The Great Acceleration

The Anthropocene narrative has made an amazing journey, from a spontaneous invention at a scientific conference in the year 2000 to a story that is now widely adopted and institutionalized within the scientific community (Crutzen & Stoermer, 2000; Hamilton, 2017; Lidskog & Waterton, 2016). The narrative has also successfully spread outside the scientific community, not only through environmental movements and governmental bodies but also through cultural institutions, such as museums and galleries, which have elaborated exhibitions and artistic performances (Robin et al., 2014). The concept's original meaning—a new geological epoch where human activities are geologically traceable—has been subordinated to a wider story of a human predicament where human impact now threatens fundamental life processes on earth. The narrative is dynamic and functions in many settings, however, most of its meaning is stabilized around a number of graphs labeled *The Great Acceleration.*

The Great Acceleration is a term that was coined to grasp a drastic increase in human polluting activities starting after World War II (Steffen et al., 2011, pp. 851–852, 2015, pp. 84–87). Twelve different indicators, such as human population, gross domestic product, fertilizer consumption, and water use, showed a dramatic increase and were then linked to major adverse environmental effects such as the concentration of carbon dioxide in the atmosphere, the global extinction of species, and ocean acidification (for an example, see Figure 1). The figure of *The Great Acceleration*—also labeled "the hockey stick" figure—has become an iconic symbol of the Anthropocene. The narrative claims that humanity has "switched gears" and is speeding up the tempo of growth, a shift that is identifiable through the rising trends of resource extraction and environmental emissions.

The narrative of *The Great Acceleration* is played an important part in making the Anthropocene a story that invokes fear, as it asserts that humanity is facing its greatest challenge ever and claims that there is a need for rapid and extensive societal changes to halt this trend. This need for a radical social transformation is a challenge not only for society in general but also for science, which has to produce relevant knowledge that facilitates and guides this transformation (Zalasiewicz, Williams, Steffen, & Crutzen, 2010). However, the narrative of the Anthropocene also includes aspects of hope, stating that there is still time to act. In this narrative, there is the great challenge of balancing the dynamic between emotional messages of fear and hope in order to create story that opens up space and also provides incentives for action.

4.2. Gapminder and Factfulness

Gapminder is in independent foundation that aims to fight devastating misconceptions about global development by producing free teaching resources based on statistics (gapminder.org). Its innovative conversion of

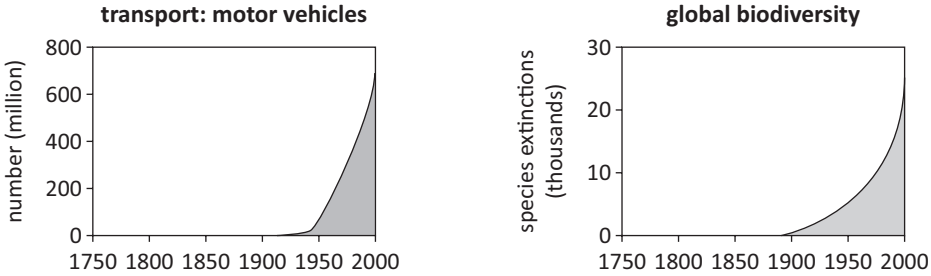

Figure 1. Examples of "The increasing rates of change in human activity since the beginning of Industrial Revolution" and "Global scale changes in the Earth system as a result of the dramatic increase in human activity." Note: See supplementary materials on the journal's website for all 24 graphs. Source: Steffen et al. (2011, pp. 851–852).

quantitative data to animated and interactive graphics (such as bubble charts and scatterplots) has made the organization known to a broader public, and on its website, people can explore global trends in a number of areas. One of Gapminder's TED Talks, "The best statistics you've ever seen" (presented by one of its founders, Hans Rosling, in 2006), is still one of the most viewed TED talks ever, and the organization's ten TED Talks have together been seen by more than 35 million people.

Gapminder's essential storyline is that the world has become a better place to live in. This storyline is argued for by showing that in a number of fields—such as health, education, and welfare—global trends give a very clear picture of increasing health and welfare. Today, for example, there is no country with a life expectancy below 50 years, and the extreme poverty rate decreased from 50% in 1966 to 9% in 2017. To show that these are broad positive trends, the narrative presents 32 improvements that show that the world is getting better (Rosling et al., 2018, pp. 60–63). First, it presents the decrease of 16 bad things concerning both human rights (such as legal slavery, infant mortality, and the death penalty) and the environment (such as oil spills from tanker ships, death from disasters, smoke particles, and ozone depletion). Second, the narrative also presents the increase of 16 good things concerning both life quality (such as literacy, democracy, and electricity coverage) and the environment (such as protected natural areas and monitored species).

Against this backdrop, it is argued that the vast majority of people have a distorted understanding of the world, believing that the world is poorer, less healthy, and more dangerous than it truly is (Rosling et al., 2018, p. 13). Thus, through his lectures around the world, Hans Rosling (Rosling et al., 2018) has found that most people have an inaccurate view of many of the measures that he uses to signify global development. Neglect of these numbers was found among audiences consisting of the general public as well as global elites—Nobel laureates, investment banks, and participants at the Davos World Economic Forum. Thus, even extremely well-educated people who deal with global issues in their professions were wrong about these aspects of global development. In the book *Factfulness: Ten Reasons We're Wrong About the World—And Why Things are Better Than You Think*, Rosling et al. (2018) seek to explain why people often have a wrong understanding of the world.

The book *Factfulness* has been translated into 30 languages and celebrated by a number of international celebrities. For example, Barack Obama has acclaimed it, and Bill Gates found it to be one of the most important books he had ever read, which prompted him to gift it to all new graduates of US colleges and universities one year (Gapminder, 2019a). The book was placed on the longlist for Business Book of the Year 2018 (Hill, 2018) and a review in *Nature* found it to be a magnificent book (O'Neill, 2018). The book explains that the reason we are getting the facts wrong is not ignorance or obsolete knowledge but rather preconceived ideas. It states that human beings carry ten instincts that distort our perspectives, making us blind to see global progress. According to Rosling et al. (2018), these instincts are evolutionarily grounded so that our brain gives precedence to dramatic information. This systematic misinterpretation results in an overdramatic worldview that leads to inappropriate focuses and bad decisions. Thus, the mission of Rosling and his colleagues is to eliminate the misguided perception of problems, thereby making space for focusing on real problems. The strategy that the narrative of *Factfulness* advocates is to widely spread information on these ten instincts and thereby let a fact-based worldview transform organizational and individual thinking. An implication of *Factfulness* is the moral imperative that we should only carry opinions that are based on solid facts. Consistent with this, Gapminder (2019b) presents itself not as a "think tank" but as a "fact tank."

5. Analysis: Stories of Fear and of Hope

Both *The Great Acceleration* and *Factfulness* are cases of scientific storytelling about the state of the world. They are both examples of a common type of narrative structure that evokes feelings of change (Stone, 2012, pp. 157–165). For *The Great Acceleration*, the direction of the change is decline and is attached to fear, whereas

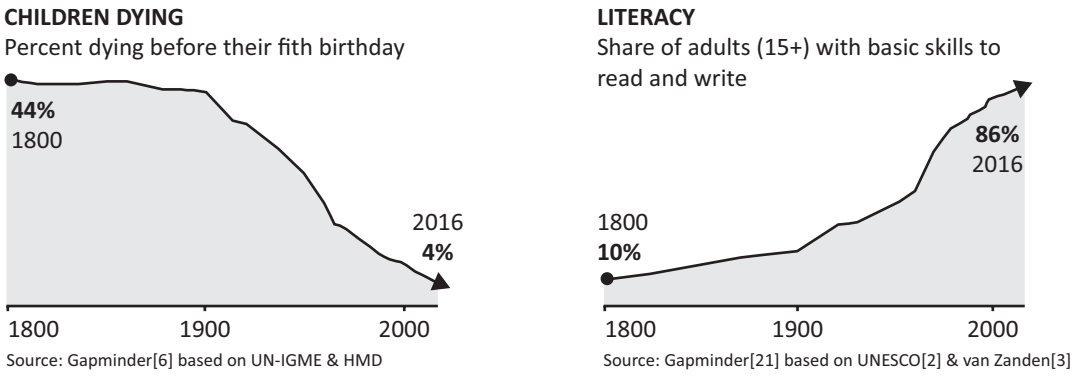

Figure 2. Examples of "bad things decreasing" and "good things increasing." Note: See supplementary materials on the journal's website for all 32 graphs. Source: Rosling et al. (2018, pp. 60–64).

for *Factfulness*, the direction of change is progress and is attached to hope. They tell very different stories, guide listeners in diverging directions and invoke different emotions. Table 1 summarizes the main differences.

The two narratives have a number of differences and similarities. The most obvious similarity is their claim on epistemic authority and their belief in scientific facts. Both storylines claim to be based on established science and they share the mission of spreading a scientifically based understanding of the state of the world. Paradoxically, despite fighting for a scientific worldview, neither of them includes a scientifically grounded view—in terms of referring to the social and behavioral sciences—on society and human beings. In this sense, they are a paradoxical form of scientific storytelling that stresses the importance of science but ignores it when presenting social causes and remedies.

5.1. Normative Guidance

Both storylines aim to present the current state of the world and, at the same time, to guide the direction of action. They illustrate their messages by use of dramatic graphs, showing with great certainty the directions of global trends, and both storylines state that the graphs are based on authoritative sources. All the graphs they present (24 for *The Great Acceleration* and 32 for *Factfulness*) support their respective main messages, thereby creating a feeling of strong certainty about the direction society is heading in. By showing in this way that humankind is on the wrong or right track, they create reasons to act. They are, however, rather vague about who should act and how those actors should act in order to counteract or support current global trends. The storyline of *The Great Acceleration* clearly states that the current development towards environmental destruction urgently needs to be halted, but the narrative also develops little practical guidance about what to do (besides making sweeping statements about the need to change values, regulate growth, reduce consumption, etc.) and who should do it (the location of power and agency). The team behind *Factfulness* is very practical in describing how to avoid being steered by the ten human instincts that create an overdramatic and inaccurate worldview. By obtaining a fact-based worldview, we can "see that the world is not as bad as it seems—and we can see what we have to do to keep it making it better" (Rosling et al., 2018, p. 255). At the same time, there is limited practical guidance given on what to do to make the world better. Instead, it seems as if science itself—"solid facts," as the narrative of *Factfulness* puts it (Rosling et al., 2018)—will give this guidance. By knowing the state of the world, it is believed that certain action will be taken or at least supported. In that sense, the storyline of *Factfulness* assumes that knowledge also gives direction, which goes against positivistic epistemology, which presumes a separation between "is" and "ought" and between facts and values. This also seems to be the case for *The Great Acceleration*, with its stress on scientific facts and scientific storytelling but with little discussion on which norms that should guide our actions.

Like many others, these storylines have a technocratic character in the sense they present the "true" nature of an issue and thereby conceal alternative views (Jasanoff, 2012; Wynne, 2005). Even if each storyline has a valid knowledge base for its views, scientific facts can be orchestrated differently; there are many ways to make facts part of a storyline's greater purpose. The contrasting images presented in these cases are a good illustration of this. The advocators of the Anthropocene probably do not question the figures and data that Gapminder disseminates but do not agree on the overall storyline and

Table 1. Comparison of the storylines of *The Great Acceleration* and *Factfulness*.

	The Great Acceleration	*Factfulness*
Main message	Things are getting worse!	Things are getting better!
Focus	Environment	Health, welfare, environment
Problem	Ignorance at a level of severity that creates low support for the needed action	Overdramatic worldview that creates stress and misguides action
Solution	Getting the facts right	Getting the facts right
Mission	Counteract environmental destruction	Counteract unnecessary anxiety and thereby focus on real-world problems
The role of the public	Mobilize public support for science-based policies	Educate people in order to help them to control their instincts
Norms	Not explicitly discussed	Not explicitly discussed
Emotional appeal	Fear	Hope
Imperative	Act now!	Don't overreact!
View on emotions	Not discussed	Emotions as a problem

its projections about future development; this because they see the positive global trends that the narrative of *Factfulness* disseminates as based on exploiting earth's finite resources. Thus, the same trends that are used to support the *Factfulness* storyline of global progression in welfare are used by *The Great Acceleration* storyline to support trends towards the overconsumption that results in environmental degradation. An example of this is that the storyline of *Factfulness* (Rosling et al., 2018, pp. 62–63) sees the global increase of cellphones as "good things increasing," whereas *The Great Acceleration* associates the increased number of phones with environmental destruction (Steffen et al., 2011, p. 851). In this sense, both cases present an unproblematized storyline in the sense that they do not discuss their selection of the trends and why they attach specific meanings to the trends. The selection of numerous graphs where the factors follow the same development provides a crucial visual expression as well as emotional stimulation. Thus, their messages build on the multiplicity of graphs.

5.2. Emotional Appeals

While both storylines are science-based endeavors, they also work emotionally. *The Great Acceleration* is a fear-eliciting story, as it argues that in our quest for increased material wealth, we have come to a point where the fundamental life processes of the earth are threatened. In contrast to this, *Factfulness* provides a comforting and hope-inspiring story that argues that we are on the right track and that human progress takes place all over the world. Our worries about the state of the world, the narrative claims, are largely groundless and are caused by emotional responses. In this sense, both storylines believe that by presenting scientific facts, proper responses will be evoked. The storylines also validate certain emotions, in the sense that they claim that there are emotions of worry or hope that are scientifically grounded.

It is interesting to note that whereas the storyline of *The Great Acceleration* does not explicitly discuss emotions, the storyline of *Factfulness* has an ambiguous view. The latter states that critical thinking should replace our instinctive reactions, and then it uses emotionally laden and lively stories to replace hot feelings with cold facts. For example, the book *Factfulness* is filled with moving stories, Rosling's TED Talks appeal to our senses and are filled with entertaining moments, and Gapminder's software converts "boring" statistics on health and wealth into moving and colorful bubbles that spur interest and curiosity. An apposite example is how Hans Rosling once ended a talk by taking off his shirt, revealing to be black linen with gold sequins underneath, and then swallows a sword. By doing this, he aimed to show that what is seemingly impossible is possible; the sword-swallowing illustrated how wrong our intuitive beliefs are (see Rosling et al., 2018, pp. 1–3). In that sense, in contrast to their lack of presence in *The Great Acceleration*, emotions play a central role in *Factfulness*, which sees them as the main problem but also uses them to disseminate its core message to wider audiences.

6. Discussion and Conclusion: Emotions Matter—Also for Science

This article discusses a particular form of scientific communication: scientific storytelling that aims to facilitate action. The article claims that the development and distribution of compelling storylines—coherent stories about societal trajectories, including causes and possible futures—are central in this. To accomplish this, storylines need to include both a normative orientation and emotional appeals. Scientific storytelling generally aims to affect how we understand an issue as well as how we navigate in the world. To do that, the story told must be seen as trustworthy and worth acting upon (Wynne, 2005). It may stress an issue's importance (e.g., it is severity and need for urgent action) or deconstruct its importance (e.g., we are misguided and should focus on other, more important issues). In doing this, storylines connect to values and evoke emotions.

6.1. Emotions in Science Communication and Knowledge Production

It seems paradoxical to use emotional appeals to counteract emotions and instincts, but this is not necessarily the case. Scientific storytelling aims to change worldviews, and emotionally laden stories may be effective for this as a means for appropriating scientific facts. Using emotions as vehicles to persuade an audience is frequently effective: Emotionally laden stories can be used to pave the road for worldviews based on science and facts, as well as for other kinds of worldviews. However, it is important to not have an overly restricted view on emotions as effective instruments to change worldviews and behaviors. Such a view seems to be encompassed by some advocators of scientific storytelling who see it as a particular narrative form that facilitates the transfer of scientific truths to nonscientific contexts (see e.g., Bickmore et al., 2009; Dahlstrom, 2014; Dahlstrom & Scheufele, 2018).

In contrast to this instrumental view on emotions—that is, emotions as an important means for transferring knowledge but not having a relation to knowledge per se—many disciplines and research areas claim that emotions are anything but opposed to reason. Emotions can be rationally motivated in the sense that they are based on deeply held values—an idea that is stressed in moral philosophy, both by virtue ethicists (Nussbaum, 2013; Taylor, 1989) and deontological ethicists (Rawls, 1972). This is also in line with risk psychology (Slovic, 2010) and the sociology of emotions (Jacobsen, 2018; Turner & Stets, 2005), which stress that emotions play an integral part in people's evaluations of claims of knowledge. Emotions are often discriminatory responses closely linked to an idea of what things are and what is important. Obviously, there are emotional responses that

are irrational in the sense that they have no specific motivation (for example, feeling anger despite no injustice having been committed) and may hinder a broader understanding of an issue. However, the point is that emotions play an important role in knowledge processes, not only in the appropriation of knowledge but also in the production of it (Berlant, 2011; Schaefer, 2018). What we find worth knowing—as lay people as well as scientists—is always (partly) guided by our particular relations to the physical and social objects at stake. Thus, emotions are active on two levels: both in the shaping of scientific storylines and science communication and also in the knowledge production of science, guiding scientists in their scientific practices—as norms and values do. In this sense, emotions are constitutive not only for science communication and the public uptake of scientific knowledge but also for scientists' production of knowledge.

6.2. Do Storylines Facilitate a Post-Truth Society?

Cold and distant scientific findings combined with passionate imperatives may foster action. Storylines are decisive in this, eliciting fear, inspiring hope, and guiding action. At the same time, if the voice of science is seen as too normative or emotional, it may lose its scientific authority and be reduced to an expression of opinion. Thus, scientists face a complex balance in shaping persuasive storylines that involve normative guidance and emotional appeals but do not cause scientists to lose their epistemic authority. Finding the right amount of emotional appeal is indeed a difficult task. For instance, the message that "all is well" may lead to public complacency and inaction, e.g., when citizens come to view risk regulation as being well above the actual safety margins (Wang & Kapucu, 2008). However, fear-eliciting messages may also trigger inaction, e.g., when the use of distressing imagery causes people to avoid or ignore persuasive messages (Brown & Richardson, 2012).

There is also another danger when scientists are developing and disseminating storylines. By telling stories, scientific storytelling aims to mobilize people and organizations and guide their actions. However, other stories are also told, and there is a discursive struggle around which storyline should be considered true and gain political influence (Hajer, 1995). This is quite visible in the case of climate denialism. Think-tanks and anti-environmental organizations have created and disseminated (especially through social media) a storyline in which current environmental claims and initiatives for change are counteracted. Climate denialists have painted a picture of strong and far-reaching scientific disagreements and controversies about climate change that are being silenced by a global conspiracy favoring the discourse on climate change and obstructing critical voices, including scientific ones (Dunlap & McCright, 2015; Oreskes & Conway, 2010). Thereby, nonexperts have to navigate in a landscape populated by diverging storylines that all claim to be based on firm science (but also, as Norgaard, 2011, shows, involving strong emotional appeals). In this sense, much storytelling, including scientific storytelling, may foster a post-truth society in the sense that scientific storytelling is placed on the same level as other stories (Dahlstrom & Scheufele, 2018). Thus, scientists are faced with a difficult dilemma here. If scientific storytelling, in its efforts to differ from other voices, includes discussions on epistemic assumptions, normative commitments, and views on emotions, the result may be less-compelling stories with limited spread and effects. Therefore, compelling stories are rarely stories that include a great amount of self-reflection and self-criticism. However, if scientific storytelling instead relies on a positivistic epistemology, believing that the storyline is solely based on unquestionable facts, it runs the risk of not fostering a science-based worldview in the sense of an unproblematized worldview with no room for complexity, contingency, and ambiguity.

In our opinion, this dilemma should not prevent researchers from developing storylines, which would only result in other storytellers populating this space (e.g., telling stories falsely claiming to be scientific, as is often the case with climate denialism). However, this dilemma means that scientists always have to reflect on how their storylines will be interpreted and what their wider consequences will be, not least how the storylines will affect the institutional trustworthiness of science. This is important because the perceived validity of scientific storylines is dependent on the trustworthiness of their sources, that is, whether the teller is seen to be representing an institution with epistemic authority.

In this sense, the general public, as well as scientific experts, need to cool down and reflect upon what kind of stories they are telling and listening to—and what the implications of such stories are. Reflexivity is needed, even when cold science is heating up to tackle global challenges.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the author (unedited).

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Article

Investigating Ethos and Pathos in Scientific Truth Claims in Public Discourse

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Abstract
The article seeks to explore the role played by the rhetorical modes of ethos and pathos when scientific knowledge is constructed in public discourse. A case study is presented on the public debate in Germany on possible risks to bees from neonicotinoid pesticides, focusing especially on a detailed analysis of scientific knowledge claims found in texts produced by two lobbying groups involved. The findings indicate distinctive rhetorical patterns in the context of scientific truth claims realising, for example, appeals to concern and the display of scientific competence and integrity.

Keywords
ethos; linguistics; pathos; public discourse; rhetoric; scientific knowledge; truth claims

Issue
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1. Introduction: Scientific Knowledge and Public Discourse

The linguistic understanding of scientific knowledge in the public sphere has changed significantly in recent years. Since the late 1990s, the relationship between scientific knowledge and the public sphere has been viewed primarily from the point of view of transfer, with knowledge first being generated within the scientific community and then being transferred to the public. This process has been described variously as transfer (Wichter & Antos, 2001), popularization (Niederhauser, 1998), and—more critically—transformation (Liebert, 2002).

For a number of reasons, the idea of unidirectional transmission no longer seems appropriate today. For one thing, the direction of knowledge transfer has been reversed in the context of citizen science. Formats of citizen participation play an increasingly important role in the public perception of science (Hecker et al., 2018). In addition, greater attention is being paid to cases in which scientific knowledge and its validity are negotiated in public discourses. Well-known examples of this include debates about climate change, vaccination, nutrition, and health, some of which have already become the subject of discourse-linguistic studies (Janich & Simmerling, 2013; Tereick, 2016). Scientific knowledge is no longer asserted by scientific experts alone and 'translated' by journalists. Politicians, lobbying groups, NGOs, and ordinary citizens also present knowledge claims in public discourses and thus participate in the co-construction of scientific knowledge in the public sphere.

Scientific knowledge, uncertainties, and technologies are often debated in the context of public debates and controversies regarding policy decisions and processes, and emotionality often plays a significant role in such debates (Gottweis, 2007). It seems clear, then, that affect is intrinsic to scientific knowledge claims in such contexts, and that it plays a key part in the linguistic form they take and in the credibility of their suggested validity. In this essay, I want to demonstrate how this connection between scientific knowledge and emotion in public discourse can be described from a rhetorical perspective. To this end, I first explain the relevance of an integrative approach that draws on rhetoric and linguistics. I then dis-

cuss how the two classical categories of ethos and pathos can be rendered useful for linguistic analysis. Finally, I use an analysis of the German public discourse on neonicotinoids to demonstrate the role ethos and pathos can play in the rhetorical strategies used by actors in the course of constructing knowledge.

2. A Rhetorical Perspective on Scientific Truth Claims

The rhetorical perspective adopted in this essay developed out of the critical engagement of discourse linguistics with scientific knowledge. However, the understanding on which it is based corresponds largely to the approaches found in the rhetoric of science. This "small but proud scholarly field" (Depew & Lyne, 2013, p. 1) has its origins in literary studies and philosophy and focuses on formal as well as heuristic aspects of scientific language use (Fuller, 1995; Gross, 1990).

2.1. Scientific Truth Claims as a Characteristic of Scientific Knowledge

The phenomenon of knowledge is addressed in discourse linguistics by examining the utterances that constitute this knowledge and their formation in discourse (Warnke, 2015). Thus, to explore the essential characteristics of scientific knowledge is to explore the essential characteristics of a certain formation of utterances. Discourse linguistics draws on the findings of the sociology of knowledge and the philosophy of science, where scientific knowledge is also regarded as co-constructed (Knoblauch, 2008). In addition, it is characterised by a systemic conciseness (Hoyningen-Huene, 2013) and, in systems theoretical terms, by an attentiveness to the negotiation of truth (Luhmann, 1990). If we apply these insights to discourse linguistic reflections on the constitution of knowledge (Warnke, 2009), it becomes apparent that the negotiation of scientific truth claims can be regarded as the central characteristic and constituting principle of scientific knowledge.

It seems appropriate at this point to introduce a careful conceptual distinction regarding the English word 'claim': On the one hand, 'claim' refers to a type of utterance which, in principle, corresponds to the illocutionary class of the representative or assertive speech acts (Searle, 1976). This class includes assertions as well as descriptions, explanations, and even rhetorical questions. Such utterances can be said to constitute scientific knowledge. Following Stocking and Holstein (1993), I will call segments of texts representing utterances of this kind 'scientific knowledge claims.'

On the other hand, utterances of this type simultaneously imply abstract claims to validity. More specifically, in the case of scientific knowledge claims, the claim to validity is that of scientific truth. The notion that there are specific types of validity claim stems from Jürgen Habermas and has been adopted as a means of characterizing different types of argumentation: Epistemic argumentation makes and contests truth claims, normative argumentation is concerned with claims to rightness, and aesthetic argumentation is concerned with claims to beauty (Eggs, 2000). I will therefore call the abstract principle of validity made and contested in texts of the kind described above 'scientific truth claims.'

Bearing this distinction in mind, it becomes clear that the discourse linguistic analysis of scientific knowledge is concerned mainly with how actors in specific discourse contexts produce scientific knowledge claims that assert or contest the scientific truth claim of a statement before other discourse participants. Such communication specifically oriented towards validity claims can be referred to as persuasion, which is central to rhetoric. Hence, this is the point at which the perspective adopted from discourse linguistics becomes a rhetorical perspective aligned with that of the rhetoric of science (Janich & Kalwa, 2018).

2.2. A Rhetorical View on Scientific Truth Claims in Public Discourse

The role of rhetoric in discourse linguistic analysis becomes even more evident when looking at a public discourse context where scientific truth is to be established by various actors as a means to pursue political aims; this is the case in the study presented in this article. Scientific knowledge in these contexts can only be properly described when understood as embedded purposefully in a broader rhetorical context and situated within a specific constellation of actors, institutions, values, beliefs, and interests. Hence, adopting a rhetorical approach to scientific knowledge in this article means looking closely at the specific form of scientific knowledge claims in a specific discourse situation, the aim being to examine precisely how these claims are rendered plausible.

From its very beginnings in Aristotelian times, classic rhetorical theory has defined three main sources of plausibility for claims. In addition to logos, rational argumentation, there is ethos, "the credibility of a speaker as a social construction," and pathos, "the ability to connect to the affective dimension of the situation for the audience" (Lyne, 1995, p. 255). Perhaps as old as this distinction is the scepticism with which scientists have looked upon personal values and emotions when it comes to scientific truth (Nate, 2009). Despite this scepticism, I will argue that both ethos and pathos play a vital role when scientific knowledge is not transferred but constructed in public discourse. Rhetorical analysis can shed light on the role emotions play when scientific truth claims are asserted, as will be demonstrated in the case study presented below.

3. Ethos and Pathos as Descriptive Categories for Linguistic Analysis

Ethos and pathos are intuitively insightful categories well established in the tradition of rhetoric. In the following,

an attempt will be made to operationalise the two categories for linguistic analysis by linking the classical understanding with contemporary considerations and strands of research.

3.1. Ethos: Language and the Presentation of Self

The validity of a claim depends on the credibility attributed to a speaker. In the classical theory of rhetoric, this kind of credibility is understood as something an orator does not simply possess but rather expresses through his or her speech (Knape, 2013). This rhetorical mode is called ethos and is often translated as self-presentation. However, as Plantin (2006) points out, the category of ethos includes a range of heterogeneous elements such as reputation, aura, and charisma. Aristotle defined ethos as being composed of ability, virtue, and benevolence. In fact, contemporary credibility research in psychology has confirmed expertise, integrity, and benevolence as distinct dimensions of trustworthiness (Hendriks, Kienhues, & Bromme, 2015). However, aspects of trustworthiness describe the perceptual categories of recipients and do not refer directly to linguistic categories (Roth, 2004).

Much of the linguistics literature on self-presentation comes from conversation analysis and refers to Erving Goffman's theory of impression management and Penelope Brown and Steven S. Levinson's face theory (Schwitalla, 1996; Spiegel & Spranz-Fogasy, 1999). Rhein (2015) offers a linguistic study on the self-portrayal of scientists in public debates along these lines. Although Knape (2013) notes that interactional concepts such as image and face can also be addressed within the framework of the Aristotelian concept of ethos, they do not seem useful for a text-based discourse analysis. One can state generally that self-portrayal can be examined on the basis of the statements made and, in particular, that it encompasses characteristics identifiable from linguistic action (Schwitalla, 1996). However, Rhein (2015, p. 71) remarks that in principle all linguistic possibilities—from prosody to lexis and from the selection of speech acts to the overall style of communication—can be used as means for self-portrayal.

With regard to the demonstration of expertise, linguistics research has identified some typical features that serve this intention (Antos, 1995). However, the practices mentioned in this context refer primarily to scientists as orators and can be transferred to public discourse to only a limited extent. Many authors cite technical scientific language as probably the most significant means of demonstrating expertise (Antos, 1995; Janich, 2012). Other relevant features of scientific texts might include numbers, graphs and tables, scientific style, and speech patterns such as explanation and complex argumentation (Czicza & Hennig, 2011). When it comes to scientific integrity and benevolence, however, there are no clearly identifiable characteristics. One aim of the case study presented below, therefore, is to develop these categories inductively for linguistic description by identifying relevant linguistic phenomena. The results are discussed in Section 5.

3.2. Pathos: Language and Emotion

Pathos is understood classically as the appeal to emotion. It was regarded by many of the ancient rhetors as the most powerful mode of persuasion. For Aristotle, the purpose of pathos was to evoke certain emotional states in the audience in order to achieve or support rhetorically persuasive effects (Aristoteles, 2007). This appears to be in keeping with modern psychological insights that affirm the effect of specific emotions on a person's judgement (Angie, Connelly, Waples, & Kligyte, 2011). Nevertheless, ancient definitions of pathos are not homogenous and do not include distinct categories for linguistic analysis (Fuhrmann, 1990). For the present analysis, the findings of linguistics research on language and emotion first had to be set in relation to the classical category of pathos, in the course of which fundamental semiotic and pragmatic insights also had to be considered.

For this purpose, it may be helpful to bear in mind the Saussurean distinction between language use as utterance (*parole*) and the language system (*langue*). Utterances are believed either to express a speaker's emotions or to evoke emotions in a listener. Luppold (2015) calls this the emotional and the emotive function of an utterance. This addresses two of the three basic communicative functions of language in the organon model put forward by Bühler (1999). Continuing along these lines, it might also be possible to represent discourse objects in emotional terms. Polo, Plantin, Lund, and Niccolai (2017) call this function "emotional schematization," while Luppold (2015) uses the term "emotional perspectivization." This kind of emotional representation is possible due to the fact that language systems do in a certain sense contain emotions (Kalwa & Römer, 2016). Herrmanns (1995) mentions affective adjectives as examples. In addition, cognitive semantic theories such as frame semantics take emotions to be essential components of our conceptual system and thus also to be components of certain semantic frames which are parts of a given language system (Ruppenhofer, 2018). The linguistic term 'semantic frame' refers to lexical meaning as a concept with its own internal structure, based on our general knowledge of the world and evoked in language use (Ziem, 2008). When a semantic frame is evoked in the course of communication, it can lead to an emotional representation of discourse objects. Rhetorical pathos can be described more specifically in linguistic terms thus:

- Expression of emotion (emotional function): Usually through non-verbal and para-verbal phenomena such as facial expression or tone used by a speaker as well as certain discourse particles such as 'unfortunately' (Herrmanns, 1995). Certain ex-

pressive speech acts (as described in speech act theory) and explicit statements can also serve this function;
- Emotion-related representation (emotional perspectivisation): This can be the lexical representation of a certain emotion explicitly attributed to a discourse object. In addition, emotions can be implicated in a text: discourse objects can become emotionally perspectivised through linguistic representation on the semantic level. One way to describe this is to analyse semantic frames with regard to emotion. This dimension of pathos will be illustrated further in the case study below;
- Evocation of emotion (emotive function): This appears to be the ultimate aim of rhetorical pathos following Aristotle's classical definition. Still there is no clear way to identify a strict set of linguistic phenomena that specifically serve the function of evoking a certain emotion in an addressee. I will argue here that to describe the emotive function of a text, it is necessary first to examine closely the expression and representation of emotion, since emotions evoked in an addressee are often either mirrored or complementary emotions to the ones expressed by a speaker (Luppold, 2015).

As will be demonstrated in Section 6, it is helpful for linguistic analysis to differentiate between the three functional dimensions of rhetorical pathos.

4. Ethos, Pathos, and Scientific Knowledge in Public Discourse: A Case Study

The findings presented in the following derive from an ongoing linguistics research project focusing on scientific knowledge and uncertainty in public discourses. They thus constitute just one part of a more comprehensive research context. The project investigates how groups of actors in a public discourse space, described by Böschen (2015) as "Gestaltungsöffentlichkeit" (decision-making public), constitute scientific knowledge and uncertainty. The object of investigation is the discourse conducted in Germany on the use of a class of pesticides known as neonicotinoids and their possible risks in relation to bees. In particular, the project seeks to explore the rhetorical strategies used by lobby groups seeking to constitute scientific knowledge in the discourse.

4.1. Discourse Segment

The discourse segment investigated in the project can be limited in time between January 2013 and April 2018. The public debate about a ban on neonicotinoids broke out after the publication of a report by the European Food Safety Authority in January 2013, which identified data gaps and possible risks to bees of neonicotinoid use. As a result, the European Commission initially imposed a two-year moratorium, after which a reassessment would provide clarity. This re-evaluation followed in spring 2018 and largely confirmed the previous findings. As a result, the use of neonicotinoids in agriculture was banned throughout the EU. In the time interval between the two evaluations and at the time of the political decisions, a number of different actors intervened in the discourse and participated in the co-construction of the scientific knowledge about neonicotinoid use. In addition to some beekeepers, scientists, and politicians, those who participated actively in the discourse included corporations and interest groups from the agricultural industry (especially neonicotinoid producers Bayer and Syngenta, the lobby association IVA, and the German farmers' association DBV), as well as environmental protection organizations (especially Greenpeace, NABU, and BUND/Friends of the Earth Germany). Both groups of actors showed a particularly high level of commitment to pressing home their perspective on the state of research in the discourse space.

4.2. Text Corpus and Method of Analysis

The analysis presented in Section 5 is based on a corpus of texts from the discourse segment described above, which focuses on the agricultural industry and the environmental organizations as the two main groups of actors. With regard to rhetorical analysis, both groups of actors can also be called the respective orators of the texts. Both groups are involved intensively in the constitution of knowledge, and each group pursues opposing goals. In order to determine which rhetorical strategies are used, texts are examined with which the actors seek to establish scientific knowledge as valid in the public discourse space. For this purpose, both groups make use of two types of texts. The first type includes press releases written in response to current events, such as new publications and political decisions, and whose aim is to influence the public. The second type includes information brochures that are available for download on the websites of the actors and whose primary aim is to convince political decision-makers, stakeholders, and interested citizens of their own position or to provide them with arguments.

The text corpus was generated by first establishing an overview of the relevant discourse actors. Following this, texts were sought on these actors' websites that could be assigned to the discourse. Keywords in favour of an assignment were 'neonicotinoids,' 'imidacloprid,' 'thiamethoxam,' 'clothianidin,' 'thiacloprid,' and 'bees,' as well as related composite words. Texts containing the keyword 'pesticides' were also checked. The resulting text corpus contained 85 press releases (54 by environmental organizations and 31 by agricultural industry) and 6 brochures (3 by each orator). Since in previous phases of the project text analyses of 6 further brochures had already been carried out without annotation support, it was also possible to fall back on existing findings for a more informative interpretation of the results.

To investigate ethos and pathos in the context of scientific truth claims the following procedure was chosen: Theoretical considerations as described above formed the basis for an analysis of the corpus, which was carried out using the annotation software MAXQDA. Due to the size of the corpus and its segmentation on different linguistic levels (such as word or clause level), quantitative analysis was regarded mainly as a possible source of indications and additional back-up for in-depth qualitative-hermeneutic analysis. Accordingly, in this essay the focus is not on quantitative evaluation but on qualitative rhetorical analysis. The findings presented here can be regarded as prototypical and as representing different possibilities of discursive strategies. All text examples presented were translated from German into English by the author. The source is indicated by abbreviations, which can be found in the corpus list included in the Supplementary Material.

Thus, the overall analysis had two objectives: One was to develop relevant categories for a linguistic description of ethos and pathos. Another was to find out how ethos and pathos function in the negotiation of scientific truth claims. In the following, the findings for both groups of actors will be presented, contrasted, and linked. An overall comparison of the two strategies is then expected to generate helpful insights.

5. Ethos in Scientific Truth Claims

During the annotation phase of the analysis it became apparent that the dimensions derived from psychological research are problematic for linguistic description. One problem that emerged was how to make the category of scientific integrity tangible. According to Hendriks et al. (2015), scientific integrity means following scientific norms and values. Thus, quoting and referencing was regarded as a corresponding self-representation procedure. If, however, one considers the public addressing of the texts, these practices can just as easily be interpreted as a demonstration of expertise. For this reason, scientific competence and scientific integrity were combined into one single category for annotation.

The dimension of benevolence likewise did not appear to be straightforward. Benevolence relates to the orator's "orientation toward others or society, for example, her or his sense of responsibility and morality. This factor represents participants' impressions regarding whether the scientist acts with the interests of others at heart and not just personal aims or benefit" (Hendriks et al., 2015, p. 16). In the context of the description of a scientific ethos, it seemed important here that the actions addressed should refer to knowledge claims and not to political demands. Text passages in which the orators talked about their commitment to research and their motivation for carrying out scientific work thus appeared relevant to benevolence. When addressing an audience of lay people, positive intentions toward the audience can also be shown by demonstrating so-called transfer qualities in using techniques to transfer knowledge from experts to laymen, such as explaining terminology and research processes (Niederhauser, 1998).

Another difficulty was that certain phenomena could not be readily recorded by means of annotation using MAXQDA, even though they appeared to be relevant. This particularly affected the layout and graphic design of the brochures as well as the overall style of the texts. A list of the subcategories derived inductively can be found in the Supplementary Material. The quantitative findings should not be overestimated, especially as annotations were made on different linguistic units. The 'scientific language' label, for example, was used primarily to annotate individual lexemes and multiword units such as 'exposition' or 'sublethal effects,' while speech act patterns and practices such as 'presenting study results' refer to larger text segments. In the following, therefore, observations from the qualitative analysis will be addressed first and foremost.

5.1. Ethos in the Environmental Organizations' Texts

With regard to the environmental organizations' texts, a certain division can be identified in relation to their respective ethos. The demonstration of scientific expertise can be found above all in more elaborate brochures, while press releases in particular show a less scientific self-portrayal. In general, the amount of scientific ethos demonstrated by environmental organizations appears relative to specific (parts of) texts. Texts addressing a broader public demonstrate little scientific competence and integrity, while texts addressing a more interested or more expert audience reveal a more dense and complex scientific ethos when presenting scientific knowledge claims. At the same time, however, they tend to lack transfer qualities.

The textual structure of the report "Bye bye Biene?" (Greenpeace, 2013a) can be used to illustrate this. Here, the main part of the text (33 pages), which provides a detailed overview of the state of knowledge on agricultural risks to honeybees, is preceded by a ten-page summary of the research results and their implications. Both parts of the text reveal the same argumentative structure. However, they differ not only in length but also in the scientific ethos demonstrated in each: In the summary part, scientific knowledge claims are largely presented with little use of scientific language, complex argumentation, or scientific apparatus (quotations, references), with the exception of a rather complicated table. However, the table itself is well designed and presented in colour. Thus, the summary part of the text demonstrates benevolence by using techniques of popularization. The main text, however, shows a shift in complexity and style. Knowledge claims are developed here using scientific terminology and citation. Also, while knowledge claims in the summary part are presented mainly in the indicative voice, instances of hedging and caveats can be found in the main part.

5.2. Ethos in the Agricultural Industry's Texts

In contrast to the environmental organizations' texts, agricultural industry texts seem to be more concerned with demonstrating scientific ethos. A fairly coherent pattern emerges throughout the discourse. The agricultural industry orators seem to be consistently interested in demonstrating scientific competence. This can be seen predominantly in the frequent use of scientific language such as technical terminology, symbols, and numbers. The validity of knowledge claims is usually supported by a more complex form of argumentation. This pattern can be found both in the more elaborate brochures and in a large number of press releases. Also, a demonstration of scientific integrity appears relevant for the scientific ethos of the agricultural industry. This is particularly evident in the citations and references within the texts and in the lists of sources at the end of the texts. Interestingly, this too applies not only to brochures but also to some press releases. In this context, it is noticeable that scientific norms and principles of scientific practice are at times stated explicitly. An emphasis on scientific values is also to be found in the naming of a large number of expert authorities who are quoted. In addition to highlighting their competence, the presentation of these authorities often emphasises their independence and their commitment to science as opposed to espousing any political goals.

The texts of the agricultural industry also show that the orator is well-disposed towards the reader. As noted above, scientific competence is realised in complex argumentation and by technical terms. The linguistic style, however, remains easy to understand. Particularly in the information sheets, scientific knowledge practices are explained in detail. This applies not only to the conduct of field research, which is also illustrated by images, but also to internal processes of scientific debate. In particular, the elaborate and well-designed information brochures, whose meaning and function it corresponds to, are characterised by a high effort to transfer knowledge.

6. Pathos in Scientific Truth Claims

Annotation for pathos was carried out using two main categories, derived deductively from the theoretical considerations described above, with subcodes in the categories being elaborated inductively during the process of annotation. The two main categories were linguistic units of emotional expression and emotion-related representation, which in turn was differentiated according to emotion vocabulary and emotion-related semantic frames.

Segments found to explicitly express emotion by the orator were identified using emotion vocabulary as indicators. The segments identified were labelled with respect to the specific emotion, which in those cases could be distinguished by lexical clues. In (1), the expression of an emotion becomes apparent through explicit naming and the use of a possessive pronoun in a self-statement:

> (1) Our handling of this specific case ultimately reflects *our general concern* about the European Commission's approach to regulating agricultural technologies. (Syngenta, 2018)

Two sub-categories emerged for emotion-related representation: explicit attribution via emotion vocabulary and implicit perspectivization through semantic frames. Explicit attributions were annotated with respect to specific emotions, in analogy to explicit self-statements. However, implicit perspectivization proved to be more problematic with respect to specific emotions. Hence, segments of texts were annotated with respect to semantic frames. To achieve the clearest possible annotation, only lexemes were annotated which, according to their lexical form, could be regarded as clear representatives of a semantic frame:

> (2) The study identifies seven pesticides that are *dangerous* to bees, three of which belong to the controversial neonicotinoid class of *highly poisonous neurotoxins*. (Greenpeace, 2013d)

In (2), the semantic frames DANGER and POISON can be identified clearly due to lexical information provided by lexemes which can then be annotated accordingly. A table with the relevant semantic frames and their distribution in the discourse can be found in the Supplementary Material. It should be noted, however, that the identification of the corresponding frames already represents a significant interpretive achievement of the analyst, which can hardly be separated from the qualitative analysis of the texts in the analytic process.

During the annotation process a number of relevant linguistic phenomena were identified. However, it also became clear that a detailed analysis of individual texts and text passages is essential for an understanding of pathos. Hence, in the following the concrete strategies of the orators will be examined by means of a qualitative analysis of individual examples.

6.1. Pathos in the Environmental Organizations' Texts: A Cause for Concern

At the centre of environmental organizations' pathos strategy is the emotion of concern. This can be seen on the level of emotional expression and it can also be deduced from the use of semantic frames for emotional perspectivization. In order to understand both, it is helpful to first see how the knowledge claims are generally integrated into the textual structure. A basic textual pattern can be identified for the discourse position that has the following syntagmatic structure: 'Bees are important helpers of humans. But bees are dying. One possible cause of bee mortality is neonicotinoids.

Researchers found out that neonicotinoids harm bees. Neonicotinoids should therefore be banned.' Within this pattern, concern can be expressed explicitly. It is typical for environmental organizations that the emotional expression in press releases is made by persons who can be regarded as representatives of their position in the discourse, such as members of the Board or responsible experts, as in (3):

> (3) Christiane Huxdorff is an agricultural expert at Greenpeace Germany and *is concerned* about the outcome of the EFSA study. (Greenpeace, 2014)

Furthermore, the main objects of discourse—neonicotinoids and bees—and their relationship are emotionally perspectivised within this pattern by expressing the underlying concept of causation using lexemes that realize emotion-related semantic frames such as DANGER, POISON, and KILL. The following examples may serve to illustrate this point:

> (4) Pesticides, especially Syngenta's thiamethoxam, *kill* bees. (Greenpeace, 2013e)

> (5) Bees *threatened* by pesticides. (Greenpeace, 2013d)

> (6) The *toxic effect* of neonicotinoids on bees is clearly proven. (Greenpeace, 2013c)

> (7) It is a fact that the neonicotinoids contained in pesticides are strongly suspected to be *responsible* for the worldwide bee *mortality*. (BUND, 2015)

In the semantic structure of (4), neonicotinoids are represented through processes of metonymy and personalization as a semantic agent affecting bees realised as semantic patient. A similar semantic structure can be observed in (5) with respect to the causation of DANGER. (6) shows less indication of agency and therefore responsibility but still represents an instance of perspectivised causation. In (7), causation between neonicotinoids and bees is represented using the concepts of GUILT and DEATH. The semantic frames identified can be related more specifically to emotion regarding this semantic structure and relating it to the model of Ortony, Clore, and Collins (1988). Here, emotions are understood as valenced reactions to events, agents, and objects. As the semantic frames represent a causal event and an inherent evaluation of its elements, one might justifiably deduce emotions such as pity, reproach, or indignation as related to the perspectivization. Another emotion that might ultimately result is concern.

This perspectivization pervades the entire discourse and thus also has an effect on scientific knowledge claims. This becomes especially apparent when scientific findings regarding the effects of neonicotinoids on bees are reported, as can be seen from the following examples:

> (8) These *neurotoxins*, which are particularly *dangerous* for bees, are used to dress the seeds and, according to toxicologists, are 6,000 to 7,000 times more *toxic* than DDT. Studies have shown that neonicotinoids in bees and birds can lead to restrictions in orientation and disturbances of the immune system. In addition, these pesticides *kill* many insect species that were used by birds as food. (BUND, 2013)

> (9) One of the causes of bee mortality is neonicotinoids. These are nerve *toxins* that are commonly found in crop protection products….Scientists from France and the UK discovered that neonicotinoids…confuse bees and decimate bumblebees. (Greenpeace, 2013b)

In (8), the linguistic appearance of the scientific knowledge claim in sentence two itself is more oriented towards a technical style. The sentences immediately preceding and following this one, on the other hand, clearly show the semantic frames POISON, DANGER, and KILL, which results in an emotional perspectivization of the larger text segment. In (9), the scientific discovery introduced in the subsidiary sentence represents a semantic structure with neonicotinoids as agent and bees as patient of causation which is coherent with the emotional perspectivization pattern described above and is indicated through the POISON frame in the preceding paragraph.

The interpretation that this perspectivization is connected with concern is supported by the fact that some text passages attribute scientific findings explicitly to the corresponding emotion, as the following example shows:

> (10) The data available for other pollinators paint a similarly *worrying* picture. (Greenpeace, 2017)

Here scientific findings are explicitly framed as discomforting and as a cause for concern. In a metonymic fashion, data is even presented as alarming, attributing to science itself an expressive quality. The findings suggest that the scientific knowledge claims in the environmental organizations' strategy do have a pathos component. Its role for the plausibility and functionality of the inherent truth claims will be discussed further in Section 7.

6.2. Pathos in the Agricultural Industry's Texts: A Need for Scientific Sobriety

Analysing the agricultural industry's texts, a different pathos strategy can be observed. Even though concern is sometimes expressed as in (1), it relates mainly to political decisions and their economic consequences. If at all, concerns about a causal link between neonicotinoids and bees are presented as a discursive phenomenon, as in (11):

> (11) Some years ago, *concerns were expressed* that neonicotinoid residues in guttation droplets secreted

by plants from treated seeds could *poison* bees. (Bayer Bee Care Center, 2016)

Concern is conceptualised here as the content of an utterance, which through use of the passive is not assigned to a speaker. In addition, the semantic frame POISON is relativised by the mode of the subjunctive and is put at a certain textual distance to neonicotinoid due to the complex syntactic structure of the nominal phrase. The entire nominal phrase, which realizes the semantic agent of poisoning, also contains an intensive use of specialised terminology. This already points to the major pathos pattern of agricultural industry: Emotion is explicitly presented as an undesired quality of the ongoing debate, one which results in demands for scientific sobriety, as in (12):

(12) Especially in a charged debate on issues such as biodiversity, bee health and the use of neonicotinoids, it should be the role of research to investigate the problems with scientific sobriety, demands the IVA. (IVA, 2016b)

While analysing the texts of agricultural industry, no emotional perspectivization comparable to that of environmental organizations could be identified. This might indeed be interpreted as an expression of sobriety. Also, it might coincide with the frequency of technical language noted above which seems to be used partly as a means of de-emotionalization, as illustrated by (13):

(13) Risk is defined as potential danger (toxicity) x exposition. (Bayer Bee Care Center, 2018)

Here the focus on the term 'risk' serves as a counter to the ecologists' focus on the term 'danger.' While both danger and risk have highly emotional connotations in colloquial contexts, risk is also used in scientific contexts. As a scientific term, risk has a clearly distinct meaning. By explicitly defining risk in scientific terms, agricultural industry tries to counter the colloquial and emotionally connoted word in the discourse with the more neutral and opaque term. Agricultural industry even expressly rejects the use of terms used by environmental organizations by criticizing them as being too emotional. This concerns the German word *Gift* (poison or toxin) for neonicotinoids:

(14) For this reason, it must be assumed that the often-heard classification as a 'neurotoxin' is also done with the intention of introducing another deterring term into the discussion. (IVA, 2016a)

In (14), the accusation of emotionalization is presented in a matter-of-fact scientific tone, which can be seen, for example, in the passive construction. Scientific sobriety is thus not only explicitly demanded by the agricultural industry but is also presented as a pathos dimension of knowledge claims in order to support their validity.

7. Summary Interpretation of Results of the Analysis

A first result of the analysis was the identification of linguistically tangible categories suited to describe ethos and pathos in the discourse context. For example, the approach to emotional perspectivization proved to be revealing. However, the linguistic description of ethos along the lines of the three dimensions of trustworthiness via annotation was shown to be somewhat problematic: Even though relevant categories could be identified, interpretation in the light of the three dimensions proved to be challenging. The categories should therefore be elaborated further within the ongoing research project and expanded in other studies on other discourses. However, the analysis revealed differences between the discourse positions, which can be further interpreted.

In terms of ethos, there is a reasonable explanation for the higher investment of communicative resources on the part of agricultural industry. If the texts in the corpus are regarded as being directed at a public audience, private economic actors—especially large enterprises—are attributed relatively little trustworthiness by the broader public. The opposite holds true for NGOs, as demographic polls in Germany show (Weitze & Heckl, 2016). As a result, agro-industrial discourse actors are obliged to invest more interactional resources in order to establish credibility.

The pathos of concern in environmental organizations could be interpreted, for example, as a kind of emotional coherence between the diagnosis of bee mortality and the more specific issue of the effects of neonicotinoids on bees. If someone considers the mass dying of bees to exist and also resonates with the associated emotion of concern, while at the same time the effects of neonicotinoids on bees are framed in the context of the same emotional state, that person might also consider the reported effects as plausible. In addition, however, the overarching emotion of concern inherent in the consistent framing could help to establish or strengthen a causal link between bee mortality and the possible effects of neonicotinoids on bees.

For a comprehensive understanding of the functionality of ethos and pathos in relation to scientific truth claims, however, it is highly recommended to consider further pragmatic and discursive conditions as well as the specific goals of the orators. For example, there are indications that agricultural industry is generally more concerned with epistemic argumentation in discourse, while environmental organizations is more focused on political demands. In this context, the high investment in scientific ethos on the part of agricultural industry can also be seen as a way to focus on scientific knowledge in general. The demonstration of scientific ethos in this respect is one device embedded in a greater strategy to give presence to the process of scientific inquiry.

Against this background, the pathos strategy of environmental organizations can also be understood as a link between epistemic and normative argumentation.

The semantic frames mentioned in Section 6.1 have not only an emotional but also a normative component, also present in the corresponding lexical forms. Mitchell and Lyne (2015), for example, have classified danger as a "hinge term," with which the transition is made from the forensic to the deliberative genre and thus from epistemic to normative argumentation processes. By evoking corresponding pathos components when raising scientific truth claims, these validity claims themselves become closely interrelated with political debate. Correspondingly, the opposite is the case with agricultural industry. Since the claims to scientific validity here have seemingly no pathos component, no political actions can be derived from them. Already in the seventeenth century, philosopher David Hume argued that no one can be persuaded to action just by force of reason (Gottweis, 2007). Taking this seriously, the implication arises that by focusing on an emotionless scientific rationality, the agricultural industry 'widens the gap' between the epistemic and the normative.

As sociologists Kleinman and Suryanarayanan (2012) have shown, there is evidence to indicate that agricultural firms such as Bayer Crop Science intentionally manufacture ignorance concerning the connection between honeybee losses and systemic pesticides in the US in order to prevent political action. It therefore appears tempting to ask if the rhetorical patterns identified in this article are not ultimately means to corresponding ends. Still, the situation in the present discourse is more complicated, since ignorance regarding possible risks may very well be used as an argument for regulatory action due to the precautionary principle. This policy principle on environmental and health issues was installed at the UN Conference in Rio de Janeiro in 1992 and states that regulatory decisions do not necessarily have to be based on unambiguous evidence of damage (Freudenburg, Gramling, & Davidson, 2008). This is likely to be an important point towards which an understanding of the rhetorical strategies of both parties must be oriented. To prevent political action, contesting the truth claims of opposing discourse parties, and thereby creating ignorance and uncertainty, is not a sufficient strategy: Instead, the connection to normative considerations must be disrupted and made more indirect. The pathos of sobriety seems an adequate measure for the agricultural industry since it loosens the tie that environmental activists try to establish between scientific knowledge and political action by emphasizing concern.

However, to reinforce such a hypothesis, the findings of this article must be considered further in the context of more complex rhetorical strategies. In particular, the interdependence with argumentation patterns and relevant topoi may well prove promising. Only in this way will it be possible to draw clear implications for the epistemic quality of statements and thus the constitution of scientific knowledge and ignorance in discourse. This represents an important objective in the further course of the project.

8. Conclusion

Rhetorical analysis can shed light on the role played by affect in the construction of scientific knowledge in the public sphere. As has been shown, it can be assumed that pathos in particular might function as an essential link between knowledge claims to scientific truth and political demands. It could also be shown that scientific truth claims can thus be supported relative to global discourse strategies by various uses of emotions. In the case study, both sobriety and concern have been shown to be functional supports of scientific truth claims in public discourse.

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Conflict of Interests

The author declares no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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COGITATIO

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Article

Emotionalization in the Media Coverage of Honey Bee Colony Losses

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Abstract
Emotionalization is increasingly used in the daily news. However, communication scholars have only just begun to explore how journalists use emotionalization in coverage of scientific and environmental topics. This study contributes to filling this research gap by investigating emotionalization in reporting on honey bee colony losses. The aim of the study is to analyze the amount of emotionalization that took place, as well as to observe changes over time. Emotionalization is assessed in two ways; by analyzing to what extent journalists (1) *explicitly mentioned* discrete emotions in news stories (joy, hope, fear, anger, etc.) and/or (2) used *rhetorical devices* to evoke emotions (affective vocabulary, metaphors, colloquial language, superlatives, etc.). Results from a quantitative content analysis of four Austrian newspapers in 2010/2011, 2013/2014, and 2017/2018 show that the coverage is highly emotionalized across all three time periods studied. Emotionalization occurs far more often by using rhetorical devices than by explicitly mentioning positive or negative emotions. Interestingly, the incorporation of emotional elements and scientific expertise in the news items do not exclude one another. Hence, there seems to be no strict dichotomy between rational/objective and emotional reporting.

Keywords
content analysis; emotionalization; emotions; environmental communication; quality newspapers; science communication; tabloid newspapers

Issue
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1. Introduction

Journalism has the potential to contribute to a well-informed and proactive citizenry by reporting on environmental issues. Accordingly, communication scholars are interested in investigating what kind of media coverage is best-suited for presenting information in a comprehensible way and for fostering engagement. For instance, research on climate change media reporting shows that journalists use adjectives and personal vignettes to generate feelings (Han, Sun, & Lu, 2017), and that emotions evoked by media coverage on climate change can influence one's willingness to make sacrifices for climate change (Bilandzic, Kalch, & Soentgen, 2017). Hence, it is important to know the precise details on how media coverage on environmental issues is presented. However, surprisingly little is known so far in this regard. This is where our study comes in. We analyze emotionalization in media reporting on environmental issues by using the case of the colony collapse disorder (CCD). CCD describes the syndrome of "large-scale, unexplained losses of managed honey bee (Apis mellifera L.) colonies" (vanEngelsdorp et al., 2009, p. 1). The case of the CCD is especially interesting as it is less researched than other environmental topics that call for action such as climate change (Cho, 2010; Smith & Saunders, 2016; Suryanarayanan & Kleinman, 2012).

Recent research shows increasing emotionalization in daily news (Donsbach & Büttner, 2005; Magin, 2017). Accordingly, this study aims to investigate whether this is

also true for media coverage on honey bee colony losses. More specifically, this article aims to show how emotionalized the media coverage on honey bee colony losses is and whether changes can be observed over time as well as differences between the newspaper analyzed. To do so, we conducted a quantitative content analysis of news stories in Austrian daily newspapers from 2010 to 2018. In the following, we elaborate on the theoretical concept of emotionalization before presenting and discussing the empirical results.

2. Emotionalization

2.1. Emotionalization of Media Content

Emotionalization can be defined as the "intentional evoking of emotions" (Flemming, Cress, Kimmig, Brandt, & Kimmerle, 2018, p. 3). Communication scholars are interested in investigating how journalists (and other societal actors) evoke emotions and how it affects several outcomes (for an overview, see Schramm & Wirth, 2006). For instance, emotionalization has been studied as a news value (Eilders, 1997; Schulz, 1977), as an indicator of tabloidization (Donsbach & Büttner, 2005; Magin, 2017), as well as in specific thematic contexts such as political communication (Brosda, 2002), natural disaster reporting (Zeller, Arlt, & Wolling, 2014) or news reporting on terrorism (Cho et al., 2003; Gerhards, Schäfer, Al Jabiri, & Seifert, 2011). Research suggests that emotions are a common feature in news coverage. For example, Uribe and Gunter (2007) showed that in 2002/2003, around 40% of British daily TV news stories contained verbal emotionality. Similarly, Leidenberger (2015) found that in 2010, 43% of German TV news items had textual emotionalization. However, the levels of emotionalization seem to vary between media outlets. For instance, Gerhards et al. (2011) found differences regarding the type of emotions used in the news coverage between the German public TV broadcast and private TV broadcasts; the private one included more positive emotions—such as hope—than the public one. The public TV broadcast entailed more sadness than the private one. Leidenberger (2015) identified differences in the use of rhetorical categories to evoke emotions. For instance, the private TV broadcast showed higher levels of colloquial language than the public one. When it comes to the printed media, it is interesting to what extent differences can be observed between elite newspapers and tabloids.

Research also reveals that journalists increasingly incorporate emotional elements in news stories. Donsbach and Büttner (2005) analyzed German TV news between 1983 and 1998 and found that while overall news contained a higher proportion of factually than emotionally presented news, the use of emotionalized elements in the news stories analyzed has significantly increased over time. Similarly, a study investigating emotionalization in German and Austrian newspapers between 1945 and 2009 shows that headlines are predominantly unemotional. The emotional vocabulary in the headlines nevertheless doubled from every hundredth to every fiftieth word in both countries (Magin, 2017). The increasing emotionalization of media content is evaluated differently by communication scholars. Some scholars speak of emotionalization as a danger and worry that rises in emotionalization, personalization and conflicts in the news might make it even harder for less-involved and less-motivated people to extract valuable information from the news (Donsbach & Büttner, 2005; Kowalewski, 2009). Other scholars criticize how the concept of emotions is treated dismissively when discussed in relation to journalism. Pantti (2010) argues that journalism's relationship with expressing emotions is a complex one on account of the challenge it poses to the key professional value of objectivity, and that equating more emotions with less journalistic quality is too simplistic. Peters (2011) states that diverse emotional styles in presenting news might help to engage disparate audiences, and goes on to call the traditional news dichotomy (rational/objective vs. emotional) into question. Indeed, research has revealed that scientific findings and emotional elements are sometimes combined in news stories. For instance, Wilms (1994) found that news stories on technology often start with negative emotions in the thematic context of uncertainty. However, in the second paragraph, journalists often subsequently present scientific findings on the topic. These findings suggest that news stories containing emotional elements are not necessarily dominated by emotions throughout the whole story.

Empirical findings on the effects of emotionalized content show no clear picture. While emotionalization has been shown to have negative effects on certain outcomes such as recall (e.g., Brosius, 1993), studies have also found positive effects (e.g., Swim & Bloodhart, 2015). Brosius (1993) showed that emotional pictures led to recall errors and to an overestimation of numbers given in the news text. Brosius argued that these errors occur because emotional pictures focus viewers' attention on specific parts of the news item. Perceptual judgments that are generalized from these specific parts are used when recalling a news item. Schultheiss and Jenzowsky's (2000) study revealed that TV infotainment shows with high levels of emotionalization (emotional pictures, music, emotional language) are perceived as less credible than those not containing emotionalizing elements. Meanwhile, contrary to that finding, Brosius and Kayser (1991) found that the information quality of news was rated better when accompanied by emotional pictures. Research also shows that emotional pictures can have a mobilizing effect. More specifically, a study on climate change communication revealed that emotional pictures (polar bears harmed by climate change) motivated participants who developed an empathic perspective toward the animals to donate money to environmental activist groups (Swim & Bloodhart, 2015). Interestingly, fearful messages on climate change

have been found to be an effective tool for increasing elaboration on information (Meijnders, Midden, & Wilke, 2001) and attracting people's attention to climate change (O'Neill & Nicholson-Cole, 2009), but do not foster engagement because people feel helpless and overwhelmed. Hence, if scare tactics are used, they should be accompanied by practical advice on the actions that can be taken as a remedy (Reser & Bradley, 2017). In addition, it also depends on the level of fearfulness. Research indicates that readers who got exposed to a high-fear appeal text on climate change were less likely to engage in pro-environmental behavior than those who read a low-fear appeal text (M.-F. Chen, 2016).

2.2. Textual Emotionalization

Leidenberger (2015) identifies three forms of emotionalization: visual emotionalization, textual emotionalization, and emotionalization transmitted through music. In our study, we focus on textual emotionalization. Textual emotionalization in the context of media coverage can be defined as journalists' use of written language to evoke emotions by including discrete emotions in the text, by using rhetorical devices that evoke emotions, or by reporting on individual cases (Donsbach & Büttner, 2005; Flemming et al., 2018). Accordingly, scholars used different approaches to capture textual emotionalization. While some analyzed emotions that are *explicitly mentioned* in news articles (e.g., Wilms, 1994; Zeller et al., 2014), others also considered *rhetorical devices* used by journalists to evoke emotions (e.g., Leidenberger, 2015; Wittwen, 1995).

When analyzing *explicitly mentioned emotions*, scholars typically use a list of terms containing positive and negative emotions. Emotions can be approached from two different perspectives: there is (1) the dimensional perspective of emotions (Barrett et al., 2007; Rubin & Talarico, 2009; Smith & Ellsworth, 1985) and discrete emotions (Ekman, 1992; Izard, 1977; Panksepp, 1998). The latter is used when investigating explicitly mentioned discrete emotion in news stories. Scholars refer to the psychological concept of primary emotions or basic emotions, i.e., emotions that are "innate, universal, and distinct affective states which evolved to serve adaptive functions" (Piórkowska & Wrobel, 2017, p. 1). Communication scholars are interested in testing whether positive or negative emotions are dominant in the reporting on specific topics or fields. For their part, for instance, Gerhards et al. (2011) investigated the reporting on terrorism and distinguished between positive (e.g., hope), negative (e.g., fear, sadness, anger) and ambivalent emotions (e.g., defiance, astonishment). Not surprisingly, negative emotions were prevalent in news reporting on terrorism. However, this is also true for some other topics that are not inherently negative. For instance, Wilms (1994) analyzed media reports on technology and found that negative emotions are dominant in the news stories analyzed.

Based on literature from linguistics, emotionalization can also be assessed by analyzing *rhetorical devices* that evoke emotions. A very common rhetorical device for evoking emotions in news stories is the elliptical construction. Elliptical construction means that in a given sentence, some words are omitted (W. Chen, 2016)—for example "Merkel in Paris" instead of "Angela Merkel is in Paris." Another common rhetorical device uses affective vocabulary such as "martial," "attack," "brutal," "murder," "malicious," etc. (Leidenberger, 2015; Mende, 1996). Journalists also use metaphors to evoke emotions in news stories. According to Knowles and Moon (2006), metaphors—the "use of language to refer to something other what it was originally applied to" (p. 3)—constitute a powerful tool in the communication of emotion because they allow writers to present meaning in a more open-ended fashion and they likewise allow readers to extract less narrow interpretations. Metaphors are often used in relation to emotions since emotions are rather abstract and figurative speech facilitates expression of emotions (Foolen, 2012). For instance, one can use "you make my blood boil" as metaphor for anger, or "my heart is on fire" as a metaphor for love (Sandström, 2006). Colloquial language is a rhetorical device characterized by expressivity and vividness (Wittwen, 1995). Finally, superlatives are common devices in journalism often used in headlines (e.g., "the best," "the worst," "the most dramatic'').

2.3. Research Questions and Hypotheses

Informed by this literature, we formulate research questions and hypotheses. Prior research has shown that with a share of around 40%, emotions are a common feature in news stories (Leidenberger, 2015; Uribe & Gunter, 2007). We are interested in investigating the extent to which the coverage on honey bee colony losses is emotionalized.

> RQ1: To what extent is textual emotionalization used in media coverage of honey bee colony losses?

Research has revealed differences in the levels of emotionalization between media outlets (Gerhards et al., 2011; Leidenberger, 2015). Since emotionalization is described as one of the central characteristics of tabloid journalism (Bruck & Stocker, 1996; Reinemann, Stanyer, Scherr, & Legnante, 2011), we expect tabloids to show higher levels of emotionalization than quality papers. We thus formulate the following hypothesis.

> H1: Tabloid papers will show higher levels of textual emotionalization in comparison to quality papers.

Prior research has shown that emotionalization has increased in daily news (Donsbach & Büttner, 2005; Magin, 2017). We test whether this likewise applies to the coverage on honey bee colony losses:

H2: The use of textual emotionalization will increase over time.

Finally, we aim to investigate how journalists use emotional and scientific elements in the coverage on honey bee colony losses:

RQ2: To what extent do journalists combine rational/evidence-based elements (scientific findings, scientific expert statements) and emotional elements within news stories?

3. Method

3.1. Sample

To study our research question, we conducted a quantitative content analysis of news stories in Austrian daily newspapers. We selected the two largest daily newspapers in the quality segment in terms of reach (*Der Standard*: 7.8% and *Die Presse*: 4.6%) and the two largest daily tabloids in terms of reach (*Kronen Zeitung*: 27.2% and *Heute*: 11.6%; see Media Analyse, 2018). We investigated three discrete time periods: (1) 2010/2011, (2) 2013/2014, and (3) 2017/2018. While the first two time periods were selected because of their proximity to important policy decisions related to bees and pesticides, the last time period was selected based on its proximity to the study date. More specifically, the starting point was chosen because in that month, the EU announced a budget increase of financial support for beekeeping (European Commission, 2010). The second relevant date was Austria's vote against the pesticide ban in the EU in 2013. As a last point in time, the current year at the time of the data collection was chosen. By using a keyword search ("bee death") in the digital newspaper archive database "APA Online Manager Library," we identified 287 relevant news stories. The original keyword in German was "Bienensterben" which is the commonly and predominantly used term in the public debate. 56.8% of all articles appeared in the tabloid *Kronen Zeitung*, 18.8% in the quality paper *Der Standard*, 17.8% in the quality paper *Die Presse* and 6.6% in the tabloid *Heute*. For an overview of the newspaper articles analyzed, see Table 1.

3.2. Measurement

Building on prior research, we included 48 categories in our codebook. Besides formal categories (ID, newspaper, date, headline, genre, division, topic, etc.), we used the following categories to capture emotionalization in detail.

Explicit mention of discrete emotions: Prior research has led to several lists of discrete emotions. Scant agreement however exists on how many emotions constitute basic ones. The number of emotions included in the list of basic emotions varies thus accordingly (e.g., Ekman, 1992; Izard, 1977; Panksepp, 2007; Plutchik, 2003; Scherer, 2005; Strapparava & Mihalcea, 2010; Turner & Stets, 2005; for criticism of the basic emotions approach, see Cohen, 2005; Ortony & Turner, 1990). We expand on lists that have hitherto been applied in communication research (Gerhards et al., 2011; Renaud & Unz, 2006; Saxer & Märki-Koepp, 1992; Wilms, 1994; Zeller et al., 2014). Building on this literature, we have created a list of positive and negative emotions. Positive emotions include pride, hope, joy, pleasure, compassion, calm, longing, affection, satisfaction, fascination, emotion, surprise, courage. Negative emotions include guilt, fear, anxiety, grief, anger, rage, dislike, aggression, restlessness, disgust, contempt. In addition, positive or negative emotions found in the texts that were not listed were entered into an open-ended category. For example, our list of negative emotions contained the word "fear." In the text, the coder found the word "panic," which means "a sudden strong feeling of fear" (panic, n.d.) and hence could be clearly identified as an emotion by the coder. The coder then entered "panic" into the open-ended category. In addition, the category "negative emotion" was coded as "yes." Hence, emotions deduced from the text were treated the same as emotions coded based on the list. The goal was to be able to capture the full range of possible emotions encapsulated in news stories.

Rhetorical devices that evoke emotions: We coded rhetorical categories that evoke emotions developed by Wittwen (1995). The list of the rhetorical devices contained the following eight types: affective vocabulary (e.g., "dramatic," "disastrous"), colloquial language (e.g., "Yeah!"), superlatives (e.g., "best," "worst"), metaphors (e.g. honey as the "sweet gold"), exclamation marks for emphasizing something (!), expressive word order (e.g., "no money, no hope"), elliptical construction (e.g., Crocuses in November!), and colon construction (e.g., "or: no more bees!"). We added two types from the study of Leidenberger (2015): we-construction (e.g., "our bees," "our nature") and neologism (creating a new word or expression, e.g., "Bienenpapst," translation: "Pope of the bees"). For each rhetorical category, we coded yes/no.

Table 1. Investigation period.

Investigation period	Years	Exact date	n
1	2010/2011	01.09.2010–01.09.2011	40
2	2013/2014	01.05.2013–01.05.2014	186
3	2017/2018	01.09.2017–01.09.2018	61
Total			287

Reference to science: We coded whether journalists referred to scientific findings or included statements from scientific experts in the news stories.

Intercoder reliability: All news stories were coded manually by two coders. Intercoder reliability between the two coders was calculated using Holsti's formula of inter-coder agreement. Intercoder reliability ranges from .69 (we-construction) to 1.00 (formal categories). Given that the study at hand also contained exploratory elements, coefficients of .70 are appropriate (Lombard, Snyder-Duch, & Bracken, 2002).

4. Results

In total, 287 articles were analyzed. Results show that in 198 articles (69%), honey bee colony losses were reported as the main topic of the article. Moreover, in 39 articles (13.6%), they were incorporated as a subtopic, and in 50 articles (17.4%), journalists just referenced the term "bee death" without going into details. Articles belonging to the latter category were excluded by further steps of analysis.

The first research question (RQ1) asked how emotionalized the media coverage on honey bee colony losses is. Results show that 94.5% of the 237 articles coded contained emotionalizing elements. Regardless of whether honey bee colony losses were reported as a main topic or as a subtopic—the share of articles containing emotionalization is very similar for both types of reporting (main topic: 94.4%; subtopic: 94.9%; $p = 1.000$; Fisher's Exact Test).

Interestingly, emotionalization occurred far more often by using rhetorical devices rather than by explicitly mentioning positive or negative emotions. Only in 38.4% of the articles coded did journalists *explicitly mention emotions*. More specifically, 17.3% of all articles mentioned only positive emotions, whilst 21.1% of all coded articles mentioned only negative emotions, and 4.2% included both positive and negative emotions. Table 2 shows examples of how positive and negative emotions were used in the media coverage.

Besides explicitly mentioning positive or negative emotions, journalists also used different *rhetorical devices* to evoke emotions. For instance, we identified a broad range of different metaphors (e.g., honey described as "sweet gold," or "beekeepers show heart for bees") and neologisms (e.g., "bee killer" or "bee disaster"). Journalists also applied "humanization" of bees by describing bees as "hard-working staff," by writing that "Maja the bee is finally able to laugh again," or by stating that "the bees say thank you."

The next hypothesis (H1) expected higher levels of emotionalization in the tabloids analyzed compared to the quality newspapers. Results in Table 3 show that indeed tabloids feature a higher share of articles containing any kind of emotional element compared to quality papers. Hence, our data support H1.

Interestingly, *explicitly* mentioning emotions occurs in a similar amount in quality and tabloid papers (quality papers: 40.5% vs. tabloid: 37.5%, $Chi^2 = .238$, $df = 1$, $p = .626$). It is the use of *rhetorical devices* to evoke emotions where tabloids show higher levels than quality pa-

Table 2. Examples of how journalists incorporated positive and negative emotions in news stories.

Emotion	Sentences used in media reports
Positive Emotions	
Hope	Hope for increased bee protection
Joy	Maja the bee would have enjoyed it
Love	Austrians love nature
Luck	Luckily, such a horror scenario is a long way off
Sympathy	Beekeepers feel people's sympathy towards bees
Negative Emotions	
Fear	Beekeepers fear honey bee colony losses
Worry	Beekeepers are worried
Sadness	The sad future awaiting our kids
Outrage	Citizens are outraged
Despair	A desperate push by local environmentalists to save our bees
Panic	Panic reaction by the European Commission

Table 3. Emotionalization in quality and tabloid papers.

Emotionalization	Quality papers	Tabloid papers	Total
Yes	89.3% (75)	97.4% (149)	94.5% (224)
No	10.7% (9)	2.6% (4)	5.5% (13)
Total	100% (84)	100% (153)	100% (237)

Notes: Table reports percentages and number of cases (in parentheses). $p = .014$; Fisher's Exact Test; sig. 2-sided.

Table 4. The use of rhetorical devices in quality and tabloid papers.

	Rhetorical device	Quality papers	Tabloid papers	Total	Chi^2	df	p
1	Affective vocabulary	63.1% (53)	65.4% (100)	64.6% (153)	.122	1	.727
2	Colloquial language	25.0% (21)	37.9% (58)	33.3% (79)	4.066	1	.044
3	Superlatives	9.5% (8)	21.6% (33)	17.3% (41)	5.499	1	.019
4	Metaphors	57.1% (48)	67.3% (103)	63.7% (151)	2.430	1	.119
5	Appeal/exclamation/question	20.2% (17)	45.1% (69)	36.3% (86)	14.496	1	.001
6	Expressive word order	4.8% (4)	5.9% (9)	5.5% (13)	—	—	1.000
7	Elliptical construction	8.3% (7)	19.0% (29)	15.2% (36)	4.748	1	.029
8	Colon construction	34.5% (29)	35.3% (54)	35.0% (83)	.014	1	.905
9	'We' construction	6.0% (5)	19.0% (29)	14.3% (34)	7.460	1	.006
10	Neologism	28.6% (24)	29.4% (45)	29.1% (69)	.019	1	.892

Notes: Table reports percentages and number of cases (in parentheses). n = 237 articles; Pearson Chi-Square Test (exc. for line 6: Fisher's Exact Test); sig. 2-sided.

pers. Results in Table 4 show that tabloid papers used colloquial language, superlatives, exclamation marks, elliptical constructions and a "we" construction more often to evoke emotions than quality papers did.

The next hypothesis (H2) stated that emotionalization will increase over time. Results shown in Table 5 do not support H2. Emotionalization remains at very similar levels in all three time periods investigated; it even decreases slightly in the last period of investigation. However, this decrease is not statistically significant.

Finally, the last research question (RQ2) asked to what extent emotions and scientific findings or scientific expert statements are combined in articles. Table 6 shows that 19.41% of all 237 articles contained both emotionalizing elements and scientific findings and/or statements from scientific experts. Hence, references to science and the use of emotions do not necessarily exclude one another. However, results in Table 6 also reveal that three quarters of all articles contained only emotionalization and no reference to science at all. The other way around constitutes the exception; only 0.84% of all articles contained references to science but no emotionalization.

The following examples illustrate two possibilities for how emotionalization and references to science can be combined in an article: (1) a journalist combined the two elements by reporting on new scientific findings related to the honey bee colony losses and also by using rhetorical devices to evoke emotions, or (2) the statement of the scientist includes rhetorical devices for evoking emotions. For example, a biologist said in an interview: "I think you've never held a bee in your hand that has been poisoned…,puts out its feelers to you and looks at you while dying." In this case, the scientist was the one to evoke emotions.

5. Conclusions

This study investigated emotionalization in media reporting on honey bee colony losses. Results from content analysis of news stories in Austrian newspapers indicate that the media coverage of honey bee colony losses was highly emotionalized across all three time periods of focus. There was no significant increase over time. While prior research found an increase of emotionalization in the daily news (Donsbach & Büttner, 2005; Magin, 2017),

Table 5. Emotionalization over time.

Emotionalization	2010/2011	2013/2014	2017/2018	Total
Yes	97.0% (32)	94.9% (150)	91.3% (42)	94.5% (224)
No	3.0% (1)	5.1% (8)	8.7% (4)	5.5% (13)
Total	100% (33)	100% (158)	100% (46)	100% (237)

Notes: Table reports percentages and number of cases (in parentheses). p = .571; Fisher's Exact Test; sig. 2-sided.

Table 6. The use of emotionalization and references to science in the articles analyzed.

Emotionalization	Reference to science	% of articles that contain...
x	x	19.41%
x		75.11%
	x	0.84%
		4.64%

Notes: n = 237 articles; "x" indicates that the element applies to this type of coverage.

this seems not to apply for science news (Berg, 2018) or for environmental topics as the one studied in the current paper.

Emotionalization occurred far more often by using rhetorical devices than by explicitly mentioning discrete positive or negative emotions. Emotion and scientific expertise did not exclude one another. Interestingly, we also found an example where a statement from a scientific expert contained emotional elements. Hence, future studies could have a closer look at such expert statements and investigate how and to what extent scientists are used as "opportune witnesses" (Hagen, 1992) to evoke emotions in news stories on scientific and environmental stories.

This study does not come without limitations. To capture explicitly mentioned emotions, we coded whether or not an article contained positive or negative emotions but did not count the numbers of emotions mentioned within each article. Future studies should assess it more precisely in order to give a more nuanced understanding of the level of emotionalization within each article. Moreover, when interpreting the results, one should be aware that while the first two time periods were selected based on important policy decisions related to bees, the last time period was selected based on its proximity to the study date. Hence, the slightly lower levels of emotionalization (statistically non-significant) in the last time period have to be seen in light of these selection criteria and point toward interesting questions for future research. That is, for example, how do different triggers influence levels of emotionalization in the news stories? And is the emotionalization of the coverage at such a high level because the topic is highly politicized in the Austrian context? Similarly, the search term (German: *Bienensterben*; translation: "bee death") used in this study is problematic to some extent. Although it is the predominantly used term in public debate and hence a very effective term for identifying relevant articles, it might have biased the sample since it is an emotionalized term in itself. Hence, while the use of the term "bee" might be too vague, combination of search terms such as "bee*" AND "loss" etc. could be applied. Cross-cultural research is needed to determine whether or not we are talking about a possibly specifically Austrian phenomenon. Hence, it would be worth analyzing the coverage on this topic in other countries as well as on other environmental topics such as bark beetles or species extinction.

This relates to the next limitation concerning the selection of media outlets, which is that we focused on daily newspapers in Austria. Readers should keep in mind that tabloids dominate the Austrian newspaper market (see Media Analyse, 2018) and that in the specific case of the honey bee colony losses, the tabloid *Kronen Zeitung* had by far the most coverage (56.8% of all articles analyzed appeared in this newspaper) and positioned themselves as clearly in favor of "saving the bees." Hence, analyzing newspaper coverage on the same topic in other countries where quality papers are more influential might show different results. Similarly, analyzing TV and radio news might reveal additional relevant findings, since further strategies for evoking emotions can be analyzed there (visual emotionalization, musical emotionalization). While we focused on analyzing the text, we think that it would be relevant for exploring visual components of printed news stories. Research is needed to capture the power of pictures in evoking emotions in media coverage of science and environmental topics. During the coding process, we noticed that news stories were illustrated by using the same recurring pictures (Maja the bee, a nice big flower with a bee on it, a smiling woman holding a glass of honey, etc.). There seems to be sort of a discrepancy between the text that deals with a serious topic and the positive, beautiful pictures. Experimental studies should investigate whether or not bees might have a similarly mobilizing effect in the fight against the use of pesticides as polar bears have when it comes to sacrifice for environmental protection pursuits (Swim & Bloodhart, 2015). Moreover, future experimental studies on the effects of emotions in science and environmental issues should take into account participants' emotions as mediators (e.g., Bilandzic et al., 2017; Lecheler, Schuck, & de Vreese, 2013).

Despite these limitations, this study provides interesting insights on how journalists evoke emotions when reporting on environmental issues. The study differentiated between explicitly mentioning positive or negative emotions in a news story and using rhetorical devices to evoke emotions. In addition, the study shows that in some cases, emotional and scientific elements are combined in news stories.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

The Emotional Effects of Science Narratives: A Theoretical Framework

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Abstract
Stories have long been discussed as a tool to make science accessible to the public. The potential of stories to stimulate emotions in their audiences makes them an emotional communication strategy *par excellence*. While studies exist that test the effects of stories in science communication on the one hand and the effects of emotions on the other hand, there is no systematic elaboration of the mechanisms through which stories in science communication evoke emotions and how these emotions influence outcomes such as knowledge gain and attitude change. In this article, we develop a theoretical framework of the "Emotional Effects of Science Narratives" (EESN-Model), which includes a typology of emotions likely to arise from reading science communication as well as mechanisms for each of the emotions to evoke the (desired) outcomes. The model serves as a heuristic to delineate the emotional effects of narratives in science coverage and will help guide research in this domain to provide a deeper understanding of the role of emotion in science news.

Keywords
EESN-Model; emotional response; emotion; narrative; narrative effects; science communication

Issue
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1. Introduction

In the audience-based approach to science communication, the transmission of facts is less important than creating resonance with an audience's everyday world (Nisbet, 2009a). Accordingly, news coverage of science is less likely to present science in its complexity, but rather follows typical media logics, such as news factors, designed to create relevance and make the abstract tangible (Dunwoody, 2014). Specifically, studies have shown that narrative elements and dramatic human-interest stories are widely present in news coverage of science (Atkin, Smith, McFeters, & Ferguson, 2008; Michelle, 2007; Nisbet, Brossard, & Kroepsch, 2003). The potential of stories to stimulate emotions in readers and viewers make them an emotional communication strategy for science communication *par excellence*. For science coverage, stories may have yet undiscovered power to serve as a format that is understood and liked by a broad lay public, as the recent lively debate about narratives in science communication shows (Avraamidou & Osborne, 2009; Dahlstrom, 2014; Dahlstrom & Scheufele, 2018; Kaplan & Dahlstrom, 2017).

Narratives, or stories, are defined as representations of events in a certain chronological order connected by causality (Abbott, 2008). In addition, Fludernik (2010) emphasizes that another important defining element of narratives is the representation of characters and their experientiality, that is, their thoughts, feelings, intentions, and motivations. At least one of the two aspects—events and characters—is necessary for a narrative. Usually, both are present but the focus may lie on one or the other. Narratives are a common everyday mode of communication, and they facilitate information

processing and memory by increasing interest, relevance, and attention (Green, Bilandzic, Fitzgerald, & Paravati, 2019). They also motivate the reader to continue reading and trying to understand—Downs (2014) sees the potential of stories in science communication in their ability to serve as "self-motivating vehicle for information delivery" (p. 13628).

We develop a theoretical framework of narrative science communication that extends existing models of narrative persuasion and emotional effects. At the core, our model assumes that stories in science coverage often evoke emotional reactions, which support, inhibit or otherwise change the processing of science information. We do not consider all the different forms of science communication but restrict ourselves to journalistic media coverage of science issues. By focusing on this important type of science communication, we are able to be more specific regarding the stories and outline prototypical narratives, which are then used to develop the emotional implications, mechanisms, and effects for each of them. This is a restriction considering that the variations of stories are manifold. At the same time, the discussion of narratives in science communication often suffers from a lack of specification of the narratives. Consequently, our model adds to existing scholarship by making the nature of stories more precise and by providing a classification of narrative properties that have implications for the audience's emotional reactions.

2. The Prototypical Science Stories

First, we will elaborate on aspects that characterize prototypical stories used in science coverage. This first step can be considered a classification of stories according to their narrative properties that are particularly prone to evoking emotions in readers. Certainly, stories have more properties than the ones we describe below. And certainly, not all stories in science coverage have these properties. Rather, each of the four prototypical stories described below (narrative of progress through research, narrative of risk through research, plot-oriented narrative, and character-oriented narrative) can be considered an ideal type of science stories which may appear in a pure form or be combined with each other, or may appear emotionally intense or less so. The reason we include a classification of the media text in a model of effects is that the media text is commonly undertheorized—in science communication as well as narrative persuasion. The focus is usually on the processes that take place in the reader. For example, the transportation-imagery model (Green & Brock, 2000) explains that readers immerse themselves in the story, generate vivid mental imagery and develop less counterarguing—all processes of the reader. Factors of the text are restricted to more general characteristics such as craftmanship (in the sense that stories by best-seller authors are more transporting). The same applies to other models of narrative effects such as the model of narrative understanding and engagement by Busselle and Bilandzic (2008) or the extended elaboration likelihood model by Slater and Rouner (2002). Approaches that reflect the use of stories in science communication also do not elaborate on the properties of stories (Dahlstrom, 2014). As a notable exception, Downs (2014) identifies three textual factors of the prescriptive scientific narrative in a synthesis of the literature: the narrator's voice, conflict/action, and resolution. Some experimental studies investigate specific properties of stories. For example, Dahlstrom and Rosenthal (2018) experimentally test differences in vivid narrative detail (e.g., character details, setting, and emotional descriptions) in a text on climate change. And Morris et al. (2019) test the effects of different emotional valences of the ending of a climate change story. All of these aspects are well-known properties of stories in general. For a model on *science stories*, it is important to identify patterns in the narrative text that are *specific for science stories*, and that offer firm grounds for deriving hypotheses on effects.

2.1. Message Momentum

Research demonstrates that two recurring themes in media coverage of science exist with clear implications for emotions: (1) narratives of progress through research, emphasizing the utility of research, and (2) narratives of risk through research, highlighting the dangers. We call this dimension the "message momentum" to denote a narrative pattern that presents research in a certain way (progress vs. risk), but at the same time is not identical to a mere evaluation.

First, narratives of progress through research present scientific research as beneficial and full of potential, ultimately helping society to further develop and increase its citizens' quality of life. Prototypical portrayals depict scientists as adventurers and brave heroes (Haynes, 2017), positively evaluated as productive and trustworthy (Van Gorp, Rommes, & Emons, 2014). Thus, images are invoked of courageous scientists venturing into the unknown to transcend human boundaries, helping to dominate nature and the foreign, as well as serving to defend humans against impending dangers (Kinnebrock, Klingler, & Bilandzic, 2019). Progress narratives are also transported in current media coverage of science by frames predominantly highlighting the potential for and benefits of scientific research. Frames, in a basic understanding, are aspects of an issue made salient in a text that suggest a certain interpretation and evaluation of the issue (Entman, 1993, p. 52). In the context of science coverage, several studies conclude that such frames of scientific progress are present throughout science coverage (Bubela, 2004; Lück, Wessler, Wozniak, & Lycarião, 2018; Nisbet, 2009b) and new methods or procedures are often celebrated as "a genius-eureka science narrative" (González Santos, Stephens, & Dimond, 2018, p. 430). To be clear, we do not equate frames and narratives. Conceptually, frames are different from narratives in that

they do not need to represent events or characters but may also put forward an abstract argument. Thus, many frames are not narrative. However, narratives may very well serve as frames. Our point here is that researchers have found frames that express progress and that this has thematic closeness to our "narrative of progress through research."

Second, *narratives of risk through research* highlight the dangers of research and its possible negative effects on society. In a similar vein, frames in science coverage focusing on risks, uncertainties, and controversies (Nisbet, 2009b; Ruhrmann, Guenther, Kessler, & Milde, 2015) convey messages of risk. Often, such *narratives of risk through research* resonate with and make use of master plots of science and scientists. Several studies show that scientists are not only presented as good but also as villains and "evil" or "mad" (Haynes, 2017). While these portrayals predominantly originate from fictional representations, themes like the *Frankenstein* motif are also used in current debates to convey the idea that certain scientific fields are dangerous, sparking public fear (Turney, 1998). Consequently, scientific research is also narrated as a threat to society—through either the loss of control over science, scientific hubris, or the willingness to sacrifice human lives (Kinnebrock et al., 2019). Several studies highlight the presence of these narratives as the dilemma of Pandora's box, Frankenstein's monster, or runaway science (Ancillotti, Holmberg, Lindfelt, & Eriksson, 2017; Gschmeidler & Seiringer, 2012; Nisbet, 2009b).

The two kinds of narrative (progress, risk) need to be understood as prototypes; they can appear in high and low intensity, but also in combinations with each other.

2.2. Focus of the Story

Apart from message momentum, we argue that the *focus of the story* in science news matters. Specifically, we distinguish between two fundamental foci of stories—plot-oriented and character-oriented—based on the two basic components of narrative definitions, the plot and the characters (Abbott, 2008; Fludernik, 2010).

(1) *Plot-oriented stories* centre around events unfolding and actions being carried out. A prominent and frequent example in science coverage is the story of the research process (Bilandzic, Kinnebrock, & Klingler, 2019). Such stories describe how an idea for a research project was developed and how the study was conducted. The following example of news on a scientific study on the evolution of moths exemplifies this focus:

> A crime thriller regularly leads to the conclusion: It happened in a different way than everyone assumed….It is not only criminal investigators who reach this insight, but sometimes evolutionary biologists too. For example, when they tried to solve the mystery of when and why moths developed the ability to hear….To reconstruct exactly when moths developed hearing, the biologists had to proceed just as meticulously as investigators in a criminal case. [Akito] Kawahara and his colleagues [from the University of Florida] examined more than 2,000 genes from approximately 180 species of contemporary butterflies. Using this data and by comparing it with fossil discoveries, the researchers compiled an evolutionary genealogy allowing them to date important stages in the evolution of butterflies. (Blawat, 2019, translation by authors)

(2) *Character-oriented stories* focus on people and their ideas, thoughts, feelings, and motivations—essentially the component of narrative that Fludernik (2010) calls "experientiality," with a focus on human consciousness. In science coverage, we find two main versions of this focus (Bilandzic et al., 2019): First, stories about people affected by a research field, which includes, for example, stories of climate change victims. Also, study participants can be the main protagonists of a story in science coverage. Here is an example from a German newspaper about a woman who is driven from her home in the Marshall Islands due to climate change:

> Mona Jetnil is ready. When she finally acquires a seat on the plane, she will leave her old life behind and start a new one….She will not take many things with her, only her few clothes, a cooler with food. And Witon, her youngest son….Mona Jetnil, 24 years old, hardly speaks any English and knows next to nothing about her destination: Springdale, Arkansas….Mona only knows that life will be better than here in Majuro, the capital of the Marshall Islands….[Here,] the scarce land is becoming ever scarcer. For decades, the sea level has been rising, centimetre by centimetre….The ocean will devour one atoll after another, and Mona, her family, her neighbours, and her people will lose their land. (Hinzel, Jose, & Wall, 2015, translation by authors)

Second, character-oriented stories can deal with the researchers themselves, with their careers, motivations and ideas, their hardships and lucky breaks. Researchers may be constructed as competitors working in the same field and try to defeat their opponent even using illegal methods to gain a competitive advantage (Bilandzic et al., 2019). The following example describes the story of a rival researcher working for a British biotech company that had released genetically modified mosquitos into natural habitats:

> For the company, certainly, it is about profits, about millions. But there are still the good guys, researchers of integrity and idealistic activists. They get on to the bad guys. In this perspective, Luke Alphey would be the supervillain. With his boyish features and narrow stature, however, he would be a poor cast for this role. At most, it is the British man's occasional bursts of

> cackling laughter that would fit best….During his time at the university, it was the geneticist Alphey who developed the novel insects. (Von Bredow, 2012, translation by authors)

We propose that message momentum and focus of a story are the message elements that may elicit emotions in readers or viewers. We will substantiate this proposition in the following sections.

3. Effects of Narratives and Mechanisms

Research in narrative persuasion has shown that stories are effective in changing beliefs, attitudes, and behaviours, albeit with a small effect size (see meta-analysis by Braddock & Dillard, 2016). Two mechanisms are usually identified as responsible for narrative effects (Bilandzic & Busselle, 2013; Green et al., 2019): First, readers or viewers may strongly focus their mental capacity on a story and engage in intensive processing and elaboration of the story events (transportation or narrative engagement, see below). Second, the same intense focus on the story reduces critical thinking about the story's message and inhibits counterarguing, that is, the generation of negative thoughts about the story's assertions. The reduction of critical thinking is mainly due to the intense focus on the story: As being absorbed into a story is an enjoyable experience, people are motivated to avoid interrupting their pleasurable state by not questioning the narrative (e.g., Green, Brock, & Kaufman, 2004). Reading a story, people lower their guard as they do not expect to be persuaded, so stories may "fly under the radar" (Dal Cin, Zanna, & Fong, 2004). These processes do not automatically and always occur when reading a narrative; sometimes a narrative is not engaging and readers do not get or want to get involved.

Strong emotional and cognitive focus on the story, called transportation (Green & Brock, 2000) or narrative engagement (Busselle & Bilandzic, 2009), was shown to be an important mediator of effects in several meta-analyses (Tukachinsky & Tokunaga, 2012; van Laer, de Ruyter, Visconti, & Wetzels, 2014). Narrative engagement encompasses strong emotional components, and stories are considered a powerful means of eliciting emotions (Oatley, 1999). Regularly, the emotional component of narrative engagement proves to be the most effective mediator for effects (Busselle & Bilandzic, 2009; de Graaf, Hoeken, Sanders, & Beentjes, 2009).

While elaboration and a reduction in counterarguing are processes that also apply to non-narrative, rhetoric texts, narratives also allow for unique experiences and thus unique opportunities to change the audience's views. Narratives are condensed social experiences. Narratives told in science coverage portray researchers who have achieved great things, patients who suffer from rare illnesses, consumers who live plastic-free, or people who have had their DNA tested. Stories show that special and remarkable things happen to people, with more intensity and frequency than in actual life (otherwise these stories would not be newsworthy). In this account, stories are a simulation of social interactions (Mar & Oatley, 2008) and allow the *vicarious experience* of the situations depicted, the ups and downs of the characters' fates (Bilandzic & Busselle, 2013). By taking the perspective of the persons in the story, audience members understand from an inside perspective what it feels like to suffer from illness, and be healed, or experience failure in research, before ultimately winning a prestigious scientific award. More complex scenarios of future or possible situations enable vivid, close-to-life mental representations, for example, regarding the consequences of climate change (Bilandzic & Sukalla, 2019). Identification with characters is closely related to vicarious experience. We understand identification as taking on the perspective of a character and emotionally and cognitively understanding what the characters go through and how they act (Cohen, 2001). Research has demonstrated that identification serves as an important mediator of narrative effects (Cohen, Tal-Or, & Mazor-Tregerman, 2015; de Graaf, Hoeken, Sanders, & Beentjes, 2012). For this reason, being able to relate to the characters is an important part of the narrative experience that is reflected in our model.

4. Emotional Effects of Science Narratives: The EESN-Model

Our model explains how narratives in science communication elicit emotions and how they influence a reader's information processing, knowledge, and attitudes. First, we develop a typology of emotions likely to arise from reading or viewing science coverage. Second, we develop mechanisms for each of the emotions to evoke the typical desirable outcomes for science communication: increased knowledge and trustworthiness of scientists, strengthened perceptions of the relevance and usefulness of science, and greater support for science (National Academies of Sciences, Engineering, and Medicine, 2017). The resulting model of "emotional effects of science narratives" (EESN-Model) serves as a heuristic to delineate the emotional effects of narratives in science coverage and will help to guide research in this domain to account for an elaborate view on the role of emotions (see overview in Figure 1).

We argued above that narratives in science coverage have two characteristics with implications for emotional reactions: Message momentum (narratives of progress vs. narratives of risk through research) and focus (character-oriented vs. plot-oriented) pave the way for specific emotional reactions, which we will elaborate below.

4.1. Definition of Emotion

Emotions are generally conceived as "internal, mental states representing evaluative, valenced reactions to

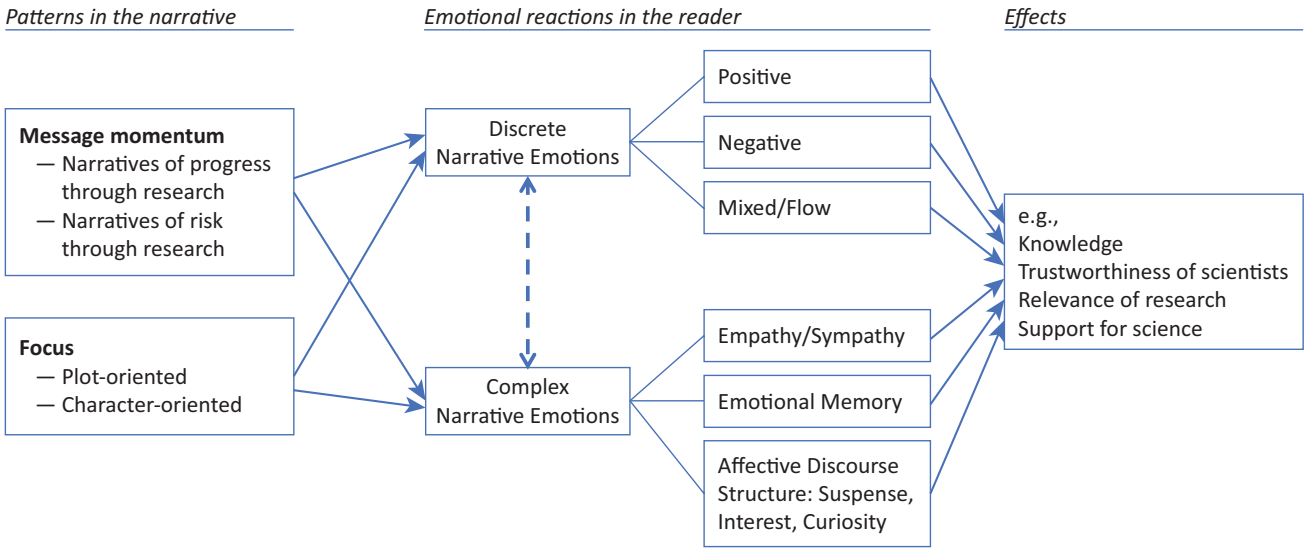

Figure 1. The EESN-Model.

events, agents, or objects that vary in intensity" (Nabi, 2019, p. 163). While many concepts of emotions exist, two perspectives are particularly prevalent in communication research (Nabi, 2019): first, dimensional models assume that emotions can be specified by their configuration along two or three dimensions. For example, the circumplex model of emotion by Russell (1980) places emotional states on the dimensions of (1) valence (from *pleasant* such as content or glad, to *unpleasant* such as sad or annoyed) and (2) arousal (from *high arousal* such as alarmed or excited, to *low arousal* such as bored or tired). Second, models of discrete emotions suggest that several emotional states exist which cannot be described using only a few dimensions; instead, there are "basic" emotional states (e.g., interest, joy/happiness, sadness, anger, disgust, and fear; see Nabi, 2010) that can be recognized by the facial expression of a person as well as by physiology or behavioural response (Ekman, 1992).

There are a number of connections between narratives and emotions. On a fundamental level, narratives may contain emotions, and they may evoke emotions in the reader. However, the basic definition of narrative as a representation of events and characters (Abbott, 2008; Fludernik, 2010) does not make the narrative contingent on the presence of emotion in the text itself. This reflects the fact that not all stories contain emotional elements. Nonetheless, even short stories such as media coverage of science may contain emotional elements, and if they do, we assume that they allow for emotional reactions in the reader and facilitate narrative effects.

Our model addresses "narrative emotions," which we define as emotions resulting from a reader's processing of narrative events and characters. Based on research in narrative experience and processing, we suggest that two types of narrative emotions may be elicited by narratives: First, discrete narrative emotions such as fear, hope, or guilt, which may be grouped into positive, negative, or mixed valences. Second, we assume that more complex narrative emotions arise from the interaction of the text and the reader. While discrete narrative emotions require a basic understanding of the story, we assume that complex narrative emotions are only perceived if readers have a sufficient level of narrative engagement in the story. In scholarship of discourse and reading psychology (e.g., Brewer & Lichtenstein, 1982; Larsen & Seilman, 1988; Oatley, 1999, 2002), we find three types of complex emotional reactions to narratives that are important drivers as well as elements of narrative engagement: (1) empathy and sympathy with the characters of the story, (2) emotion memories triggered by the text, and (3) responses to the affective discourse structure. We will detail these narrative emotions below, distinguish complex from discrete emotions, and describe their potential consequences for the readers.

4.2. Discrete Narrative Emotions

Narratives of progress and narratives of risk through research should evoke *positive* and *negative* emotions, respectively; the more a narrative makes the case for progress or risk, the stronger the emotional reactions should be. Of course, presenting both progress and risk is possible and quite common; in this case, *mixed* (ambivalent) emotions should arise (for example, both hope and fear).

To explain why narratives of progress and narratives of risk through research evoke emotions, we can make use of appraisal theories (e.g., Lazarus, 1991), and in particular Nabi's (1999) adaptation to media messages in her cognitive-functional model: a media message is first appraised according to its relevance for a person's own personal well-being. The resulting patterns of appraisal lead to the subjective perception of emotions. In particular, the "core relational themes," which represent harms and benefits apparent in the relationship between people and their environment, are connected to typical emo-

tional reactions (Nabi, 1999, pp. 296-297): a "concrete and sudden danger of imminent physical harm" creates fear (matching our narratives of risk, which we assume to evoke fear), while "making reasonable progress toward the realization of our goals" creates happiness or joy (matching our narratives of progress, which we assume to evoke hope).

In general, emotions may serve as frames for the perception, processing, and effects of information (Nabi, 2019). The emotions-as-frames model (Nabi, 2003) suggests that media messages may contain information that triggers a certain emotion and is used as an interpretational foil for incoming stimuli. For example, reporting about the potential of genome editing to cure genetic disease in a patient may trigger hope in readers. According to the emotions-as-frames model, this emotion of hope will render information compatible with hope more accessible in memory and in turn will make subsequent judgments and actions also consistent with the emotion. In our case, the emotional response in the reader results from a narrative. We identified two prototypical stories in science communication, the story of progress and the story of risk through research. The link to emotions functions in a similar way as valence framing, where information is either presented in a positive or a negative light (Levin, Schneider, & Gaeth, 1998), with the "positive light" being a gain frame describing the benefits of an action or outcome, and the "negative light" a loss frame describing the downsides or risks of an action or outcome. In effect, our stories of progress and risk through research may serve as gain and loss frames, which are known to elicit hope, and fear, respectively. Nabi et al. (2019) recently found in a meta-analysis that gain frames indeed elicit positive emotions, and loss frames elicit negative emotions, and both emotions enhance framing effects. Emotions here serve as mediators for effects between the frame in the text and the outcomes.

In addition to the predictions of the emotions-as-frames model—that emotion-consistent information will be more accessible in memory and will influence judgments and actions in an emotion-consistent sense—positive and negative emotions (as well as mixed emotions) may have other consequences as well. Positive emotions elicited by narratives pave the way for a mindset that creates openness for differing views, as argued by broaden and build theory (Fredrickson & Branigan, 2005). People who experience a positive emotion integrate bits of information more quickly, show less distortion or inflexibility in thinking, and are more open to new and unfamiliar information (Estrada, Isen, & Young, 1997). Especially relevant to our topic of science communication, Fredrickson (2004) suggests that the positive emotion of interest "creates the urge to explore, take in new information and experiences, and to expand the self in the process" (p. 1369). Narratives are known to generate interest, which may, in turn, facilitate the processing and elaboration of the information "accompanying" the narrative. In general, Fredrickson (2004) argues that positive emotions foster action-thought tendencies of play, exploration, and integration rather than the narrowing action-thought tendencies of negative emotions which involve alarm and threat, triggering the reactions of "escape, attack, expel" (p. 1369). In threatening situations such as these, evolution dictates that it is beneficial for the individual not to linger and think but to run and think later.

While emotions elicited in a narrative context have not yet been explored in science communication, there is some evidence that (non-narrative) positive emotions foster beliefs and attitudes. For example, Smith and Leiserowitz (2014) found that interest and hope predicted global warming policy support. Several studies established that hope was a mediator of effects (Bilandzic, Kalch, & Soentgen, 2017; Chadwick, 2015; Feldman & Hart, 2016, 2018; Nabi, Gustafson, & Jensen, 2018).

Whereas the broaden and build theory predicts a general narrowing of information processing as a response to negative emotions, research on fear appeals (a message that describes a threat) has shown that fear generally facilitates persuasive outcomes (Myrick & Nabi, 2017) and serves as a robust persuasive strategy (Tannenbaum et al., 2015). This is not a contradiction but simply evidence for different information processing in the presence of positive and negative emotion. With the negative emotion of fear, information processing is narrow and probably focused on immediate action-relevant aspects. Readers take in the message but do not spend time seeking further information or integrating other arguments.

Again, fear was not yet investigated as a consequence of reading stories in science coverage, but there are a number of studies finding that fear elicited by science coverage mediates related persuasive outcomes (e.g., Bilandzic et al., 2017; Spence & Pidgeon, 2010).

Nabi argues that it is not the single emotion of fear that is effective but the emotional *sequence* within a story—the emotional flow (Nabi, 2015; Nabi & Green, 2015). In a study on climate change communication, Nabi found that participants experienced more hope to a threat message when it was accompanied by an efficacy message; the emotional flow from fear to hope was the most effective influence on advocacy behaviour (Nabi et al., 2018).

4.3. Complex Narrative Emotions

As for the focus of the story, stories about affected people and researchers are essentially about characters—their fate, actions, and especially their feelings, thoughts, and motives. This invites the reader to feel with and about the character (empathy and sympathy). Also, readers may be reminded of their own experiences and emotions (emotion memories). Stories that focus on the scientific process may capture readers through the structure employed in the story, which may create experiences such as surprise, curiosity, and suspense.

4.3.1. Empathy and Sympathy

The readers can assume the perspective of the character and engage in empathy and sympathy. Empathy describes the phenomenon where the readers share the feelings of a character; to feel anger, when the characters are angry, or fear, when the characters are fearful (Oatley, 2002). In contrast, sympathy denotes feelings of the reader about the character, feeling with and for the character rather than just feeling the same way (Oatley, 2002). A reader may feel pity or shame for the character when the character herself feels anger. For example, the newspaper excerpt cited earlier about the mother from the Marshal Islands, states:

> Her older sons, Peterson, 6, and Ranson, 4, are sitting on the floor, cooking ramen noodles on a propane gas stove. They do not yet know that their mother will leave them behind. Mona has not yet dared to tell them. She did not have enough money for them. Their father will look after them and follow later, when Mona has saved enough money for the expensive tickets to the US. (Hinzel et al., 2015, translation by authors)

This text is suitable to create empathy with the mother and make the reader feel heartbroken; at the same time, readers may feel pity for the woman who is in such a desperate situation that she has to leave her children behind.

Intertwined with empathy and sympathy is the idea of affective disposition theory that audience members form positive dispositions towards protagonists or characters who behave in a morally acceptable way, and form negative dispositions towards antagonists or characters who behave in a morally unacceptable way (Raney, 2011). These positive and negative emotions, as well as feelings of empathy and sympathy, will influence how readers or viewers process information from science coverage and how they evaluate what happens to the characters. In affective disposition theory, audience members enjoy it when characters they like experience positive outcomes. Accordingly, audience members may pay selective attention to and recall specific facts that are beneficial for the story's characters but not those that are detrimental. Through processes of empathy with a favoured character, readers or viewers will share the cause of the character and attribute greater relevance to the scientific domain and be more supportive of science policy. This process is akin to motivated reasoning (Jain & Maheswaran, 2000). And this form of motivated reasoning, again, is shaped by the narrative, rather than pre-existing attitudes and world views (Druckman & Bolsen, 2011; Hart & Nisbet, 2012).

A similar idea is expressed in the cognitive-functional model of emotions, in which Nabi (1999) suggests that negative emotions drive motivated attention and motivated processing of a message. Negative emotions that imply avoidance such as fear, disgust, and guilt, will reduce the motivation to attend to (motivated attention) and to process the remainder of the message (motivated processing). Negative emotions that imply approach such as anger and sadness will increase both motivated processes.

4.3.2. Emotion Memories

A vivid story of a person going through some extraordinary fate, hardship, or lucky circumstance, allows the reader to retrieve similar experiences from their own lives and evoke emotion memories (Oatley, 1999). These emotion memories from a person's own life serve to intensify the narrative experience, as both narrative and remembered emotions mingle together. Dill-Shackleford, Vinney, and Hopper-Losenicky (2016) accordingly suggest an interaction between personal and narrative processing in the process of "dual empathy": readers of stories feel empathy for the character and at the same time for themselves. Resonance of stories with the readers' lives is well documented in research on "reminding" (Larsen & Seilman, 1988). Similarly, Dunlop, Wakefield, and Kashima (2008) assume that emotional responses may be elicited by the content of the message (message-referent emotional responses, for example, disgust at seeing effects of smoking on the lung) as well as by the plot (plot-referent emotional responses, for example, feeling sadness for a lung cancer victim). Both of these emotional responses may then trigger "self-referent emotional responses," emotions in response to one's thoughts about one's life and self—which is the same concept as emotion memories.

As a consumer of science coverage is reminded of his or her own experiences and past emotions, the information may become more relevant and be processed in a more involved way. An example from science coverage may be a report about genetic testing for the risk of breast cancer, telling a story about a woman who had a prophylactic mastectomy at the age of 34. This may trigger a memory of the reader's mother who also had breast cancer and died at an early age. The emotion memory associated may be a feeling of loss and grief for the mother, but also discrete emotions such as fear or anger.

Finally, while we think that emotion memories are most likely to arise in character-oriented narratives, we also assume that there is some fluidity: plot-oriented stories may also activate emotion memories, in the same way that Dunlop et al. (2008) elaborate that self-referent emotional responses may arise from the emotions sparked by the plot.

4.3.3. Affective Discourse Structure

Stories about the scientific process invite emotional responses to the plot, or more precisely, the arrangement or structure of the plot. In their structural affect theory of stories, Brewer and Lichtenstein (1982) distinguish be-

tween the *event structure*, that is a temporal sequence of events in a narrative world, and the *discourse structure*, which denotes the arranged sequence of events in a narrative. The discourse structure explains *how* something is told, as opposed to *what* is told on the event structure level. Different types of re-arrangement on the discourse level (that is, the affective discourse structure) have specific consequences for the emotional experience. Brewer and Lichtenstein (1982) identify three discourse structures:

(1) A structure creates surprise when crucial information is held back at the beginning and the readers are unaware that any information is missing. In the end, the information is revealed, forcing the readers to re-interpret the story. For example, consider a report in a German weekly newspaper on a rare genetic disorder that prevents people from feeling pain (Henk, 2014). A story is told of a young girl named May Linn who suffers from this disorder. A suspense structure could look like this: 'May Linn is a reckless child, fearing nothing and suffering frequent injuries. Her parents were accused of maltreatment for all the damage to the girl's body. Her toe had to be amputated because she had not paid attention to the wound. After years of seeking medical help, she received the diagnosis that she cannot feel pain because she has a rare genetic disorder.' In this example, the crucial information—that May Linn has a genetic disorder—is held back until the end; reading the last sentence should evoke surprise.

(2) A structure generates curiosity when the beginning of a story starts to tell an event, but does not finish telling it. The reader is aware of the missing information and waits for it over the course of the story. In our example, a curiosity structure may look like this: 'After years of seeking medical help, May Linn received the diagnosis. She was a reckless child, fearing nothing and suffering frequent injuries. Her parents were accused of maltreatment for all the damage to the girl's body. Her toe had to be amputated because she did not pay attention to the wound. Her diagnosis was that she cannot feel pain because she has a rare genetic disorder.' In this example, the information that something is wrong with May Linn is given in the first sentence, but the information as to exactly what is wrong is omitted. Thus, the reader is aware of the missing information (unlike in the surprise structure where the reading is *not* aware that information is missing); the reader will wait for the diagnosis while reading the rest of the story.

(3) A structure facilitates suspense when the course of a story is uncertain. An initiating event is presented, but several outcomes are possible, which causes the reader to worry about the character and fear for their fate. The suspense structure is closest to the actual event structure. In our example, a surprise structure may look like this: 'May Linn was a reckless child, fearing nothing and suffering frequent injuries. Her toe had to be amputated because she did not pay any attention to the wound. After years of seeking medical help, she received the diagnosis that she cannot feel pain due to a rare genetic disorder. When she was a teenager, she thought she was going to die soon when she read that people without the ability to feel pain rarely reach their twenties. The doctors told her that she would never be able to have children, yet today, May Linn is in her thirties, she has made her home in London and given birth to two children.' For the reader, getting to know the different dangers of this particular disease opens up a series of possible outcomes for May Linn, all of which are negative. The last sentence states the outcome, which in this case is positive. Brewer and Lichtenstein (1982) emphasize that between the initiating event and the actual outcome, most often we find additional discourse, stretching the period in which the reader is uncertain of the character's fate.

The effect of all three discourse structures is that readers are drawn into the story and become motivated to continue reading. Also, an intense story will be retained in memory to a greater extent. While a plot-oriented story may not seem like a very emotional part of the text, it can evoke emotional reactions in the reader by making use of affective discourse structures and stimulating surprise, curiosity, or suspense.

4.3.4. Distinction between Complex Narrative Emotions and Discrete Narrative Emotions

Complex narrative emotions require the reader to get involved in a story, for example, to assume the perspective of a character, to try to understand the situation and what it means for the character, or to play along with the author's way of telling a story and experience surprise, curiosity, or suspense. Complex narrative emotions are based on a higher level of narrative processing, in which the reader intensively follows the story, and they are more complex because the *process* by which a narrative evokes emotions is more complex. Conversely, for discrete emotions, the minimum requirement is lower: Readers simply need to make sense of the story in order to perceive discrete emotions. This does not mean, however, that higher levels of narrative engagement are incompatible with discrete emotions—on the contrary, discrete emotions may also appear in states of intense narrative experiences. They can be part of the more complex emotions. In the prophylactic mastectomy example, the emotional memory of grief for the mother may encompass the discrete emotion of sadness. Discrete emotions may be included in the more complex ones, but the more complex ones need more processing effort on the part of the reader.

5. Conclusions

Our EESN-model offers a heuristic for research on the emotional impacts of stories in science coverage and shows possible pathways of emotional reactions to prototypical stories. Rather than using generic properties

of stories (such as narrative perspective, writing quality etc.), we provide a classification of stories that is specific for science coverage and identifies typical patterns in science story content resulting in four prototypical stories arranged on two dimensions: On the dimension of momentum, stories may (1) describe the dangers of research and possible negative effects on society (narratives of risk through research). Other stories may (2) describe scientific research as beneficial and advantageous for society and the quality of life of its citizens (narratives of progress through research). On the dimension of focus, stories may portray (3) scientists and people concerned by the scientific problem or research (character-oriented) or (4) the process of research (plot-oriented). This distinction is also ideal-typical, meaning that the classification describes the purest form and that actual empirical reality may contain weaker examples as well as combinations.

The EESN-model goes on to elaborate the different kinds of emotions that may be evoked, i.e., discrete narrative emotions (positive, negative, mixed emotions/emotional flow) as well as complex narrative emotions (empathy/sympathy, emotion memories, responses to affective discourse structure). It illuminates the mechanisms that may ultimately lead to effects, for example, on knowledge, understanding, the trustworthiness of scientists and science, the perception of relevance and usefulness of science, as well as support for science. The unique contribution of our model is that it focuses on emotional processing and reactions. It connects content properties with these emotional reactions and specific mechanisms for each pathway. The systematic connection between narrative content in a specific domain and ensuing processing and effects is what constitutes the theoretical progress compared to existing models of narrative persuasion. For example, neither the transportation-imagery model (Green & Brock, 2000), nor the model of narrative understanding and engagement (Busselle & Bilandzic, 2008), nor the extended elaboration likelihood model (Slater & Rouner, 2002) make a distinction between different patterns in stories; all of these models suggest the same mechanisms for narrative persuasion (e.g., immersion, elaboration, reduced counterarguing, mental imagery). However, it seems appropriate to assume that stories with greater potential to trigger empathy will elicit different kinds of processing than stories that primarily work with suspense. And this is what our model calls for: a differentiated view on the narrative text, combined with a differentiated (and matching) view on processing and effects.

Our model also does not consider the factors of the reader or the communicator. We intended to create a theory that connects content, processing, and effects. This does not mean that other factors such as the reader's prior knowledge or credibility of the communicator are irrelevant. It only means that the theory is focused and, all else equal, the content factors and the emotional reactions we describe matter for effects. Should researchers want to address reader characteristics in any future study, our model certainly needs to be combined with other theories. For example, to explore whether the effect of stories in climate change coverage depends on prior attitudes, we could complement our model with the value-belief-norm theory (Stern, Dietz, Guagnano, & Kalof, 1999). This particular model suggests that existing environmental attitudes are relevant for behavioural outcomes. Thus, the propositions in the EESN-model will need to be combined with a moderator of prior environmental attitudes.

Finally, there are also risks of using narratives as a strategy in science communication. For example, processing the narrative may distract readers or viewers from the content of the actual message. This is particularly true for highly intense emotional cues which may steal attention away from the scientific issue and excessively highlight the emotion. The same is true for stories that do not integrate the facts or the persuasive message sufficiently into the story: In this case, the story will draw processing capacity away from the message and will not prove beneficial (Bilandzic & Busselle, 2013). Moreover, a central mechanism of narrative persuasion is a reduction in counterarguing, that is, being less critical of the content. However, uncritical processing of media coverage on science may also have detrimental effects, because readers are more sensitive to assertions backed up by no or weak scientific evidence. This is certainly a crucial point when considering the value of narratives for science communication and may be responsible for some of the cautionary voices on this issue (e.g., Dahlstrom & Ho, 2012). Narratives can serve as evidence or counterevidence for scientific findings—and it is up to the communicator to ensure that their narratives (especially those with a focus on characters) are representative, typical, and in accord with scientific insight. Similarly, there is a fine line between a gripping story that supports desired outcomes of science communication and a gripping story that overwhelms the reader to no avail. It requires a great deal of responsibility and sensitivity on the part of the communicator to cause the "proper" amount of emotion to be evoked by a story. More research is needed to delineate the effects of the different types of emotions we outlined in our model and to determine what stories on what scientific issues in what context are appropriate to serve as functional tools for science communication.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

Feeling Left Out: Underserved Audiences in Science Communication

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Abstract
Science communication only reaches certain segments of society. Various underserved audiences are detached from it and feel left out, which is a challenge for democratic societies that build on informed participation in deliberative processes. While only recently researchers and practitioners have addressed the question on the detailed composition of the not reached groups, even less is known about the emotional impact on underserved audiences: feelings and emotions can play an important role in how science communication is received, and "feeling left out" can be an important aspect of exclusion. In this exploratory study, we provide insights from interviews and focus groups with three different underserved audiences in Germany. We found that on the one hand, material exclusion factors such as available infrastructure or financial means as well as specifically attributable factors such as language skills, are influencing the audience composition of science communication. On the other hand, emotional exclusion factors such as fear, habitual distance, and self- as well as outside-perception also play an important role. Therefore, simply addressing material aspects can only be part of establishing more inclusive science communication practices. Rather, being aware of emotions and feelings can serve as a point of leverage for science communication in reaching out to underserved audiences.

Keywords
emotion; exclusion; feelings; focus groups; inclusion; marginalisation; science communication; underserved audiences

Issue
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1. Introduction

Science communication is more than just imparting scientific knowledge. Emotions play an important role in how messages are received and understood, if the messages get through at all, or if they even cause alienation: "Skepticism of scientific advice was strongly filtered by feelings of distrust and alienation, feelings that were forged by local history, communication mistakes by scientists" (Nisbet & Scheufele, 2009, p. 1769). This observation was initially described for the (rather unfavourable) reaction of English sheep farmers to communication of scientists following the Chernobyl nuclear accident (Wynne, 1992).

The change from a 'deficit model' understanding of science communication to a dialogue approach—which includes considering context, values, interests, and emotions as part of the communication—is a key aspect for the modern understanding of science communication. Although the deficit model persists (Simis, Madden, Cacciatore, & Yeo, 2016), current research on science communication and the development of new forms and communication approaches increasingly consider emotional and experiential aspects of science communication beyond the imparting of knowledge: be it the experience of science festivals as informal leisure activities and sources of pleasure (Bultitude & Sardo, 2012; Davies, 2019) or the specific utilisation of emotions as a tool

for an effective communication about climate change (Roeser, 2012).

While the role of emotions with a positive connotation as an integral component of science communication is increasingly paid attention to, another crucial aspect received only "a limited amount of research" (Dawson, 2019, p. 24) and awareness so far, despite being named as "one of the most pressing problem[s] in science communication" (Scheufele, 2018, p. 3): The question of which audiences are actually not reached by science communication, why they are not reached, and what role emotional barriers play therein. Answering these questions is highly relevant, considering that being included in science communication is an important prerequisite for participation in modern society, e.g., as a support for evidence-based individual decisions (The Royal Society, 1985, p. 10), for personal career development (Blanton & Ikizer, 2019, p. 155), or the informed participation in democratic processes and public debates (Thomas & Durant, 1987, p. 5).

What is known is that the typical audience for science communication has a high formal education, is already knowledgeable, very interested in science, predominantly white and is affluent (cf. Borgmann, 2005; Gruber, Unterleitner, & Streicher, 2010; Kennedy, Jensen, & Verbeke, 2017; Pandya, 2012).

Research and practical approaches in science communication in many cases address only specific aspects of marginalisation, e.g., on gender equality in Science, Technology, Engineering, and Mathematics (STEM) fields (cf. Wang & Degol, 2017). However, current research in the UK (Archer, Dawson, DeWitt, Seakins, & Wong, 2015; Dawson, 2019) addresses the broader issue of science communication, education, social exclusion, and marginalisation in a more comprehensive approach, but more focused on the social dynamics and less on the systematisation of underlying drivers and factors. An overarching analysis of exclusion in science communication, based on a systematic literature review, shows that there is a broad range of potential exclusion factors (Schrögel et al., 2018). While some of them, termed 'material exclusion factors' in the following, present concrete barriers (e.g., entrance fees), others ('emotional exclusion factors') include feelings and emotional aspects such as trust, disappointment or fear. For both types of factors, the exclusion can have considerable emotional effects and consequences on excluded groups, who end up with the impression that science is "not for me" (Office of Science and Technology & Wellcome Trust, 2001, p. 328; see also Koch et al., 2019; Schäfer, Füchslin, Metag, Kristiansen, & Rauchfleisch, 2018, p. 850):

> One of the most difficult feelings to rid oneself of is the emotional turmoil associated with being marginalised by a person or group in the position of power. Feelings of anger and confusion are often followed with those of inferiority. (Granger, 2013)

Tackling this problem requires a profound understanding and respect for the marginalised groups, as otherwise attempts might backfire and become patronising, reinforcing the feeling of exclusion (Granger, 2013).

In this article, we are going to provide a qualitative assessment of the emotional aspects of marginalisation and discrimination in science communication and seek to carve out the roles and relations between the various exclusion factors and their emotional components. The analysis builds on a typology of exclusion factors (Schrögel et al., 2018). The qualitative assessment helps to better understand the shape and intersection of the exclusion factors and their emotional properties and, most importantly, gives access to the voices of the underserved audiences themselves.

Our empirical data is based on focus groups and guided interviews with three demographic groups in Germany chosen as exemplary case studies of underserved audiences in science communication: residents of a marginalised city quarter, students in vocational training (Berufsschüler), and young Muslims with a migration background. The three groups are each characterised by one of the identified exclusion factors, however, it is important to note that they are a statistical group of people with one common attribute, rather than a social group (Vester, 2009, pp. 80–81) with a self-identification as a group. In many other aspects, the members of the groups can be very heterogeneous (Brackertz, 2007, p. 1). Also, the exclusion factor is not to be seen as an attribution of responsibility, nor even as causal for the exclusions. Particularly young Muslims with a migration background are often confronted with discrimination based on external attributions and assumptions, while their religiosity itself might have no impact on the topic (Uslucan, 2014).

Our exploratory analysis of the data seeks to carve out the roles and relations between the various exclusion factors for science communication and their emotional components and provide evidence for the exclusionary effects of feelings and emotional barriers.

2. Emotions and Exclusion in Science Communication

2.1. Emotions in Science Communication

The role of emotions and feelings in science (communication) has been discussed in regard to several problems—e.g., for effectively communicating climate change (Roeser, 2012; Smith & Leiserowitz, 2014), for science storytelling (Martinez-Conde & Macknik, 2017), for the experience of visitors to science centres (Falk & Gillespie, 2009) and science festivals (Davies, 2019), for the activities and motivation of scientists themselves (Barbalet, 2004) including engaging and communicating with the public (Mizumachi, Matsuda, Kano, Kawakami, & Kato, 2011).

The definition of emotions and feelings varies in these studies widely. Some use catalogues of discrete

emotions derived from psychology (Smith & Leiserowitz, 2014, p. 940) or apply psychological measuring instruments (Falk & Gillespie, 2009, p. 113) while others give no definition but list exemplary emotions (Roeser, 2012). This multitude of understandings is not surprising because one can find as much as 92 definitions in the research literature on emotions and feelings (Kleinginna & Kleinginna, 1981). For this article, we do not expand further on the detailed psychological distinctions between emotions and feelings, but rather use them both in parallel as general concepts of—more or less concrete—affective attitudes towards something.

2.2. Emotions and Exclusion

Non-participation in science communication is influenced by a multitude of factors. In the literature on science communication as well as other similar fields—e.g., health communication, political participation or adult education—one can identify more than 30 exclusion factors. To provide a more structured overview on the range of factors, we previously proposed a typology (Schrögel et al., 2018) which categorises exclusion factors into three layers: individual factors (e.g., language, reading, and writing skills); social factors (e.g., regional affiliation, disabilities); and structural factors (e.g., location, available support, and services). The factors reach from 'lack of interest' to more complex structures like science literacy or habitus (Bourdieu, 1982). Also, they are often interwoven, which impedes an isolated examination.

However, in the already scarce research literature on exclusion in science communication, the role of emotions and feelings for non-participation remains largely unexamined. The effect of 'feeling left out' has been described for ethnic minorities and their participation in everyday science learning practices. For them, "emotional labour, the extra work required to 'fit' and the discomfort of not 'fitting"' (Dawson, 2019, p. 91) leads to exclusion, because "walking into a science museum or similar everyday science learning practice carries a significant emotional burden, a burden that plays into dispositions and tastes, as a preference not to be in such spaces" (Dawson, 2019, p. 103). This "emotional work" (Hochschild, 1979) can contribute to a feeling of 'not for me' in marginalised groups.

The engagement with science in schools seems to be patterned by the amount of science capital students command. The concept builds on Bourdieu's capital theory and comprises "science-related forms of social capital (e.g., contacts, social networks, knowing people who work in STEM…) and cultural capital (qualifications, enduring habits/dispositions, scientific literacy…)" (Archer, DeWitt, & Willis, 2014, p. 5). The amount students command correlates with "whether they feel that others see them as a 'science person"' (Archer et al., 2015, p. 941). Students with low science capital "lack confidence in their science identities and feel that others do not see them as 'science people"' (Archer et al., 2015, p. 941).

The importance of emotions and feelings for social exclusion and (non-)participation has been described for other areas as well. The "emotional effect of family poverty" has been listed as one of five barriers hindering participation in adult education and the "level of emotional support a person receives can also affect the likelihood that she or he will engage in literacy programs" (Flynn, Brown, Johnson, & Rodger, 2011, p. 44). For students with a socio-economically disadvantaged background, with disabilities or from ethnic minorities, "negative attitudes towards their study from friends, parents and partners" (Bamber & Tett, 2000, p. 65) and their own unfavourable school experiences are additional burdens besides more material problems, like lacking financial resources. Emotions can also influence political participation, with anger showing a positive effect and anxiety a negative effect with regard to participation in elections (Valentino, Brader, Groenendyk, Gregorowicz, & Hutchings, 2011; Valentino, Gregorowicz, & Groenendyk, 2009).

The role of "emotional oppression" (Watermeyer, 2013, p. 152) has been described for the social exclusion of people with disabilities, where these emotional barriers intersect with "material barriers" (Watermeyer, 2013, p. 44), like poverty. We adopt this distinction between emotional and material barriers to broadly categorise the aforementioned exclusion factors in science communication. Furthermore, we also subsume specific, but not necessarily tangible, factors like language skills under material factors, besides physical factors like accessibility or financial resources. Subsequently, we distinguish between two types of exclusion factors: those on the level of emotions and feelings on the one hand, and material factors on the other. The former includes, among other things, the feeling of not being addressed by offerings or the fear of embarrassment by a lack of knowledge. The latter can be for example time constraints because of shift work or a lack of money to afford entrance fees.

3. Methods and Data Basis

The data presented in the following is based on three demographic groups: residents of a marginalised city quarter in Berlin-Spandau, students in vocational training in Karlsruhe, and young Muslims with a migration background from Berlin. The groups have each been chosen as three exemplary case studies representing often—by science communication—not reached segments of society. The aim of the focus groups and interviews (for an overview, see Table 1, or the Supplementary Material for more details) was to learn more about the everyday lives of the groups, their attitudes towards science and science communication, their (non-)participation therein and the reasons behind it. Besides members of the groups, we also surveyed various other actors who can be described as socially engaged persons or in short engaged person—for example, community representatives, social workers, teachers and stakeholders. These

engaged persons have a strong connection and privileged access to the communities. They were included for two reasons: First, as a pragmatic solution to the difficulty to access the communities; and secondly to provide a broader and more reflected perspective than interviews with 'isolated' individuals could.

Socio-economically disadvantaged and marginalised urban communities often live in certain city quarters, although social-spatial theories describe more complex theories for marginalisation overall (Otto, Ziegler, & Landhäußer, 2006). These quarters are often characterised by an above-average unemployment rate, lower formal educational backgrounds, and less scientific, educational and cultural infrastructure. Due to this lack of access points contact with science communication—if not mediated via mass media—is limited. For our study, we chose the formally defined district development areas Falkenhagener Feld East and West in Berlin-Spandau. In these two areas, 45,6% to 49% of residents have a migration background (the average for Berlin is 32%), the percentage of residents receiving transfer income is around 33% (the average for Berlin is 16,59%), the unemployment rate is at around 7% (the average for Berlin is 4,3%), the percentage of children in poverty lies at around 55% while the average for Berlin is 29,8% (GeSop mbH, 2019a, 2019b).

We conducted one focus group with engaged persons and semi-structured street interviews with residents. The engaged persons included a person from neighbourhood management (*Quartiersmanagement*), representatives of various informal learning initiatives and a volunteer social worker. The street interviews were

Table 1. Overview of the data basis.

Group	Method	Date	Demographics	Abbreviation
Vocational Students	Focus group (n = 10)	25/09/2018	age: 19–25 mean age: 20.7 men: 8 women: 2 engaged persons: 3 students: 7	Voc_F-1
Vocational Students	Focus group (n = 17)	06/11/2018	age: 18–25 mean age: 20.1 all male engaged persons: 0	Voc_F-2
Marginalised City Quarter	Focus group (n = 5)	26/07/2018	men: 1 women: 4 engaged persons: 5	Mar_F
Marginalised City Quarter	Guided interviews (n = 18)	08/09/2018–15/09/2018	age: 16–55 mean age: 33.1 men: 6 women: 12 engaged persons: 0	Mar_I-1…Mar_I-15
Young Muslims with a Migration Background	Focus group (n = 10)	09/04/2019	age: 19–25 mean age: 21.4 men: 9 diverse: 1 engaged persons: 0	You_F-1
Young Muslims with a Migration Background	Focus group (n = 6)	27/04/2019	age: 21–23 mean age: 22.2 men: 1 women: 3 diverse: 2 engaged persons: 0	You_F-2
Young Muslims with a Migration Background	Guided interviews (n = 10)	16/01/2019–28/02/2019	men: 5 women: 5 engaged persons: 10	You_I-1…You_I-7

Notes: Demographics where available. The age of the teachers and the expert in the first vocational student's focus groups is not known. The students of the vocational school are typically men (more than 90% of the pupils are male).

a substitute for a focus group with residents because it turned out to be impossible to organise a focus group with enough participants. All interviews were conducted during several days in September 2018 with passers-by at several locations within the quarter, i.e., at a central square, during a street festival, and a garage sale. The interviews lasted about five to ten minutes each.

Students in vocational training are often not considered in public debates on education (Blaß & Himmelrath, 2016). They are usually neglected by science communication, as they are neither addressed by science communication focusing on high school students as potential future university students nor are they addressed by adult science communication. We conducted two focus groups with students in vocational training from a school for plumbing and heating in the city of Karlsruhe. The first focus group consisted of a mixed group of committed students and engaged persons (two teachers and one external expert—a scientist researching political participation of vocational students in another German city). The second focus group was made up of seventeen students attending the same class.

Religious beliefs can influence actual or perceived attitudes towards science and science communication (Hagay et al., 2013). Furthermore, (externally perceived) religious affiliation can be a potential target to discriminate against, which is especially true for Muslims in Europe. In this case, religion is often only a proxy and discrimination is targeting actual or perceived migration backgrounds (European Union, 2017). That such experiences of discrimination can negatively affect participation in science communication has been shown for the UK (Dawson, 2019). This phenomenon has been reported for young Muslim people in Germany independently of their cultural or family background (El-Mafaalani & Toprak, 2011).

We conducted two focus groups with young Muslims with a migration background in Berlin. The focus groups were organised together with two non-governmental organisations that work together with Muslim youths with a migration background. This access to the field was chosen because both organisations are not addressing exclusively certain ethnical backgrounds, e.g., Turkish or Islamic faiths (e.g., Sunnites). Of the 16 participants in both focus groups three were born outside of Germany, eight reported that both parents were born outside of Germany and four stated that one of their parents was born abroad. Only one participant stated that he/she and her/his parents were born in Germany. Thus, the overall majority of the participants had a migration background in a wider sense (Kroh & Fetz, 2016). Additionally, guided interviews with ten engaged persons from seven organisations and initiatives were conducted.

The abbreviations used to label quotes from the data follow the scheme group, data collection method (F for focus group, I for guided interview) and the interview or focus group number. Additionally, if the person quoted is an *engaged person* this is marked by the suffix 'engaged.'

Video, or where not possible audio, recordings were made of all interviews and focus groups. The recordings were then transcribed and analysed according to qualitative content analysis (Mayring, 2010). The categories used to code the transcripts were, in the beginning, deductively based on 31 exclusion factors identified in a literature review (Schrögel et al., 2018, p. 57). The categories were then inductively further adapted and refined to reflect the new perspective of the group's reported exclusion factors found in the material (Kuckartz, 2016, p. 47). Subsequently, these factors were categorised as either emotional or non-emotional, i.e., material.

During the analysis, it became clear that emotions and feelings concerning science communication cannot be easily separated from those associated with science and the education system in the broader sense, as they are often interwoven.

4. Results

One commonality between all groups was that they seldom consume science communication at all. If they do, then mostly by consuming TV formats, like documentaries or science shows, or by using online formats, like videos on YouTube or Wikipedia. This observation fits in with a qualitative media diary study on science communication audiences in Switzerland (Koch et al., 2019, p. 13) as well as with the results of the survey *Wissenschaftsbarometer* for Germany (Wissenschaft im Dialog & Kantar Emnid, 2018, pp. 9–12). In all three groups, some participants reported that they had visited museums in the past. However, almost all of these visits did take place as part of compulsory school activities. Science communication via print media played virtually no role in the answers.

However, the relevance of exclusion factors varied partly between the groups. While most found factors were relevant for all groups—i.e., financial resources, fear, frustration, and insecurity, emotional and habitual distance and self-perception and outside-perception—others only affected a part of the groups, i.e., lack of (local) offerings and infrastructure, language, and time resources (see Table 2).

Exclusion factors found in the data that are identical to the typology are 'financial resources,' 'language,' and 'time resources.' The name of the factor 'fear' from the previous typology has been changed to 'fear, frustration, insecurity' to better reflect its scope. The 'lack of (local) offerings and infrastructure' cannot be found in the typology but featured prominently in the material. Also missing in the typology are the factors 'emotional and habitual distance' and 'self-perception and outside-perception.' They could be both subsumed under the relatively wide exclusion factor 'missing familiarity/habitus/science capital' in the original typology. However, such subsumption would not adequately represent the specific characteristics of the exclusion mechanisms found in our data and might indicate that the fac-

Table 2. Overview of the exclusion factors found in the data.

Type of Factor	Identified Group-Reported Exclusion Factors	Residents in a Marginalised City Quarter	Vocational Students	Young Muslims with a Migration Background
Material Exclusion Factors	Lack of (local) Offerings and Infrastructure	X	X	—
	Financial Resources	X	X	X
	Language	—	—	X
	Time Resources	—	X	X
Emotional Exclusion Factors	Fear, Frustration, Insecurity	X	X	X
	Emotional and Habitual Distance	X	X	X
	Self-Perception and Outside Perception	X	X	X

Notes: There are several explanations for not finding the exclusion factors of language, lack of (local) offering and infrastructure, and time resources in all groups. Maybe the groups are not, or less, affected by them, or they did not mention them because of recruiting and interview effects.

tor in the typology is too broad to be a suitable category for analysis.

4.1. Material Exclusion Factors

The identified material exclusion factors comprise concrete tangible resources such as infrastructure or financial means as well as specifically attributable factors such as language skills.

4.1.1. Lack of (Local) Offerings and Infrastructure

One exclusion factor only brought forward in the city quarter was the lack of local science communication opportunities:

> Interviewer: Did you attend scientific events in Spandau? Is there anything around here where you would like to go to?
>
> Resident: No, unfortunately, there is nothing here. (Mar_I-6)

This impression was stated by engaged persons too: "So, we have a lot of social institutions in the area [in Spandau], we don't have a university, we don't have a university of applied sciences. That's what we are lacking" (engaged person 4, Mar_F_Engaged).

At first, this might be surprising because Berlin as the German capital is home to a multitude of scientific institutions engaging with the public. However, in a city quarter with a high level of unemployment and a low average income people might lack the financial means to afford mobility beyond the limits of their Kiez (how Berliners call their neighbourhoods): "I think this has a lot to do with the personal economic situation. Whether I can afford a car or a bus ticket, BVG [public transportation in Berlin]" (engaged person 4, Mar_F_Engaged).

In a broader sense, a lack of opportunities was also articulated as an exclusion factor by the vocational students. In their case, the locality of a science event is not as much of a problem, but the (perceived) disinterest from science communicators in reaching out to them. This, in turn, creates a feeling of 'not for us':

> Expert 1: I often heard something like you [directed to the vocational students present in the focus group] have said…that you never really came into contact with [science communication]. But it was also strongly mentioned that they have the feeling that they are not welcome there [at science organisations] at all. (Voc_F-1_Engaged)
>
> Vocational Student 6: People from the university could maybe more often go to middle schools [Hauptschulen] and perhaps introduce something or cooperate with them. But one doesn't notice anything like that. (Voc_F-1)

4.1.2. Financial Resources

Besides the lack of financial resources for transportation to get to science communication formats mentioned above, the aspect of money was also brought forward in one of the focus groups with young Muslims with a migration background as a reason for not going to museums:

> Well, it's again a question of access. The Pergamon Museum [in Berlin], I think, costs 12 euros to enter….And when my parents came to visit me, we were lucky that there was a day with free admission, because otherwise I could not have brought them in. And these are people who are interested in it, but…you pay 50–60 euros if you go somewhere together. (young person 1, You_F-2)

The difficult economic situation also leads to the problem that—according to the engaged persons—inhabitants of the marginalised city quarter are preoccupied with their own lives and imminent challenges. Together with the isolation within their quarter, this seems to lead to a kind of "tunnel vision that most people

have," as one engaged person put it (Mar_F_Engaged), where science (communication) plays no role.

Interestingly, money is a concern not only featured in relation to entrance fees or transportation costs, but it also came up concerning going to university; among the young Muslims with a migration background:

> Another problem is, although we came here [to Germany] with the dream to become a scientist or something like that, there is simply a lack of resources. Even if you do your Bachelor or Master studies, there is family pressure to earn money. (young person 4, You_F-2)

As well as among the vocational students:

> Moderator 2: Is there anyone else…who has thought about [studying]?
>
> Vocational Student 7: The dream is shattered anyway when you realise that the money is missing. (Voc_F-2)

4.1.3. Language

Language as a barrier for participating in science communication appeared in all three groups, though in three different ways. For non-German speakers, monolingual science communication can function as a barrier, this was mentioned for the city quarter and by the young Muslims with a migration background. For example, when asked what is needed in science communication one participant stated: "But what is also very important: more interpreting services. There are so many languages…that are hardly represented. And today it is simply not enough anymore—if you're really, really lucky—to have a Turkish interpreter [at an event]" (young person 4, You_F-2).

While language in this context functions as an exclusion factor because it impedes understanding, the usage of a certain language can also exclude people by creating a habitual distance as we show in Section 4.2.2.

4.1.4. Time Resources

For the vocational students, a big barrier was the time that they were willing or able to spend on science communication as part of their leisure time. Between going to their school and working in their firms they simply do not seem to find time to attend science communication events:

> There are people who work from Monday to Friday and then also work on Saturdays, too, so that they somehow make ends meet. Then only Sunday remains. That's just far too little time to recover or do anything in general. (vocational student 7, Voc_F-1)

One interpretation of this statement could also be that rare spare time to spend for leisure time is preferably devoted to activities that guarantee a relaxed or confident surrounding, features which a science communication might not offer—due to exclusion factors noted above, like the language used by communicators and the audience.

Available leisure time can also correlate with socioeconomic background: "Maybe people with a migration background are more likely to do shift work and therefore don't have the time for it, and the cause is not a lack of interest due to their migration background" (young person 6, You_F-1).

4.2. Emotional Exclusion Factors

The emotional factors comprise a less narrowly definable set of feelings and emotional reactions to marginalisation.

4.2.1. Fear, Frustration, and Insecurity

Not being familiar with science communication and its institutions can evoke feelings of fear and insecurity and thus make people refrain from taking part in it. The following excerpt from the focus groups with engaged persons in the marginalised city quarter illustrates how this kind of insecurity is passed on from parents to children. Furthermore, it shows how science communication is interwoven with school education:

> [Parents] have the problem that they do not know these areas. So, university, graduating from high school, going to a museum. The parents don't know that. That's why they don't pass it on to their children…the parents just feel insecure.
>
> It must also be said that many parents, especially those with a migration background, have perhaps attended the fifth grade at most and the school is above all a place of failure [for them]. (engaged person 3, Mar_F_Engaged)

The bad experiences and frustration with the school system lead not only to negative feelings towards schools—as 'places of failure'—but also 'spill-over' to other places associated with education, like museums or libraries, which can also be places of science communication, and lead to negative emotions or disinterest towards science itself:

> Well, I've never heard the word science from the mouth of a teenager before. But, so, if you associate science with learning. Well, learning has rather negative connotations….And if you deduce from the way we set our pedagogical goals about how learning is connoted, then I would say, [it is] not a term with a positive connotation. Neither is education. (engaged person 1, Mar_F_Engaged)

Furthermore, 'higher' educational aspirations of the children are met with scepticism and resistance: "The [child] had one, a recommendation for high school, but the mother said, 'yes, you now go to the ISS [Integrierte Sekundarschule; Integrated secondary school]'…, 'don't do your high school diploma [Abitur], you can't do that anyway" (engaged person 2, Mar_F_Engaged).

Contributing to this disconnection with the science system is a lack of scientists from underserved communities as role models: "Simply this role model thing. I believe this is a very important point. When, in a certain group, nobody shares any [science] experience with me, just because there is nobody, then I don't have any relation to it" (young person 5, You_F-2).

Fear and insecurity were not only reported in the marginalised city quarter but also in the Muslim group. One participant expressed his fear of being embarrassed because as a non-native speaker he might not understand everything. This shows that even material barriers—such as language skills—have an emotional component:

> I don't understand everything because it's in German…that's why I'm afraid to go there [to science communication events], because I think people may ask me questions. And then I'm like "I don't know, I don't know what I am doing here." (young person 6, You_F-2)

This anxiety of failing or being embarrassed was also voiced by the vocational students, however not so prominently:

> If you go to a public talk, you'd rather ask the questions towards the end, and if you sit there in the talk you couldn't ask a question if you didn't understand something, then you don't ask at the end either. Then it comes across like this, yes, the middle school [Hauptschule] pupil didn't understand anything again. (young person 6, Voc_F-)

4.2.2. Emotional and Habitual Distance

For the young Muslims with a migration background as well, as for the vocational students, one reason for their distance towards science and science communication was that they did not feel that they were being taken seriously. For example, one participant reported that she feels not being taken seriously at university (You_F-2), while—according to the invited external expert—vocational students often "[have] the feeling that they are never asked or consulted" (Voc_F-1_Engaged).

One point where the habitual distance became visible for the young Muslims with a migration background was in the used language in science communication. In this case, language serves as a signifier of habitual distance by being elitist, signalling the belonging to a certain social class. This was brought up several times:

> Now for science slams. Well, I was at two [of them], for example. I just found…both super classist [as an expression of classism]…[in] one [slam where] maybe four people have performed something and three out of four just somehow made fun of…ghetto language and ghetto slang and things like that in a bourgeois manner…and that was just super exhausting because…there are suburban children…and then they just start like "yes, I was in the ghetto" and by that they mean [Berlin] Kreuzberg or something. (young person 2, You_F-2)

Such emotional and habitual distance means that participating in science communication activities can require additional emotional labour. This was observed for ethnical minoritized groups in England (Dawson, 2019, pp. 91, 103) and it also was an important point for participants in our focus groups of young Muslims with a migration background:

> You are never allowed to show feelings, because then you are entering an emotional level, being unscientific. I think the problem is that science—that is to say what we understand by science—is a very Western concept, which is incompatible, for example, with many of our cultural experiences or the way in which we discuss things at home, but one has to adopt a mentality in order to be taken seriously [in science]. (young person 4, You_F-2)

Thus, one could argue that while "[e]ngagement with science, of any kind, may demand…emotion work" (Davies, 2019, p. 19), this is even more laborious for excluded audiences—to the point of being too laborious to participate. Notably, such direct references to emotional work as a factor hindering the participation in science communication was not mentioned in the city quarter or among the vocational students.

4.2.3. Self-Perception and Outside Perception

Instead of seeing themselves as a "science person" (Archer et al., 2015, p. 932), marginalised groups take on an identity where science—and science communication—is 'not for me.' The following answer to the question of why the person does not engage with science communication illustrates this for the residents of the city quarter 'Falkenhagener Feld': "I've never been a person really interested in science. I've always been the guy for physical work" (resident, Mar_I-7).

The same observation could be made for the vocational students:

> Well, I guess you often think about it, shit, these are smart people and maybe I'm not the smartest here… (vocational student 7, Voc_F-1)

> We are just craftsmen; we have to see what we do. (vocational student 6, Voc_F-1)

Therein, their self-reception is similar to what has been described for other excluded audiences (Dawson, 2019, p. 71). The young Muslims with a migration background, additionally, remark that it is not only a matter of self-perception but also of being recognised by others as a 'science person': "We're not even considered scientists. So, when one talks about a person with a migration background, or, let's call a spade a spade, when one talks about me…a Turk…one doesn't think about science" (young person 1, You_F-2).

This becomes apparent for them, for example, through schoolteachers recommending not to go to university, because of their migration background or social class, or when they observe a lack of diversity at German universities. Because they experience science as 'white,' they associate it with being elitist and hence they feel excluded. This was not only mentioned by the young persons themselves, but also by one engaged person from the group (You_I-1_Engaged). Feeling uncomfortable has real consequences for the participants in discouraging them and diverting them from science:

> And I think it also does a lot of unconscious things…when you know you wouldn't be seen as a scientist, then it does a lot of unconscious things to you. I think to myself: 'I won't do it at all, I won't be able to do it.' That does so much to me. (young person 6, You_F-2)

Of course, this is directed more broadly towards participation in science in general than just only towards participation in science communication. However, as participants in all three groups often did not clearly distinguish between taking part in and conducting science and science communication, one can assume that there is a spill-over effect between the two.

5. Conclusion

When interpreting our results, one has to keep the limitations in mind. The data is based on three demographic groups and a limited number of interviews and focus groups. As both methods used to collect data—guided interviews and focus groups—rely on the self-disclosure of participants, their answers might be affected by cognitive and social effects, like question order and wording (Scholl, 2018) or—especially for stigmatised and minoritized groups—stereotype threat (Spencer, Logel, & Davies, 2016) and, thus, social desirability. However, our findings are in line with previous findings with regard to access to and exclusion from science and science communication (Archer et al., 2015; Davies, 2019; Dawson, 2019) and the data can, therefore, be assumed to be exemplary for other not reached groups in science communication. To corroborate the findings and provide more robust insights, it would be fruitful to collect more data for other typically not reached groups as well and from further members and engaged persons of the three groups examined here. This would also allow for the development of a comprehensive typology of emotional exclusion factors and the emotional effects of exclusion in science communication.

There are likely other reasons why people are (feeling) excluded from science communication. The fact that we identify more exclusion factors in the literature is an indicator thereof (Schrögel et al., 2018). We assume at least three reasons for not finding more or other of these factors in the data. First, our exploratory approach might only have delivered the most relevant factors for the surveyed persons. To capture this relevance criterion by the groups themselves we did not ask them a checklist of all exclusion factors from the literature review. It is conceivable that although there are factors that apply to the groups, these are not relevant or conscious enough to be mentioned. Second, the factors not mentioned might not affect the groups. Third, they might not have been mentioned because of the effects of the methods used.

Furthermore, the study is not based on an in-depth psychological model of emotions and feelings and does not develop a detailed classification of these notions. This aspect lies beyond the scope of this work, which is meant to provide an overview of the emotional component of marginalisation in science communication and showcase the width of effects.

Nevertheless, several conclusions can be drawn from the presented data. First, to broaden the diversity of science communication audiences it is not enough to just tackle the material barriers, e.g., reduce entrance fees. The experience with removing entrance fees to some large museums in the UK illustrates this:

> While the number of people visiting these 'free' museums increased significantly, it turned out that this was simply because more of the same kinds of people (white, middle-class, urban families) visited these museums and repeated their visits more often….In other words, getting rid of upfront entrance costs did little to change the visitor profile to these museums. The economics of participation run deeper than entry costs and are about far more than socio-economic position or class background. (Dawson, 2019, p. 95)

Instead, we argue from our data that emotional factors play a crucial role as well in excluding groups from science communication—possibly making the difference between inclusion in or exclusion of science communication. Thus, these factors have to be considered and addressed if science communication shall reach broader and more diverse audiences.

Second, emotional exclusion factors in science communication cannot be easily distinguished from emotional experiences and barriers in the education system and science in general. They often intersect, especially

bad experiences in the school system seem to have a lasting impact on participation in science communication. This has also been described by Dawson (2019, p. 71):

> Science education research has found that school science has a widespread influence on how people see science, not least in the seemingly inescapable framing of science in general in terms of school subjects, namely, biology, chemistry and physics (Osborne, Simon, & Collins, 2003).

These experiences "are lasting and salient features of how people relate (or not) to everyday science learning" (Dawson, 2019, p. 68) and, thus, to what we call science communication. Consequently, it is hardly surprising that in our data people often did not distinguish between science communication, science and school education, but mixed it up. For many people, the education system is still the first point of contact with science and science communication (being it in school lessons or through school visits to museums, for example). Furthermore, the emotions towards science and the feeling of being left out seem to get 'passed on' from parents to their children. While this observation needs further investigation, it would fit in with the relation between the education of children and their social background, for example, as reported for Germany (Kuhlmann, 2008).

Third, these emotional barriers can only get successfully tackled by long-term activities building trusting relations because the barriers' causes lie in long-term negative experiences, as Dawson (2019) shows and our data support, with discrimination and neglect by science communication practices. Therefore, it is important not to understand these barriers as deficits of the not reached groups, but as factors for which science communication is responsible. One of our participants verbalised this 'deficit look' as follows:

> When I now look at Muslims in Germany in general, I find that the view of this group of people is rather deficient.…I don't see much of this look: "Hey, how can they feel better, how can they be happier with one thing," but rather so: "How can we offer them something so that they don't harm society or so that this group doesn't endanger another group." (young person 1, You_F-1)

However, emotions and feelings can be a starting point for successful science communication with non-reached groups, as engaged persons in our focus groups pointed out:

> It is also very important to take the person seriously. So that you also give them the feeling "you are an individual, your opinion has a value, you can achieve something with that opinion" and if the community or that person…if they notice "okay, they take me really seriously and the offer is also specifically for me or I fit to this offer" then this is embraced. (engaged person 2, Mar_F)

To give a very concrete example: One of our engaged persons reported that the participants of a visit to the Museum for Islamic Art Berlin "felt highly esteemed" (You_I-3) because the museum's guides were also Arabic-speaking Syrians. This emotional access can also provide the basis to build trust towards scientists: "If you have a person who knows what he or she's talking about and can convey things in an interesting way, then that's respected and acknowledged, and that's not through the title, expert XY, but through an emotional approach" (engaged person 3, Mar_F).

Such an 'emotional approach' requires changing established science communication practices and starts with listening to underserved audiences and taking their (emotional) needs seriously. This includes measures to reduce the (emotional) distance, e.g., through the use of humour or by giving up the display of an academic habitus, as well as to critically reflect and change practices that might have—intentionally or unintentionally—a discriminatory effect on people. Especially regarding the needed emotional labour to participate, communicators should "ask the question: what are we asking of people? And to what extent will this be experienced as laborious?" (Davies, 2019, p. 19).

Not only could the science communication practice profit from addressing material and emotional exclusion factors, but also research should focus more on the role of factors—especially emotional—in fostering or hindering participation in science communication. To broaden participation and engagement, we have to understand what leads to exclusion on both a material and an emotional level in the first place.

In conclusion, we hope that this study can serve to inform science communication researchers as well as practitioners and contribute to improving equity and inclusiveness in science communication.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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Article

Science Slams as Edutainment: A Reception Study

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Abstract
Science slams are a prominent form of science communication especially in Germany that seeks to entertain. While some view science slams as an excellent vehicle for disseminating knowledge, others argue that the imperative to entertain undermines the scientific value of this form of presentation. Drawing on empirical data from three science slam events, this explorative study examines how audiences and presenters perceive the science slam, particularly as it relates to entertainment and the communication of scientific knowledge. Our multi-method analysis includes audience surveys (n = 469), an eye-tracking study, and interviews with science slammers (n = 18). Our results show that the main reason audiences attend a science slam is for entertainment, yet they also have a strong interest in scientific content. Assessing the slammers' aspirations concerning the audience, we find entertainment to be an important part, but the motivation to impart scientific knowledge is key for most. When asked to evaluate individual presentations (n = 20), spectators tended to rate both the entertainment and scientific value of the presentations as high. However, in terms of visual attention within individual presentations, spectators spent more time considering scientific content than entertainment content. Overall, we do not find evidence for the common claim that the focus on entertainment undermines the scientific value of science slam presentations—rather, entertainment and scientific content are combined to produce "edutainment" in a positive sense.

Keywords
entertainment; eye-tracking; presentation forms; science communication; science slam

Issue
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1. Introduction

A science slam is a presentation competition in which scientists—typically doctoral students—showcase their own research. It is a form of science communication that seeks to entertain (Niemann, Schrögel, & Hauser, 2017, pp. 103–108). This combination of science and entertainment, often subsumed under the term "edutainment," is seen by some as an opportunity for science communication to appeal to a wider audience (Eisenbarth & Weißkopf, 2012, p. 162). However, other individuals view science slams rather critically, arguing that the imperative to entertain naturally undercuts the scientific and pedagogic value of the form (Griem, 2018, p. 3; Klaue, 2015, p. 543). To date, the participants in this debate have mainly relied on normative assertions unsupported by empirical data. This article seeks to remedy the lack of empirical data in this area. In doing so, it focuses on an explorative study on spectators as the recipients of science slam presentations. The analysis considers the general motivations and expectations of the spectators as well as their assessment of individual presentations. Special attention is devoted to effects that emerge from presentational aspects that seek to entertain.

Although the focus of this study is on the reception of a specific science communication form by individ-

ual spectators—especially concentrating on the aspect of entertainment—it also addresses a general research deficit that is described by Weingart and Joubert (2019, p. 5): "Evaluations of different science communication formats are…rare and inaccessible although the respective organisations stress their importance." When looking at the evaluation of specific science events, there are hints that entertainment (often addressed as "fun" or "enjoyment," cf. Section 2.2) is an important motivation for people attending these events (e.g., for science festivals, see Canovan, 2019; Jensen & Buckley, 2014), but these studies usually do not analyse what is perceived as entertaining or how expectations and experiences match. These research gaps are addressed in this study with regard to science slams.

2. Science Communication and Science Slams

A science slam consists of a series of entertaining and easily understandable talks that are usually limited to ten minutes in length. At the end of the event, a winner is chosen based on audience voting (Eisenbarth & Weißkopf, 2012). The science slam is based on the poetry slam—a presentation competition for literary texts (Wildemann, 2011). While the first science slam in Germany was held in 2006, there are now 58 regular science slam event series in the country, most of which are supported by research organizations and initiatives (Schrögel, Niemann, Bittner, & Hauser, 2017, p. 3).

One defining feature of the science slam is the event format and setting. Usually, the science slam takes the form of a hosted evening event outside of scientific institutions—for example, at clubs or cultural centres—in order to distinguish them from traditional academic lectures (Hill, 2015). Furthermore, the mode of presentation is unique: participants seek to present their own research (e.g., a doctoral thesis) in a clearly understandable and compelling way. Indeed, the entertainment value of the presentation is a key concern, which is why "slammers" usually put a great deal of effort into the design of their presentations. While there are no real restrictions on presentation aids, the de facto standard is creative and humorous PowerPoint slides (Schrögel et al., 2017, p. 3).

While the science slam is primarily a phenomenon in German-speaking countries and has only recently gained more international presence (Lederman, 2016) there are some similarities to other, more international forms. One of them is e.g., famelab, an international presentation competition for students and young researchers in science, technology, and engineering (Zarkadakis, 2010). Major differences to science slams are that famelab presentations have a stricter time limit (only three minutes) and more limits to presentation techniques (e.g., no slides allowed). TED and TEDx Talks are other presentations forms that differ from science slams in not being primarily focused on science topics and following a more uniform presentation style, which is evoked by guidelines and mandatory presentation training (Anderson, 2016; Sugimoto et al., 2013).

2.1. Science Slams as a Form of Presentation

Science slams are a multimodal form of science communication in which the spoken word of the presenter is supplemented with other communicative modes such as imagery, video, audio, written text, and gestures or facial expressions (Bucher, Niemann, & Krieg, 2010, p. 376). Analytically, we can differentiate between three presentational modal domains: the mode of the speaker's spoken language; the visual mode (e.g., image, text, design); and the performative mode (e.g., the speaker's pointing actions or facial expressions; Bucher & Niemann, 2015, p. 76). Usually, all three of these presentational modal domains are combined in PowerPoint presentations.

In order to distinguish between forms of presentation in science communication, Niemann et al. (2017) proposes four classification parameters: the degree of multimodality; the degree of interactivity; the degree of performance; and the degree of "event and entertainment orientation." Drawing on this typology, Niemann, Bittner, Hauser, and Schrögel (in press) conduct a detailed analysis of science slams, concluding that the science slam is primarily characterized by a very high degree of "event and entertainment orientation." However, science slam presentations can also exhibit a high degree of multimodality, interactivity, and performance, depending on the individual presentation in question (Niemann et al., in press).

2.2. Entertainment as "Pleasure" and "Appreciation"

In the public discussion of science slams, critics repeatedly underscore how the imperative to entertain can be at odds with the aim to educate and to inform (Griem, 2018; Thiel, 2018, p. 3). Klaue (2015, p. 543) even speaks of a "mixture of populism, hubris, and witlessness," contending that slammers believe "the sciences can only be brought closer to the masses if one adapts to their limited everyday understanding, simplicity, and need for entertainment.''

Against the backdrop of such partial polemical attacks, this article seeks to shed light on the tension between entertainment on the one side and scientific content on the other. How does the audience perceive this combination of entertainment and science, commonly referred to as "edutainment"? What relevance does entertainment have for the audience's expectations concerning this form of presentation? And what role does entertainment as well as scientific knowledge play in the reception of individual science slam presentations? To answer this last question, we carefully examine the entertainment potential of science slams in addition to their specific scientific content. To complete the picture, we also explore how slammers and audience members perceive the science slam as a vehicle for entertaining and informing.

First, however, the concept of "edutainment," as well as the underlying concept of entertainment, must be clarified. Edutainment—as well as the concept of infotainment in a mass media context (Wirth, 2014)—is an umbrella term describing various approaches that combine education and entertainment. It can be traced back to the pedagogic concept of "experiential learning" (Nahrstedt, 2002, p. 152), but lacks a detailed definition. While various definitions can be found in the pedagogic literature, the term usually refers to a form of education that seeks to captivate, instil excitement and evoke emotions—a "rousing of learners' feelings" as Aksakal (2015, p. 1233) puts it. However, the combination of education and entertainment is not unanimously seen as positive (Okan, 2003).

The term "entertainment" also lacks a clear-cut definition in the communication sciences and reception research, prompting Vorderer and Reinecke (2012, p. 20) to remark "that the description and explanation of (entertainment) has remained under-differentiated." It seems clear that entertainment consists of more than just emotions such as joy or happiness, that it does have "emotional components" (Wirth & Schramm, 2005, p. 14). Wirth (2014, p. 61) even sees entertainment as a "meta-emotion" that arises as a reaction to other emotions. A commonly accepted definition is to view entertainment as "hedonic entertainment"—an experience that primarily aims to engender feelings of well-being "in the sense of pleasure" (Vorderer & Reinecke, 2012, p. 18). Furthermore, more recent research (Schramm, 2019, p. 48) assumes a further, more complex and more intensive form of entertainment experience (non-hedonic), which can be characterized by the term "appreciation" (Vorderer & Reinecke, 2012, 2015). It remains controversial whether this is about "satisfaction of basic needs" or a "sensation of personal significance triggered by reception (>Meaningfulness<)" (Vorderer & Reinecke, 2012, p. 21).

Empirical reception studies on the experience of entertainment are scarce and have so far been published primarily in the field of political entertainment research (e.g., Schneider, Bartsch, & Gleich, 2015; Weinmann, 2019).

Referring to a hedonic conception of entertainment, Wirth and Schramm (2005, p. 14) state: "In this way, the layperson's understanding is not too far away from what our science has found out about the phenomenon of 'entertainment' so far." Thus, we assume that visitors to science slams generally understand "entertainment" in the hedonic sense of the term.

Especially when talking about a hedonic, joyful entertainment experience, there is another terminus to be considered: humour. Similarly to entertainment, the concept of humour is rather easily accessible with a heuristic understanding, but difficult to grasp with a theory-based definition (Goldstein & McGhee, 1972; Veatch, 1998). The specific effects of humour in science communication have been studied for written forms of communication (Pinto & Riesch, 2017) as well as for live comedy presentations (Pinto, Marçal, & Vaz, 2015). The results of these studies as well as theoretical considerations (Riesch, 2015) show a heterogeneous picture: While humour can have a positive impact on the reception of scientific presentations or articles, it can sometimes also invoke negative reactions.

2.3. Reception as Interaction

In addition to exploring what audiences expect from science slams, our research is concerned with the reception of individual science slam presentations. Our theoretical basis is a concept of reception based on an interactional theory that was developed by Bucher (2012). For Bucher, reception is a "regular, competence-based and supply-dependent sequence of acts of appropriation" (Bucher, 2005, p. 91), in which active users—comparable to a traditional face-to-face conversation—enter into a quasi-dialogical exchange with media content, or, in this specific case, with a science slam presentation (Bucher, 2012, p. 24; Niemann, 2015, p. 40). Key to this approach is the concept of attention integrating intentional (schema-based) and non-intentional (salient-based) forms of attention (Bucher & Niemann, 2012; Bucher & Schumacher, 2006).

To what extent can the "appropriation process" performed by audiences be ascribed to those elements of the science slam presentation that have the potential to entertain? In principle, this can involve all elements of the presentations, such as images or the text parts on PowerPoint slides, verbal expressions by the slammers or props they use. To operationalize such an understanding of reception within the framework of an empirical study, we require a method that directly considers the moment of contact between science slam presentations and recipients, and is thus able to shed light on this quasi-dialogical process of appropriation. In other words, the method has to allow for analysing the recipients' allocation of attention (cf. Section 4).

3. Data and Research Questions

In order to conduct a detailed investigation of the reception of science slams, we selected events that allow generalizable statements about this form of presentation. Specifically, we chose the final event of the 2016 German Science Slam Championships and a Best-Of Event (which were attended by renowned slammers), both took place in Darmstadt, December 2016. In addition, a further event was selected that can be described as a "normal" science slam (with novice and experienced slammers). The latter event took place in February 2017 in Karlsruhe. Overall, the corpus consists of twenty individual presentations. In the following sections, we devote special attention to a single presentation—the talk given by Reinhard Remfort as part of the Best-Of Event in Darmstadt—in order to conduct

a more in-depth analysis. This example has been chosen since he can be considered an experienced and generally well-received slammer (e.g., German science slam champion 2013). In addition, being a male science slammer from the natural sciences—specifically physics—he represents a major share of the current slammer's community (Schmermund, 2018).

Studying these events, we focused on the following three research questions—each specifically regarding the role of scientific content and entertainment:

RQ1: What are the general motivations and expectations of science slam audiences?

RQ2: How do these fit with the ideas that the science slammers themselves associate with this form of science communication?

RQ3: How do spectators perceive individual science slam presentations?

4. Research Methods

To address the questions, we used an explorative multimethod design. We conducted audience surveys, and also interviewed the slammers. To record the appropriation process at the moment of contact between presentations and recipients, we recorded eye movements, which can be interpreted as indicators of attention (Bente, 2004, p. 298).

To address the general motivations and expectations (RQ1), the science slam audiences were asked to participate in a survey. Audience surveys are a common method for evaluating science communication activities (Boyette & Ramsey, 2019; Canovan, 2019; Jensen & Buckley, 2014). The audience surveys in our study were conducted by means of a standardized written survey. At each of the three science slam events, 100 paper questionnaires were distributed. In addition, flyers with invitations to participate in the same questionnaire (except the questions regarding individual presentations to be filled out directly after each talk) in an online format were distributed to the rest of the audience to broaden the data basis for the overall assessment. In each case, between 73 and 90 paper questionnaires were returned, while the number of completed online questionnaires was between 23 and 143. A comparison of the paper and online questionnaires revealed no significant differences in terms of sociodemographic characteristics or response behaviour. Accordingly, all data sets were evaluated together ($n = 469$). Specifically relevant for RQ1, the science slam audiences answered the question "how important were the following aspects in your decision to come to the science slam/to the TEDxKIT Event/famelab today" on a scale with five options ranging from "very important" to "not important at all."

To put the motivations and expectations of the audiences into context, we also assessed the presenters' view on the task of communicating their findings. Also, here their view on the tension between scientific content and entertainment (RQ2) was of particular interest. For this purpose, semi-structured interviews were conducted with 18 of the 20 science slammers that participated in the science slam events.

The assessment of individual science slam presentations concerning the entertainment and informational value (RQ3) was measured by means of the audience survey. Recipients answered the questions "how do you rate the information content of the presentation" and "how do you rate the entertainment value of the presentation?" Both items were measured on a scale with five options ranging from "very good" to "inadequate." Respondents could choose "unable to answer."

To analyse the spectators' immediate perception of the individual science slam presentations (RQ3), gaze recordings of selected participants were conducted at the three science slam events. Among other things, eye movements provide information on the recipients' selection and inference strategies, as well as on the attention and interest they devote to individual presentation elements, including those designed to entertain, which is the particular focus of this study (cf. on PowerPoint presentations Bucher et al., 2010, p. 385). Following the eye mind assumption (Just & Carpenter, 1980) and the critical reflection of this approach (Geise, 2011; Schumacher, 2012), the fixation of elements, as measured by an eye tracker, allows for a drawing of inferences on potential cognitive processing. However, to assess the actual processing of information, additional methods would be necessary (Schumacher, 2012, pp. 115–116).

Using eye-tracking in reception research that is based on an interactional theory is a well-established method in communication science in general (e.g., Gehl, 2013; Niemann, 2015; Schumacher, 2009) as well as specifically in science communication research (e.g., Böhmert, Niemann, Hansen-Schirra, & Nitzke, in press; Bucher & Niemann, 2012, 2015; Niemann & Krieg, 2011). For several years now, the method is gaining importance in science communication research resting upon other theoretical backgrounds (e.g., Kessler & Zillich, 2018; Rotboim, Hershkovitz, & Laventman, 2019). In this study, one to two randomly selected people from the audience were asked to wear mobile eye-tracking glasses (SMI Eye Tracking Glasses) for two to three presentations at each event. After a technical pre-assessment of the material regarding data quality, gaze recordings for a total of nine presentations remained for further analysis. To make statements about the distribution of attention between those parts of the presentations that can be attributed to entertainment and those that consist of scientific content, specified areas of interest (AOIs) were generated (cf. Section 5.2.2) prior to the analysis of the gaze data. The essential measurement used in the analysis of the gaze data is the "viewing rate," i.e., the gaze time as percentage of the total reception time recipients spend on these (AOIs).

5. Results

5.1. Audience's Expectations and Motivations of the Science Slammers

The audience that attended the three science slam events was similar in terms of sociodemographic characteristics. With a view to completed questionnaires, the majority of participants were male (56.2%). The average age was 31 years. The best represented age group was 21 to 30 years. The spectators were more educated than the average population. The vast majority had a university entrance qualification or higher (81.2% in total, of which 24.7% had a university entrance qualification, 56.5% a university degree, and 8.5% a doctorate).

This suggests that science slam events are particularly attended by highly educated recipients who actively come into contact with the science system or have come into contact with it through their education. The stated interest in science corroborates this interpretation. Among attendees, more than half of those surveyed (56.9%) answered that they were very interested in science, while another third said they were "rather interested."

When asked about the relevance of different aspects for their decision to attend the science slam event (RQ1), four-fifths of the respondents stated their interest in science as "very important" or "important." Yet the expectation to be entertained was even more important: Almost two-thirds of the respondents (63.2%) cited this as a very important reason for their visit, while another third (32%) viewed it as an important reason (Figure 1). The identified differences are statistically significant (based on a paired sample t-test), even if the effect size is small (Cohen's d = 0.417 [Cohen, 1988, p. 40]; T = −8.729, df = 437/interest in science: M = 1.84, SD = 0.861; entertainment: M = 1.42, SD = 0.632). By contrast, the opportunity to learn something was a less relevant factor (very important: 22.5%, important: 38.4%). Furthermore, the effect size was small when comparing the differences between interest in science and learning (d = 0.419, T = −8.787, df = 437/interest in science: M = 1.84, SD = 0.861; learning: M = 2.30 SD = 0.979) and of medium strength when comparing the differences between entertainment and learning (d = 0.781, T = −16.344, df = 437/entertainment: M = 1.42, SD = 0.632; learning: M = 2.30 SD = 0.979). These findings correspond with the audience assessment of science festivals as studied by Jensen and Buckley (2014, p. 565). They find that creating interest ("exciting, colourful, creative, unusual, inspiring, bright"—falling into our category of entertainment) is the dominant aspect, but gaining knowledge is still relevant.

When looking at the comparable science communication forms famelab and TEDx (Figure 1), some aspects of audience expectations differ while others are rather similar to expectations regarding science slams:

- Interest in science: The interest in science as a reason for visiting these forms is somewhat higher than reported for science slams. This assessment is based on data collected at a famelab and a TEDx event in Karlsruhe in 2017. Statistically significant differences based on independent samples t-tests can be seen only to the TEDx event, but the effects are small (d = 0.304; T = 1.155, df = 530/sci-

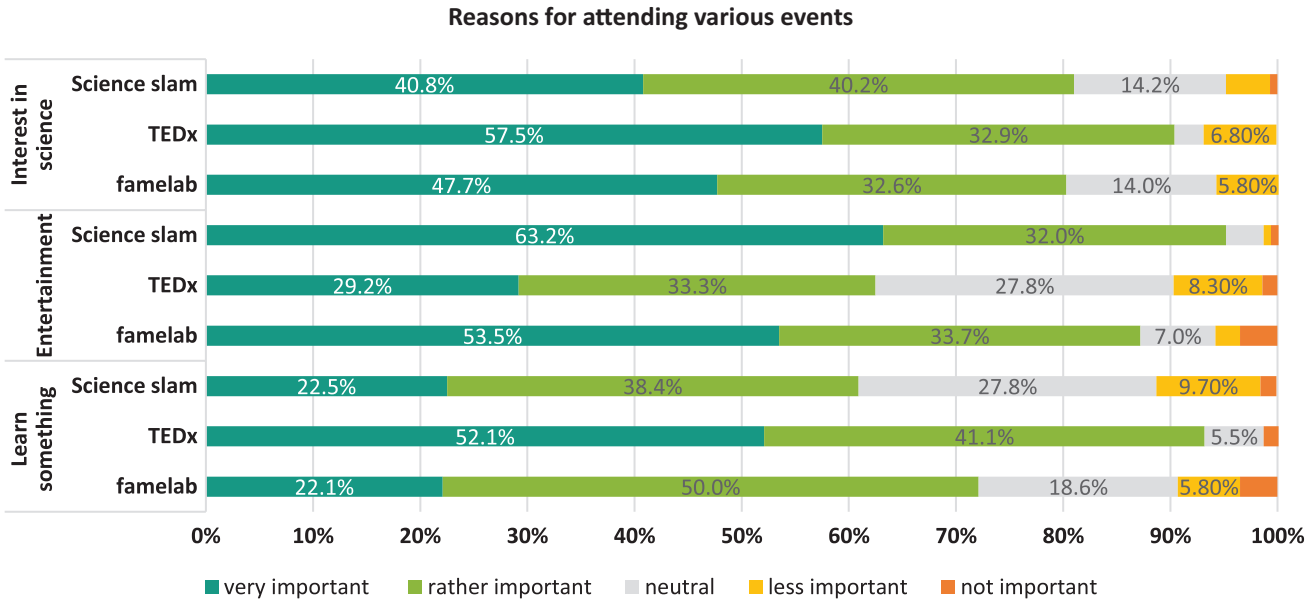

Figure 1. How important were the following aspects in your decision to come to the science slam/to the TEDxKIT Event/famelab today? Notes: Science slam: 444 ≤ n ≤ 458; TEDx: 72 ≤ n ≤ 73; famelab: n = 86). Values < 5% are not specified due to clarity reasons.

ence slam: M = 1.84, SD = 0.866; TEDx: M = 1.58, SD = 0.844).

- Interest in entertainment: The comparison with these other forms also confirms the strong focus of science slam visitors on the entertainment aspect. However, the differences between the individual forms (all significant, p = 0.05) vary in size: Although there is a significant difference between the science slam and famelab events in terms of entertainment experience, this is only small with an effect strength of d = 0.303 (T = −2.967, df = 540/science slam: M = 1.44, SD = 0.66; famelab: M = 1.69, SD = 0.961). In contrast, the difference to the TEDx event is more pronounced (strong effect, d = 0.87, T = −8.207, df = 527/science slam: M = 1.44, SD = 0.66/TEDx: M = 2.18, SD = 1.005).
- Interest in learning: A strong effect can also be seen when comparing the answers of the visitors of science slam and TEDx events regarding the interest in learning something (d = 0.81, T = 5.906, df = 525/science slam: M = 2.29, SD = 0.973; TEDx: M = 1.59, SD = 0.739)—just vice versa: This aspect is most important for TEDx visitors, while it is regarded as less important by the audience of science slam events. A significant difference between science slam and famelab events could not be observed for this aspect.

In summary, it can be concluded from the audience survey—concerning RQ1—that science slams are strongly associated with entertaining aspects among the audience and that this is also a strong focus in comparison with other forms.

To put these findings into context, after the science slam events, semi-structured phone interviews were conducted with 18 of the 20 science slammers. In these interviews the slammers were asked to explain their reasons for participating and to evaluate their presentations and the science slam form in general with regard to entertainment value and scientific content (RQ2).

While several slammers directly or indirectly voiced the motivation to inform the public about their research and science in general, 12 of them explicitly mentioned the joy of presenting as a major reason for participating: "It is just fun; you don't get so much applause or stadium waves at conferences!" (slammer 15).

Regarding the balance between entertainment and scientific content, the science slammers provided very differentiated and heterogenous assessments. All 18 respondents saw a very close connection between both aspects. As one slammer put it:

> Well, I think you don't come [to a science slam] to spend a sad evening, but to have some fun. And I find that the pairing of some scientific content, shown in a playful and entertaining way, is very important. (slammer 11)

Five interviewees did not explicitly rank one aspect over the other. Nine slammers clearly assigned priority to the scientific content:

> A science slam has two central goals: I want to impart knowledge and I want to entertain people. In a scientific talk, even for a lay audience, entertainment is at best a secondary goal, which I use to achieve my primary goal, which is to impart knowledge. (slammer 3)

On the other hand, four interviewees described entertainment as a defining aspect of the science slam and also identified it as the key concern of audiences in some cases, while taking a critical perspective: "I think that entertainment is very important [for a science slam] and the main point of focus….This is a pity, because I think it is sometimes at the expense of content" (slammer 1).

Overall, the slammers had very differentiated and reflective perspectives on the science slam. Regarding their personal motivation, a majority of presenters cite fun and enjoyment. At the same time, another central motivation for many slammers is to impart knowledge and showcase research projects. Entertainment is seen as a tool to attract audiences in the first place and ensure their interest.

5.2. Entertainment and Informational Value in Individual Science Slam Presentations

5.2.1. Audience's Assessment

The audience members participating in our paper survey (250 in total) were also asked to assess the entertainment and informational value of the twenty individual science slam presentations (RQ3). Our case study, the presentation by Reinhard Remfort (talk no. 4), was rated by the audience as good or better in both respects by an overwhelming majority (82.7% and 76.9%, respectively). At the same time, the audience clearly considered the entertainment value of the presentation as superior to its informational value, with a much higher number of "very good" ratings granted to the entertainment category (51.9% versus 32.7%).

Looking at all 20 science slam presentations, the median percentage of survey participants ranking the entertainment value as "good" or "very good" is 84% (the median was used instead of the arithmetic mean as a more robust measure against outliers). The median percentage of participants ranking the informational value as "good" or "very good" is 72% (Figure 2). The assessments of individual talks have a heterogeneous distribution, marked by isolated particularly positive evaluations (e.g., talk no. 3) and isolated less positive evaluations overall (e.g., talk no. 5). In 11 out of 20 presentations the respondents rated the entertainment value more positively than the information value, while the reverse was true in 8 cases. Equal rankings were seen in just one case (talk no. 17).

Examining the difference between the assessments granted to entertainment value and information con-

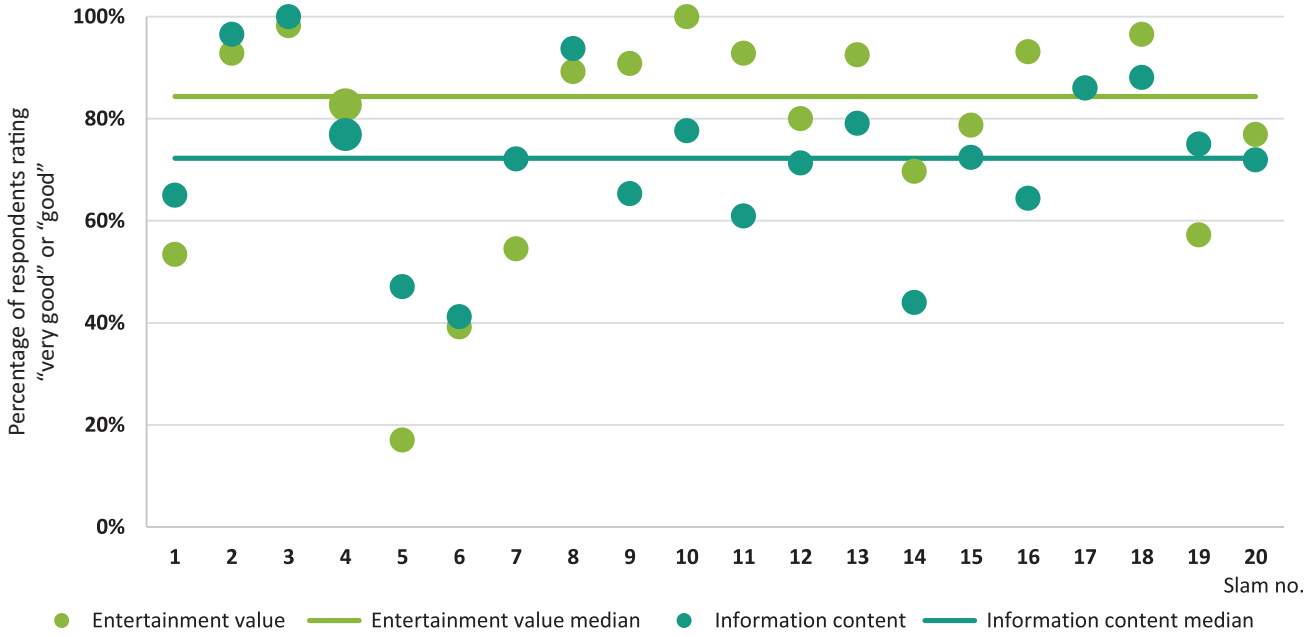

Figure 2. Audience assessment of the entertainment value and the information content of the 20 presentations, both measured as the percentage of survey participants ranking the respective category as either "very good" or "good." Notes: The data points represent the values for each presentation; the medians of both values are drawn as continuous color-coded lines ($51 \leq n \leq 89$).

tent in paired samples t-tests for each presentation (for a table with all statistical information see Supplementary Material), we find significant divergence in three-quarters of the presentations ($p < 0.05$). However, in nine of 20 cases, the effect strength is small ($0.242 \leq d < 0.465$; see Supplementary Material for detailed information). Five presentations had an average effect strength ($0.533 \leq d < 0.717$) and only one presentation (no. 16) had a strong effect ($d = 0.861$). In this way, we find divergence between the assessments granted for entertainment value and information content, but they are not particularly pronounced. Accordingly, at least from the perspective of the audience, an entertaining presentation is not necessarily poor in terms of information content or "unscientific."

5.2.2. Reception Data

In the following, the relationship between entertainment and information content is examined based on the concrete reception of science slam presentations (RQ3). By analysing the eye-tracking data collected from individual test persons during the science slams events (cf. Section 4), information can be gained about the type of content available for reception as well as about the degree of visual attention and interest in this content among recipients.

Before the eye-tracking data can be evaluated, we must first define specific AOIs (Rotboim et al., 2019, p. 88–89; see Figure 3). For this purpose, we developed a category system that differentiates between various elements of the science slam presentation. This system first differentiates between the human presenter and the PowerPoint slides. The typical approach of segmenting AOIs by modal categories (Bucher & Niemann, 2015, p. 82–83) is not sufficient for our analysis since for example, an image could be either a scientific data visualization or a rather humorous decoration. Elements belonging to the slides were therefore assigned to the categories "science," "hybrid," or "entertainment." "Science" includes all material that would be at home in scientific lectures, diagrams of research data or scientific formulas (Figure 3, dark green). The category "hybrid" includes material which, although related to the topic under discussion, is not normally found in scientific lectures (Figure 3, dark blue), e.g., because of their form of presentation (personal photos, cartoons). Finally, material was classified as "entertainment" if it had little or no relation to the content and was included merely to entertain or embellish (e.g., humorous references to pop cultural phenomena, such as the Telly Tubby in Figure 3).

Based on these AOIs and category assignments, we can calculate the "visibility" of material from each category for the audience as a share of the total presentation time. In the presentation given by Reinhard Remfort, scientific material had a visibility of 60%; by contrast, the corresponding figures for hybrid and entertainment were 48.5% and 46.2%, respectively (see Figure 5, left part). Accordingly, we do not find support for the common view that science slams neglect scientific content in an effort to merely entertain audiences.

In our analysis of eight other science slam presentations (as shown in Figure 4), we find a similar preponderance of scientific content.

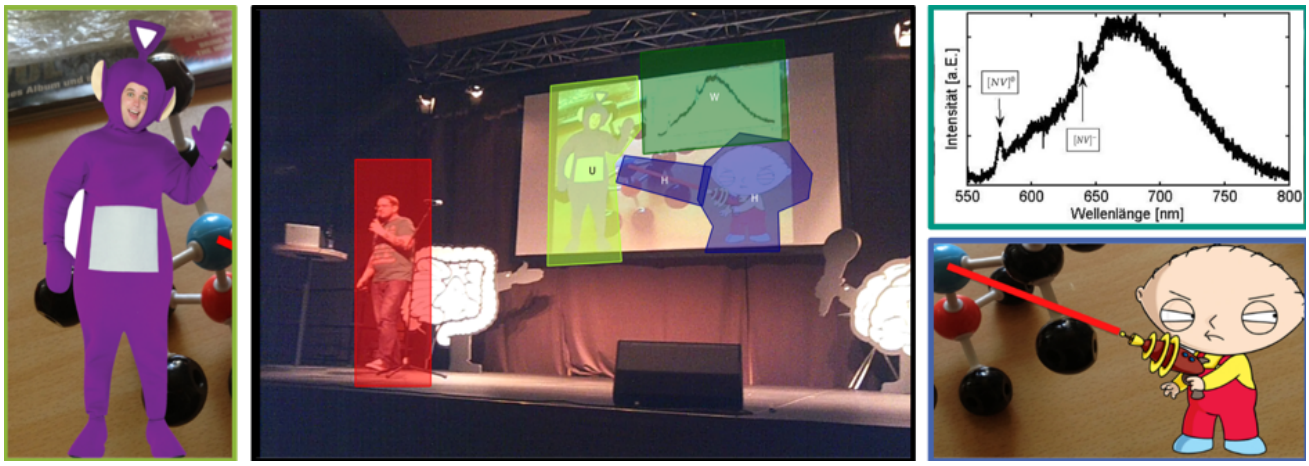

Figure 3. AOIs in the talk by Reinhard Remfort. Notes: Examples of material assigned to the categories "science" (dark green, top right), "hybrid" (dark blue, bottom right), and "entertainment" (light green, left). The presenter is marked in red.

Figure 4 also shows two dimensions of the "visibility" of the categories "science," "entertainment," and "hybrid" in the science slam presentations: specifically, the number of elements in a category (the size of the circles), and the average visibility of these elements (y-axis). In the slam by Reinhard Remfort (Figure 4, slam number 4), the hybrid elements (dark blue) were the longest visible, but there were considerably fewer elements in this category than in the categories science (dark green) and entertainment (light green). Although the number of elements in these latter two categories is roughly the same in his presentation, the scientific elements were visible for much longer. Material from the entertainment category had the shortest visibility duration.

In general, these findings also applied to the other science slam presentations: In the eight other slams, entertainment material had the shortest average visibility duration, regardless of the number of coded elements. By contrast, the scientific material had a longer average visibility and was also predominant in terms of total numbers. Only two slams—15 and 19—diverged from the norm due to their remarkably high number of hybrid elements (Figure 4). These two presentations had a similar format: they used slides in a cartoon style, personally drawn by the slammer.

The so-called "viewing rate" is a tool for assessing the reception behaviour of science slam audiences. The viewing rate (gaze time as percentage of total reception time) expresses how long the presenter or an element from the aforementioned categories was actually viewed by recipients. It thus provides "information about the degree of attention and interest" (Bucher et al., 2010, p. 385) for this element. In Reinhard Remfort's slam, the most attention (26.2%) was paid to the presenter

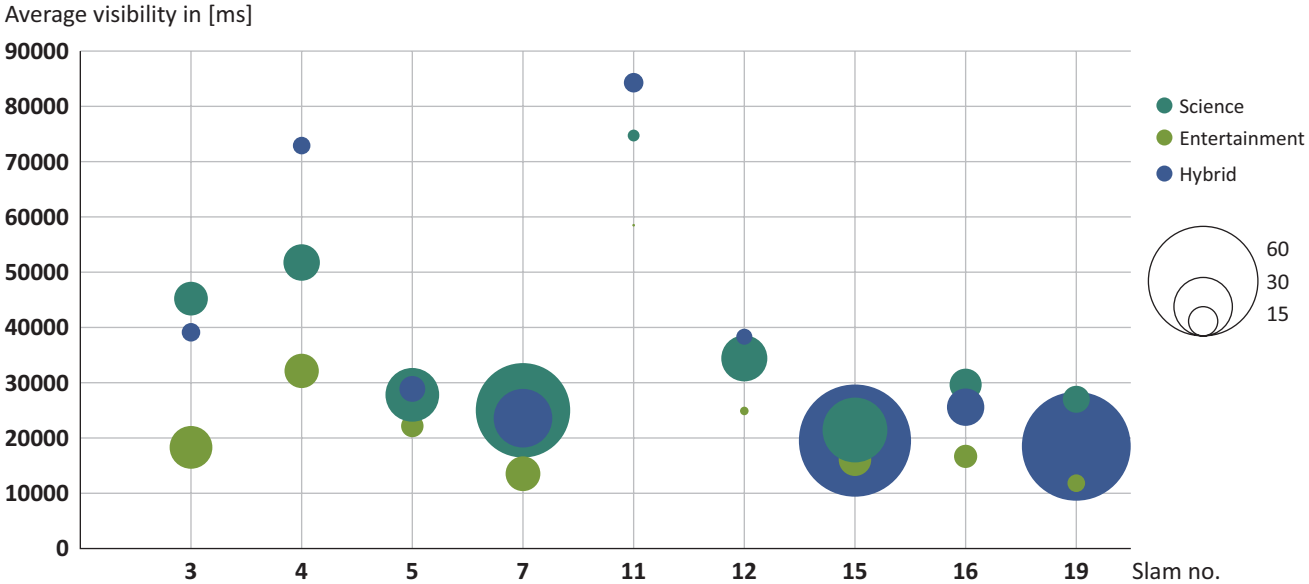

Figure 4. Average visibility of the elements attributed to the three AOI categories in 9 different science slam presentations. Notes: The numbering corresponds to that in Figure 2. The size of the circles denotes the number of elements in a category.

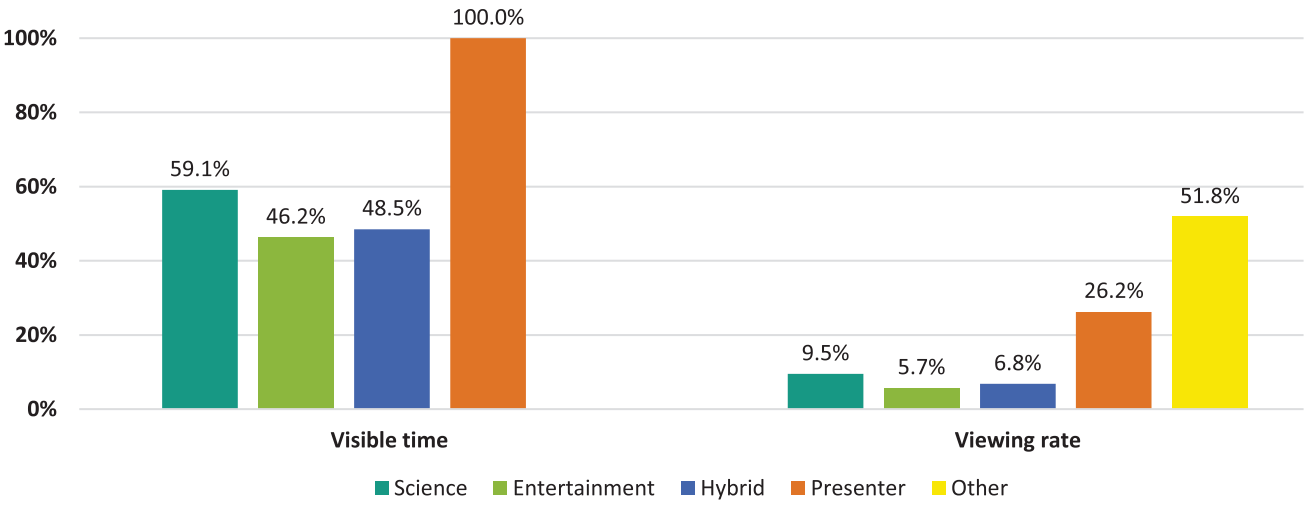

Figure 5. Cumulative visible time (as percentage of total reception time) and viewing rate (gaze time on visible elements as percentage of total reception time) for the three categories and the presenter in the presentation by Reinhard Remfort. Note: The category "other" in the section viewing rate includes gazes on all other, unclassified elements in the scenery.

(Figure 5, right part). With regard to the PowerPoint slides, we find a clear relationship between visible time and viewing rates: The scientific elements received the most attention (9.5%), followed by the hybrid material (6.8%). Meanwhile, the entertainment material received the least attention (5.7%). The remaining gaze time ("other") consisted of gazes outside the defined AOIs (e.g., background, audience).

The other science slam presentations show a similar tendency. Due to the data quality, in addition to the slam of Reinhard Remfort (slam no. 4), only five other presentations were considered in this part of the analysis: two from the Best-Of Event in Darmstadt (3, 5), and three from the 2016 German Science Slam Championship (7, 11, 12).

In half of the science slam talks, the presenter received the most attention (slam no. 7, 11, 12), in the other half the majority of visual attention was diverted to areas not related to the presentation (slam no. 3, 4, 5). If we discount these other areas and the presenter and only consider the contents of the PowerPoint slides, the category of science received the most attention in five of the six presentations. Also in five cases, entertainment elements received the least attention. Hybrid elements ranked in between. In talk 11, we find a remarkable picture: Hybrid content received by far the most attention. It should be noted that among the six presentations considered here, talk 11 was the presentation with the fewest PowerPoint slides and the lowest number of slide elements in the three categories. In addition, 65%

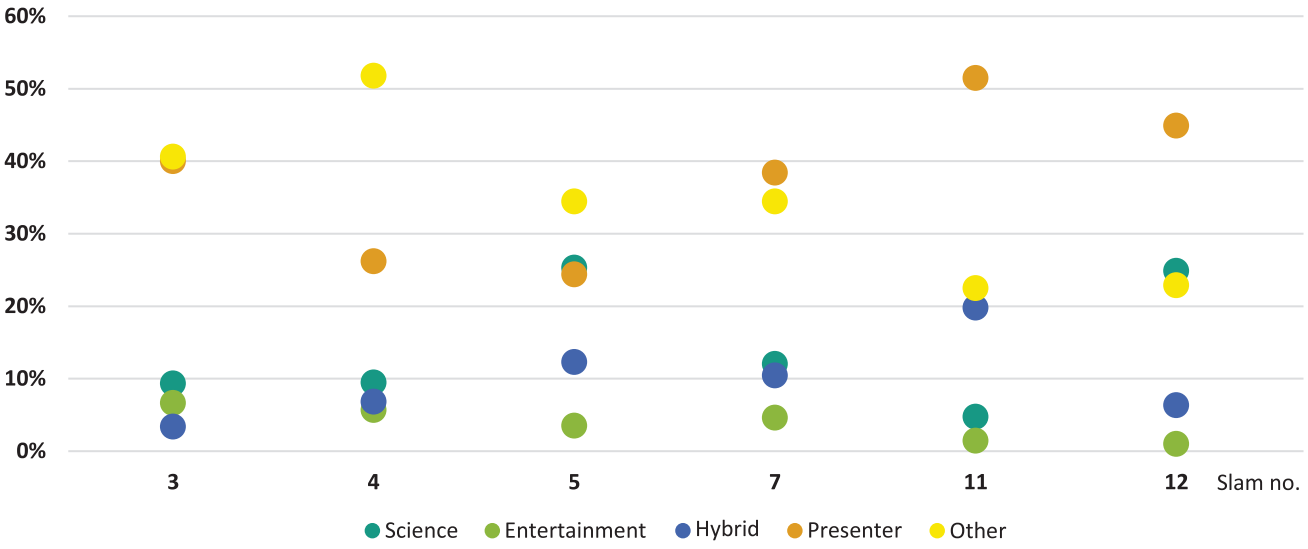

Figure 6. Viewing rate (gaze time on visible elements as percentage of total reception time) for the three AOI categories, the presenter and "other" unclassified elements in the scenery in six science slam presentations. Note: The numbering of the slams corresponds to that in Figure 2, the presentation by Reinhard Remfort is slam no. 4.

of the slide elements of talk 11 were attributable to the hybrid or entertainment categories, with entertainment only accounting for one element. As talk 11 was an outlier, we excluded it from the following analysis.

When watching a presentation, individual elements can be viewed more than once and in alternating succession. In order to take this into account and draw conclusions about the reception of the talks beyond cumulative gaze time, we also considered how long the recipients focused on one element per individual viewing. In light of our research questions, the duration of focus on scientific and entertainment material is of particular interest. In order to exclude shorter gaze times—as occurs, for example, if an element is merely glanced at momentarily—we only consider top 50% of viewing instances when sorted by gaze duration for this analysis. Results show that in four of the five presentations considered (talks no. 3, 5, 7, 12) scientific elements constitute the majority of these most viewed elements. Against the backdrop of our findings regarding visibility and taking into account that the visual attention of the viewers can only lie on a limited number of elements, this analysis shows a clear preference for scientific content over entertainment and hybrid elements.

On the basis of gaze data, it can therefore be said concerning RQ3 that in terms of both pure visibility and the viewing rate, entertainment content garnered considerably less attention than scientific content. Accordingly, with regard to visual attention allocation, there are no empirical indications that scientific content is displaced by a focus on entertainment, as is sometimes claimed by science slam critics. However, further analyses would be necessary to explore the reasons for the differences in viewing rates which e.g., might be influenced by the varying complexity of the scientific and entertainment material.

6. Conclusions

Our evaluation of various empirical data gathered with regard to science slams paints a clear picture concerning the compatibility of scientific content and entertainment:

1) Entertainment is cited as a key reason for attending science slams, closely followed by an interest in science itself and the desire to learn something (cf. Section 5.1);
2) In line with these findings, two-thirds of presenters cite fun and enjoyment as the major personal motivation to participate in a science slam. For half of all slammers, the desire to educate is a key concern, while for one quarter, the goals of entertaining and educating are on an equal footing (cf. Section 5.1);
3) Viewers do not perceive entertaining presentations as devoid of scientific content and therefore unscientific—in fact, the opposite tends to be true (cf. Section 5.2.1);
4) Both in terms of pure visibility and viewing rates, the entertaining elements of the science slam were considerably less prevalent than the scientific elements (cf. Section 5.2.2).

In light of the foregoing, science slams would appear suitable for conveying scientific content, despite the fact that audiences rate their entertainment value as high (cf. Section 5.2.1). This explorative study did not find evidence for the assertion that science slams are a "populistic" presentation form at odds with genuine scientific understanding. Rather, the results suggest that science slams should actually be characterized as a form that accords equal value to science and entertainment—that they represent a form of "edutainment" in a positive sense. Although the empirical analyses of this study consider science slams only, the results of the reception data also shed light on other forms of presentation with strong similarities to the science slam, such as famelab or TED: An entertaining presentation may still contain substantial scientific content. And, more fundamentally, entertainment and scientific content are not natural antipodes, but may interact in such a way that science finds its way to recipients in a pleasant form (Lederman, 2016).

It should be noted, however, that both the survey responses and the eye-tracking data were gathered at just three selected science slam events. In addition, eye-tracking data are not available for all 20 presentations, thus reducing the pool of data for analysis. Furthermore, only gaze surveys by one spectator could be analysed for each presentation.

Aside from these data limitations, a further limitation concerns the focus on visual attention data, which was necessitated by the research method. The analysis of visual attention does not allow for direct inference on information transfer, processing and ultimately learning (Schumacher, 2012, p. 115). As this is the first reception study on science slams, we consciously chose an explorative approach to show a holistic picture of this form of presentation. To address these other questions, a further study, building on the results presented here, would need to work with a more experimental laboratory setting. This would allow for interviewing test persons immediately following the reception of a science slam presentation or for recording the transmission of structural knowledge by means of concept mapping (Gehl, 2013).

Furthermore, at this stage we did not include a detailed analysis of the presenters and their oral communications. These are additional key factors for the reception of presentations, as indicated by the high viewing rates the presenters receive in our analysis, and are a further necessity for investigating information transfer. A first linguistic study on the exemplary science slam presentation by Reinhard Remfort has been conducted by Hanauska (in press), the next steps would be to expand the linguistic corpus and connect with the data presented here. Future research could potentially seek to gather real-time response measurements,

as is performed in research on political communication (Waldvogel & Metz, 2017): Viewers of science slam presentations could be asked to rate the degree to which a talk is entertaining on a continuous basis.

In order to address the deficit in evaluation research brought up e.g., by Weingart and Joubert (2019, cf. Section 1) and to carry out in-depth comparative analyses, various science communication formats would have to be examined with a similar mix of methods. In addition to the aforementioned famelab and TED, science cafés, pub science events, and science festivals would be suitable forms for further investigation.

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Conflict of Interests

One of the authors of this article (Philipp Schrögel) was moderator of the science slam in Karlsruhe and was therefore not involved in data collection for this event. Beyond that, the authors declare no conflicts of interest.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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Article

Why Are Scientific Experts Perceived as Trustworthy? Emotional Assessment within TV and YouTube Videos

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Abstract
Due to the rise of the Internet, the effects of different science communication formats in which experts appear cannot be neglected in communication research. Through their emotional and more comprehensible communication 'sciencetubers'—who frequently differ from the stereotypical image of scientists as white, old men—may have a considerable effect on the public's perceived trustworthiness of scientists as well as their trust in science. Thus, this study aims to extend trust and trustworthiness research to consider the role of emotion in science communication in the context of emerging online video content. Therefore, perceived trustworthiness was examined in an experimental online survey of 155 people aged 18–80. We considered different potential influencing variables for trustworthiness (expertise, integrity, benevolence) and used six different video stimuli about physics featuring scientific experts. The video stimuli varied according to format (TV interviews vs. YouTube videos), gender (male vs. female), and age of the experts depicted (old vs. young). The results suggest that: (1) Scientific experts appearing in TV interviews are perceived as more competent but not higher in integrity or benevolence than sciencetubers—while scientists interviewed on TV are regarded as typical scientists, sciencetubers stand out for their highly professional communication abilities (being entertaining and comprehensible); (2) these emotional assessments of scientists are important predictors of perceived trustworthiness; and (3) significantly mediate the effect of the stimulus (TV interview vs. YouTube video) on all dimensions of perceived trustworthiness of scientific experts.

Keywords
entertainment; public trust; science communication; science video; stereotype; television; trustworthiness; YouTube

Issue
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1. Introduction

Scientific topics are often very complex and difficult to grasp, particularly for non-experts. However, scientific findings form the basis for many everyday life decisions which is why the public require a certain degree of trust in science and the work of scientists.

This is especially true nowadays, given that the public now has the ability to immediately access information at any time from a wide variety of sources. The Internet has a great deal to offer non-experts who wish to inform themselves on a topic. New online platforms allow scientists to easily communicate their results to the public and other scientists. The Internet thereby helps to make science more accessible and enables the public to engage with science or even publish their own content about science. At the same time, correctly evaluating an alleged expert and their trustworthiness becomes more challenging (Hendriks, Kienhues, & Bromme, 2015), as "[d]ifferent levels of expertise, qual-

ity, balanced outcome, and scientific evidence can be found online" (Taddicken & Reif, 2016, p. 318).

Furthermore, science content on social media has the potential to portray the true diversity of scientists more realistically and thereby has the potential to break down the existing stereotype of scientists as being competent but cold (Jarreau et al., 2019), as well as to increase trust in scientists and science in general. Increasingly, formats such as science videos uploaded to online platforms such as YouTube can help present scientists as 'normal' people by not only disseminating facts but also emotions. In this article, we argue that the perceived trustworthiness of scientific experts is merely based on a 'gut feeling' and emotional processes. By emotional and more comprehensible communication 'sciencetubers'—who often also differ from the stereotypical image of scientists as white, old men—may have a considerable effect on the public's perception of scientists as trustworthy and thereby on the public's trust in science.

By considering different theoretical and methodological frameworks of trust, trustworthiness or credibility, we use the epistemic trustworthiness inventory by Hendriks et al. (2015) as a starting point which was specifically developed for evaluating scientific experts in online environments. We present results from an experimental online survey ($n = 155$) comparing perceptions of scientific experts appearing in classical TV interview settings with sciencetubers. We address the underlying question of what the predictors of perceived trustworthiness are and which role emotional assessment plays.

2. Trust in and Trustworthiness of Scientists as Research Issue

2.1. Science Media Use: Building Trust through Emotional Responses

Moving image content is the most frequently used source of information about science in Germany. Whereas TV is the overall most frequently used source, the Internet is in second place including online TV libraries and video platforms such as YouTube (Wissenschaft im Dialog, 2018). While science magazines and documentaries on German television are mostly produced by journalists or professional freelancers, scientists often 'only' appear as interview guests (Janecek, 2008). These established formats are supplemented by online video platforms, with new science video formats and new actors on stage. A recent study found that user-generated science videos are more popular than professionally generated ones (Welbourne & Grant, 2016). However, nowadays it has become hard to differentiate between user and professionally generated content as, for instance, so-called 'influencers' or 'sciencetubers' are often professional communicators as well.

Social media allows for direct communication between scientific experts and the lay audience and has been postulated as a way to increase the perception of scientists' trustworthiness (Jarreau et al., 2019) as well as trust in science (Lakomý, Hlavová, & Machackova, 2019). Polls indicate that people have more trust in information produced directly by scientists than scientific information mediated by the journalistic mass media (European Commission, 2013). However, surveys asking for the trustworthiness of social versus traditional mass media find that most people in Germany do not evaluate social media as trustworthy (Kaczinski, Hennig-Thurau, & Sattler, 2019). Often, social media is accused of being connected to disinformation, so-called 'fake news' (Spohr, 2017). Those surveys do, however, neglect the fact that social media are not to be seen as 'the opposite' of traditional journalistic media; journalistic content is also widely distributed in social media and integrated into social media content. Thus, it is important to thoroughly distinguish between various dimensions and aspects when researching different video content.

One key distinguishing factor may be the emotions that sciencetubers arouse. For media reception in general, positive feelings of enjoyment and pleasure are at the core of entertainment experiences (Schweiger, 2013). Many science communicators hope to better reach the public through an 'edutainment' approach that focuses on the emotional experience of audiences (Gerber, 2012) and is easy to access (Friesen, van Stan, & Elleuche, 2018). Yet, while many scientists call for a more entertaining style of science communication (Friesen et al., 2018; Gigante, 2018), the effects of edutainment-focused science communication have hardly been studied outside of the context of the educational system. The literature here indicates that entertainment-focused methods of teaching (such as gamification) increase student engagement and interest (Rabah, Cassidy, & Beauchemin, 2018). New online formats such as YouTube videos and TED talks often focus on entertainment (Sugimoto et al., 2013). In addition, one could also assume a connection to trustworthiness, for example, because of the stronger personal connection between the communicator and the audience.

According to qualitative group interviews among non-scientists, good and trustworthy scientists stand out for their ability to explain highly complex scientific issues in a way that even non-experts can understand (Reif, in press). Therefore, comprehensibility can be expected to positively affect the perceived trustworthiness of scientific experts. Compared to scientists in traditional TV formats, sciencetubers are expected to explain scientific content in a more comprehensible way. They are often experienced and professional science communicators. By analysing direct user feedback, they are able to evaluate which ways of communication and video styles viewers appreciate or even expect.

2.2. Trust in Stereotypical Scientists

Previous studies have empirically proven that children (e.g., Buldu, 2006; Finson, 2002; Türkmen, 2008) and

adults (Carli, Alawa, Lee, Zhao, & Kim, 2016; Reif, in press) have stereotypical beliefs about scientists as being older, white men, and consider Albert Einstein and Stephen Hawking as typical and at the same time trustworthy scientists. Scientists and researchers are "[a]mbivalently perceived high-competence but low-warmth, 'envied' professions" in the scheme of the stereotype content model (Fiske & Dupree, 2014, p. 13593)—traits that stereotypically are also attributed to men. Stereotypical beliefs about women, by contrast, still picture them as low in competence but high in warmth (Fiske, Cuddy, Glick, & Xu, 2002). The media also reinforces these stereotypical views (or may have even caused them, according to cultivation theory). Until today, female science experts are underrepresented in the media. Male scientists are quoted as experts more frequently while women's voices are often only heard as everyday people (Kitzinger, Chimba, Williams, Haran, & Boyce, 2016; Röben, 2013). In German television, more than two-thirds of experts who appear are male (Prommer & Linke, 2017). By contrast, social media may help to break down existing stereotypes about scientists by presenting them more realistically as a diverse group of people (Jarreau et al., 2019). However, only less than ten percent of the most popular science, technology, engineering, and mathematics (STEM) related YouTube channels are hosted by women (Amarasekara & Grant, 2019).

2.3. Defining and Examining Trust and Trustworthiness

In order to embed the present study in the context of previous research, we will clarify how we define and distinguish trust and trustworthiness in the following section. Most studies so far have focused either on trust or trustworthiness/credibility, and often use the different terms interchangeably (Hasell, Tallapragada, & Brossard, 2019).

Psychological research often focuses on how trust is gained and lost. However, these processes are still far from being fully understood (Simpson, 2007). The term and its derivations and negations can be described by a variety of concepts that include personal and situational conditions (Dernbach & Meyer, 2005). Among others, trust is defined as the willingness to make oneself vulnerable to the actions of another party (Mayer, Davis, & Schoorman, 1995), in this case, to rely on the statements of experts. This vulnerability demonstrates that trust is always based on emotion rather than logical evaluation (Aljazzaf, Perry, & Capretz, 2010). Furthermore, previous research distinguishes between trust in people and trust in systems (Giddens, 1991; Hendriks et al., 2015) as well as between generalised and specific trust (Grünberg, 2014). General trust in a system (here: science) or a group of people (in this case: scientists) is developed based on cumulative experiences with specific people. In these specific situations and communicative contexts, the credibility of scientific information (Hasell et al., 2019) and trustworthiness of a specific individual are evaluated.

Trustworthiness can be defined as a feeling that a person can lead others to trust that person, a group of people, an organisation or even a system (Grünberg, 2014). Trust in turn influences evaluations of trustworthiness of specific individuals (here: other scientists; Aljazzaf et al., 2010) in a specific context. When evaluating a person who belongs to a group of people such as scientists, existing beliefs about this group are used to compare the person's appearance, character, and behaviour. Thus, while trust is a procedural variable that can change over time, trustworthiness is situational. Although both variables can logically be argued to be connected, the nature of this link is difficult to examine empirically.

Several researchers examine either general beliefs towards different groups of people (e.g., Fiske et al., 2002; Hovland, Janis, & Kelley, 1953) or scientists in particular (e.g., Fiske & Dupree, 2014) and thereby focus on trust according to the definition used here. Others apply experimental designs and stimulus material to examine how scientists' (e.g., Gheorghiu, 2017) and scientific experts' (e.g., Hendriks et al., 2015) trustworthiness is evaluated. Different theoretical constructs and dimensions, as well as the measures developed, are in many ways very similar. At the same time, constructs and measures differ regarding labelling and allocation of items.

Most commonly, constructs comprise either two or three dimensions. In the two-dimensional construct of so-called 'source credibility,' groups of people are always perceived on their competence/expertise (referred to as confidence by Earle & Siegrist, 2006) as well as their warmth/trust/trustworthiness (e.g., Fiske et al., 2002; referred to as social trust by Earle & Siegrist, 2006). Competence denotes "the knowledge and ability to be accurate" (Fiske & Dupree, 2014, p. 13593). Warmth denotes the perceptions of people's intentions. As stated above, according to this scheme scientists and researchers are stereotypically believed to be high in competence and low in warmth (Fiske & Dupree, 2014). While the dimension of competence/expertise seems uncontested by both, the two- as well as three-dimensional constructs, there are diverse approaches about how the warmth dimension may actually comprise two distinct dimensions. For example, Gheorghiu (2017) distinguishes between how likeable (sociability) and how trustworthy and honest (morality) a person is perceived by others. By contrast, McCroskey and Teven (2009) consider goodwill (the level at which people are believed to care about others) and also measure honesty and morality as trustworthiness. More specifically for the perceived trustworthiness of scientific experts in online contexts, Hendriks et al. (2015) differentiate between honesty regarding scientists' work (integrity) and scientists' good intentions and moral behaviours (benevolence).

3. Aims of Research and Hypotheses

The first aim of this research is to examine whether there are differences in how diverse scientific experts

(male vs. female, old vs. young) appearing in different video formats (TV interviews vs. YouTube videos) are perceived. Following the METI-scale developed specifically for the perceived trustworthiness of scientific experts in online contexts, we measure perceived trustworthiness (expertise, integrity, benevolence) and distinguish it from emotional assessment of scientific experts. Based on the state of research, we sum up three different types of emotional assessment: a) Feeling entertained by a scientific expert is understood as affective assessment. Cognitive evaluations of scientific experts appearing in science videos include b) how comprehensible experts communicate science information and whether they are perceived as c) being typical scientists.

A vast body of literature has examined the stereotypical perceptions of scientists. Therefore, it can be assumed that male scientific experts are perceived as more competent but possessing less integrity and benevolence than female scientific experts. Furthermore, older scientists are assumed to be evaluated as more trustworthy than younger experts. Contrary, regarding potential effects of different video formats on trustworthiness, no unambiguous direct assumption can be made. Although it may seem plausible that sciencetubers are evaluated as more honest and benevolent, no clear effect is expected for expertise (Jarreau et al., 2019). Thus, we ask the first research question:

> RQ1: Do scientific experts differ in their perceived trustworthiness (expertise, integrity, benevolence) when appearing in TV interviews compared to sciencetubers?

Although in light of the state of research no specific assumptions can be formulated for gender and age-related effects on the emotional assessment of scientific experts, we predict the following directional effects by video format:

> H1a: Sciencetubers are perceived as more entertaining than scientific experts appearing in classical TV interviews.

> H1b: Sciencetubers are perceived as communicating scientific information more comprehensibly than scientific experts appearing in classical TV interviews.

> H1c: Sciencetubers are perceived as being less typical scientists than scientific experts appearing in classical TV interviews.

The second aim of this research is to identify the predictors of perceived trustworthiness in a regression model. We especially focus on the question:

> RQ2: What role do different video formats as well as emotional assessments of scientific experts play?

We also include the gender and age of scientific experts as stimulus variables in our model. While we cannot predict the effect of scientific experts' varying abilities to entertain (affective assessment), we hypothesise the following for the cognitive assessment based on the literature review:

> H2a: The assessment of scientific experts' ability to communicate comprehensibly positively predicts perceived trustworthiness.

> H2b: The evaluation of scientific experts being typical scientists positively predicts perceived trustworthiness.

Based on the assumption that general trust in scientists and perceived trustworthiness of specific scientific experts are positively linked but different constructs, we test H3 in order to explore the size of potential effects:

> H3: General trust in scientists is a positive predictor for perceived trustworthiness.

In addition to the potential predictors of perceived trustworthiness mentioned above, we also test the effects of viewers' attributes. Past research has shown that men report higher trust in science than women (Huber, Barnidge, Gil de Zúñiga, & Liu, 2019; von Roten, 2016). For Germany, it has been shown that 59% of men and 48% of women have trust in science, with women being more likely to be undecided or to report distrust (Wissenschaft im Dialog, 2018). However, this gender effect could also indicate that women do not feel represented by science. As the media still often strongly reflects the stereotypical images of scientists. Thus, women may perceive science to be mainly male-dominated and therefore find it more difficult to have trust in science. The Wissenschaftsbarometer in Germany further reveals that older people have a lower level of trust in science (Wissenschaft im Dialog, 2018). This may indicate a possible decline in trust with age. But more likely, this is a reflection on an effect triggered by educational attainment. Higher knowledge about science was previously found to predict higher appreciation of (Lakomý et al., 2019) and increased trust in science (Wissenschaft im Dialog, 2018). These results may indicate that a higher degree of contact with science leads to a higher trust in science. We expect similar effects for the perceived trustworthiness of scientific experts and will therefore also test how viewers' attributes predict the three dimensions.

The final aim of the research is to test, by conducting parallel mediation analyses, the following research question:

> RQ3: How do emotional assessments mediate the perceived trustworthiness of scientific experts appearing

in different video content (TV interviews vs. YouTube videos)?

While the sciencetubers' higher ability to explain scientific content in a more entertaining and comprehensible way may mediate perceived trustworthiness, for scientific experts in classical TV interviews the stronger perceptions of them as being typical scientists may positively mediate perceived trustworthiness.

4. Methods

4.1. Measures

We used the METI-scale developed by Hendriks et al. (2015) as the primary tool for this online survey with experimental design. As the initial scale was only applied to the trustworthiness of scientists in blog articles/text descriptions, we tested the scale reliability using video stimuli in comparison to blog texts in a first pre-test (n = 82) in summer 2018. Seven-point semantic differentials from negative to positive were applied. Expertise was measured by six items: incompetent/competent; unintelligent/intelligent; poorly educated/well-educated; unprofessional/professional; inexperienced/experienced; and unqualified/qualified. Four items were used to assess integrity (insincere/sincere, dishonest/honest, unjust/just, unfair/fair) as well as benevolence (immoral/moral, unethical/ethical, irresponsible/responsible, inconsiderate/considerate). Results revealed even higher internal consistencies for the dimensions when scientific experts in videos are evaluated compared to blog texts (α = .92–.96). In addition to the dependent variable of perceived trustworthiness, we measured variables regarding the affective (boring/entertaining) and cognitive assessment of scientists (incomprehensible/comprehensible, atypical/typical) as single items on seven-point semantic differential scales. Furthermore, respondents' interest in science ("no interest" to "high interest"), general trust in scientists ("very low" to "very high"), as well as science TV use and online video use about science ("rarely or never" to "daily") were assessed as single items on a five-point scale.

4.2. Stimuli

We decided to use real stimulus material to simulate realistic media exposure. In order to minimise effects outside the scope of investigation in this study, stimuli were selected to be about similar scientific topics and with the experts speaking in similar settings presenting not own but summarising the field's general scientific results. In total, six one-minute long excerpts of videos (TV interviews and YouTube videos) on different topics in physics were used as stimuli (Table 1). Physics was chosen because of its distance to the science-policy-interface, meaning that content is seen as comparably uncontroversial. The four stimuli were television interviews with scientists talking about their own research (two males, two females). The experts' names, academic titles, and affiliations were not presented in the video clips. We chose videos from the TV series "alpha-Forum" with classic interview settings (host and scientific expert sitting opposite each other). The studio is dark and focuses on the host and scientist who both appear in formal clothing. The scientist answers questions about their research field, addressing the host rather than the viewer and uses technical terms. The text does not seem scripted. Furthermore, two science videos that were produced for YouTube were used in which a young, casually clothed expert (male/female) comprehensibly explains a topic in a studio setting with professional quality production. Sciencetubers who, for example, explain a topic in an outside setting or a private office were disregarded. Both sciencetubers have chosen to face the camera and use a scripted text.

4.3. Sampling and Procedure

Participants were recruited through two channels. Firstly, a short description of and the link to the study was emailed to the university department's pool of study participants. Secondly, a similar text was posted to different online forums and Facebook groups. In order to reach both users who are actively interested in science and those who are not, discussion communities with a focus on science and fan communities of entertainment-focused YouTube channels were selected. In the text, the study was described as investigating the formation of opinions on scientists without stating which attributes were examined.

Respondents completed a standardised online survey in which they were first asked to indicate their interest in science, trust in scientists in general, and frequency of science TV use and online video use about scientific topics (Figure 1). Next, each participant was presented with a randomly assigned video stimulus. After watching the video, they were asked to evaluate the person shown (referred to as "expert") regarding their trustworthiness and emotional assessment. The items were not randomised. Following this, they were shown and asked to rate a second video stimulus, which was also randomly chosen but with the restriction of being of the opposite gender to the first one, meaning that each participant rated a male and a female expert. Concluding the survey, the demographic data age and education were captured.

After data collection, we included video type (TV interview vs. YouTube video), gender (male vs. female expert) and age (old vs. young expert) as dummy variables to the data set. Six participants who stated that they already knew the expert in stimulus 6 were removed. For data analysis, analyses of variance (RQ1, H1a–c), linear regressions (RQ2, H2a–b, H3), and parallel mediation analyses using Haye's PROCESS macro (version 3.0, model 4, RQ3) were calculated with 10.000 bootstrap samples.

Table 1. Short description of video stimuli.

TV interview stimuli		YouTube videos stimuli	
Stimulus 1		*Stimulus 5*	
Topic:	Astrophysics: Formation of celestial bodies	Topic:	General physics: Subject matter light
Expert:	Male expert, 50 years of age	Expert:	Male expert, 34 years of age
TV series:	alpha-Forum	Channel:	musstewissen Physik
Video title:	Josef Martin Gaßner, Mathematiker und theoretischer Physiker (Josef Martin Gaßner, mathematician and theoretical physicist)	Video title:	Lichtquellen I Lichtausbreitung I Optik I musstewissen Physik (Light sources I Propagation of light I optics I musstewissen Physik)
URL:	https://www.youtube.com/watch?v=9OoHZuu_kwA	URL:	https://www.youtube.com/watch?v=Ilaoa5LHsgA
Stimulus 2		*Stimulus 6*	
Topic:	Astrophysics: Movement of bodies in space	Topic:	General physics with aspects of chemistry: Conductivity of substances
Expert:	Male expert, 80 years of age	Expert:	Female expert, 31 years of age
TV series:	alpha-Forum	Channel:	maiLab
Video title:	Eine Folge Alpha Forum—Im Interview mit Rudolf Kippenhahn (Astrophysiker & Autor) (2006) (One episode of Alpha Forum—Interview with Rudolf Kippenhahn [astrophysicist and author] [2006])	Video title:	Solarautos (Solar-powered cars)
URL:	https://www.youtube.com/watch?v=uamiDEpec78&t=8s	URL:	https://www.youtube.com/watch?v=kmNRhO-_7w8
Stimulus 3			
Topic:	Theoretical physics: Effect of magnetic fields		
Expert:	Female expert, 61 years of age		
TV series:	alpha-Forum		
Video title:	Gisela Anton, Lehrstuhl für Experimentalphysik Universität Erlangen-Nürnberg (Gisela Anton, Chair in experimental physics University Erlangen-Nürnberg)		
URL:	https://www.youtube.com/watch?v=rTIa6fZuhPI		
Stimulus 4			
Topic:	Theoretical physics: Cycle of matter		
Expert:	Female expert, 36 years of age		
TV series:	alpha-Forum		
Video title:	Sibylle Anderl, Astrophysikerin und Wissenschaftsjournalistin—ARD-alpha (Sibylle Anderl, astrophysicist and science journalist—ARD-alpha)		
URL:	https://www.youtube.com/watch?v=qVT6XJuv-GU&t=7s		

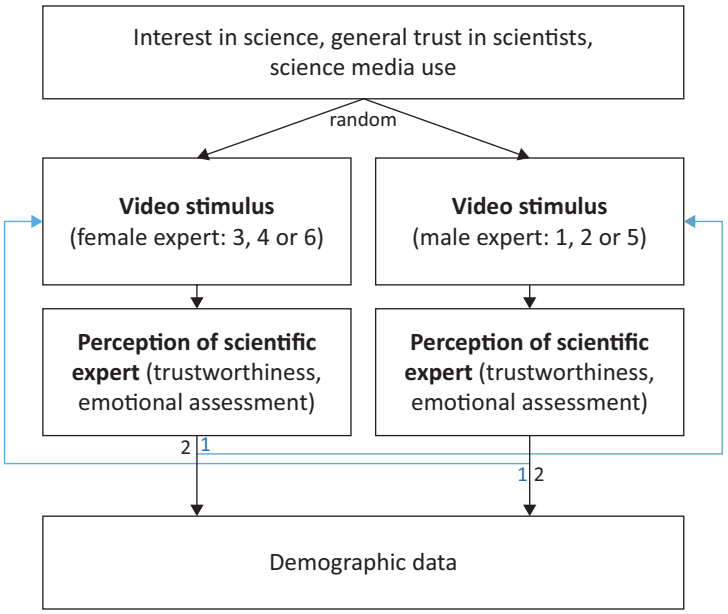

Figure 1. Experimental design of the study.

5. Results

The final sample consisted of 155 people aged between 18 and 80, with 48% of participants aged between 20 and 29. More males than females completed the questionnaire and most people in the sample are highly educated (Table 2). Further, the respondents are rather interested in science (M = 4.04, SD = .88), trust in scientists to a good degree (M = 3.86, SD = .69). They use online videos about scientific topics more often (M = 3.08, SD = 1.38) than science TV (M = 2.24, SD = 1.31).

In total, and as with previous research (Fiske & Dupree, 2014), respondents rated the scientists' expertise higher than their integrity and benevolence (Table 3). However, these findings do not support the assumption of there being an ambivalent stereotype of scientists as the experts, in fact, were perceived as possessing rather high degrees of integrity and benevolence. Regarding zero-order correlations, perceived expertise has a strong positive correlation with integrity and benevolence. Integrity and benevolence are highly correlated. An exploratory factor analysis also provides a possible hint towards only two dimensions: expertise and one other factor that combines integrity and benevolence (similar to e.g., Fiske et al., 2002; Hovland et al., 1953).

Table 2. Socio-demographic data of participants.

	%
Gender	
Male	61
Female	39
Age	
14–19	2
20–29	48
30–39	11
40–49	10
50–59	13
60+	16
Education	
Graduation from Secondary Education (Hauptschule)	2
Graduation from Secondary Education (Realschule)	9
Higher Secondary Education (Abitur)	36
University Degree	46
Doctoral Degree	6

Note: n = 155.

Table 3. Descriptive statistics and Pearson correlations for dimensions of trustworthiness.

	M (*SD*)	Expertise	Integrity
Expertise ($\alpha = .92$)	5.91 (.98)		
Integrity ($\alpha = .87$)	5.47 (1.02)	.48***	
Benevolence ($\alpha = .92$)	5.10 (1.09)	.37***	.80***

Notes: $n = 302$; ***$p \leq .001$ (one-tailed); *M* = mean, *SD* = standard deviation.

5.1. Impacts of Stimulus Exposure

In a comparison of means of the six different video stimuli (Table 4), the experts depicted in stimulus 1 and 3 (TV interviews, older experts) received the highest rating of perceived expertise, while the younger sciencetuber in stimulus 5 received the lowest mean (RQ1). In addition to the mean differences between all six stimuli, we conducted analyses of variance for all three stimuli dummy variables as independent group variables and each dependent variable. These additional analyses indicated significant group differences regarding perceived expertise between the TV interview stimuli ($M = 6.02$, $SD = .92$) and YouTube stimuli ($M = 5.66$, $SD = 1.08$): $F(1, 288) = 8.21$, $p = .004$, $\eta^2 = .03$. This could also be observed between older ($M = 6.10$, $SD = .92$) and younger ($M = 5.71$, $SD = 1.01$) scientific experts: $F(1, 288) = 11.72$, $p = .001$, $\eta^2 = .04$. Contrary to assumptions drawn from past studies, there is not prove in the data regarding significant gender difference or any effects regarding integrity and benevolence.

While there are only a few small differences in perceived expertise, the chosen stimuli differ strongly regarding emotional assessment. Regarding the experts' ability to entertain (Table 4), all significant differences are between TV interviews and YouTube videos. When testing the effects of the stimulus dummy variables in additional analyses of variance, sciencetubers are significantly rated as more entertaining ($M = 5.64$, $SD = 1.27$) than scientific experts interviewed on TV ($M = 4.73$, $SD = 1.48$): $F(1, 288) = 25.23$, $p < .001$, $\eta^2 = .08$. Thus, H1a is supported although the difference is smaller than one might expect. A similar, although, smaller effect appears when comparing older ($M = 4.71$, $SD = 1.56$) and younger scientists ($M = 5.32$, $SD = 1.33$): $F(1, 288) = 12.40$, $p < .001$, $\eta^2 = .04$. There is no significant difference in perceived entertaining abilities of male ($M = 5.14$, $SD = 1.48$) compared to female scientific experts ($M = 4.88$, $SD = 1.47$): $F(1, 294) = 2.11$, $p = .15$, $\eta^2 = .01$.

The two sciencetubers are also evaluated as being able to explain in the most comprehensible way—stimulus 5 shows the highest and stimulus 2 the lowest mean comprehensibility (Table 4). Confirming H1b, sciencetubers in sum ($M = 6.34$, $SD = 1.01$) received significantly higher ratings than scientific experts interviewed on TV ($M = 5.30$, $SD = 1.62$): $F(1, 288) = 31.31$, $p < .001$, $\eta^2 = .10$. The effect by age revealed to be even higher with younger experts being evaluated as explaining more comprehensibly ($M = 6.14$, $SD = 1.15$) than older experts ($M = 5.11$, $SD = 1.68$): $F(1, 288) = 36.90$, $p < .001$, $\eta^2 = .11$. Additionally, according to the respondents' evaluation, female experts explain scientific information slightly more comprehensibly ($M = 5.79$, $SD = 1.39$) than male experts ($M = 5.44$, $SD = 1.64$): $F(1, 294) = 9.03$, $p < .05$, $\eta^2 = .01$.

Furthermore, whether a scientific expert is rated as being a typical scientist may be connected to the video format and the expert's age. The scientists who were evaluated as most typical (stimulus 1, 3) were both middle-aged and are also the ones whose expertise was evaluated highest. The least typical scientists were the young sciencetubers (stimulus 5, 6, Table 4). Revealing in the biggest effect here and confirming H1c, sciencetubers were regarded as significantly less typical ($M = 3.52$, $SD = 1.69$) than scientists appearing in TV interviews ($M = 5.14$, $SD = 1.40$): $F(1, 288) = 73.40$, $p < .001$, $\eta^2 = .20$. As a logical consequence, younger experts are perceived as being less typical scientists ($M = 3.90$, $SD = 1.66$) than older experts ($M = 5.37$, $SD = 1.33$): $F(1, 288) = 69.08$, $p < .001$, $\eta^2 = .19$. By contrast, no significant gender difference was found between female ($M = 4.56$, $SD = 1.59$) and male experts ($M = 4.70$, $SD = 1.74$): $F(1, 294) = .50$, $p = .48$, $\eta^2 = .002$.

In sum, while the different stimuli and therefore scientific experts in TV interviews and YouTube videos show only minor significant differences regarding expertise and none regarding integrity and benevolence, they strongly vary in the levels of emotional assessment.

5.2. Predictors of Perceived Trustworthiness

Our second aim of this study is to identify the predictors of perceived trustworthiness using a linear regression model with the focus on the role of the video format and emotional assessment (RQ2). The predictors explain an especially high amount of variance for expertise and greater variance for perceived integrity than benevolence (Table 5).

In contrast to our previous assumption, viewing a stimulus featuring a female STEM expert as opposed to a male expert has a small positive and significant effect on perceived expertise. Furthermore, as predicted, viewing an older as opposed to a younger expert also leads to a higher rating in perceived expertise. No other statistically significant effects were found for gender or age. Additionally, the video format itself does not significantly predict scientific experts' perceived trustworthiness.

The central assumption that trustworthiness is formed by emotional processes is confirmed by the model. The level of perceived entertaining abilities of

Table 4. Mean differences in the evaluation of scientists per stimulus (ANOVA with post-hoc test).

	Total average ($n = 302$)	Stimulus 1 ($n = 52$)	Stimulus 2 ($n = 52$)	Stimulus 3 ($n = 46$)	Stimulus 4 ($n = 56$)	Stimulus 5 ($n = 50$)	Stimulus 6 ($n = 46$)	F (df)	η^2	f
Expert's gender		m	m	f	f	m	f			
Expert's age		50	80	61	36	34	31			
Video format		TV	TV	TV	TV	YouTube	YouTube			
Perceived trustworthiness										
Expertise	5.91 (.98)	6.15 (.79)^{a}	5.86 (1.08)	6.33 (.81)^{b}	5.80 (.88)	5.49 (1.14)^{a,b}	5.88 (.99)	4.41*** (5, 284)	.07	.27
Integrity	5.47 (1.02)	5.52 (1.01)	5.41 (1.10)	5.56 (1.17)	5.48 (.84)	5.52 (1.01)	5.30 (1.05)	.36 (5, 283)	.01	.10
Benevolence	5.10 (1.09)	5.20 (1.01)	5.00 (1.18)	5.18 (1.24)	5.23 (.98)	5.06 (1.05)	4.89 (1.09)	.67 (5, 281)	.01	.10
Emotional assessment										
Boring/entertaining	5.01 (1.48)	5.30 (1.34)	4.44 (1.63)^{a,b}	4.38 (1.54)^{c}	4.78 (1.27)^{d}	5.71 (1.15)^{a,d}	5.55 (1.41)^{b,c}	7.96*** (5, 284)	.12	.37
Incomprehensible/comprehensible	5.62 (1.53)	5.58 (1.41)^{a,b}	4.31 (1.77)^{a,c,d,e,f}	5.51 (1.55)^{c,g}	5.81 (1.29)^{d}	6.50 (.68)^{b,e,g}	6.13 (1.28)^{f}	14.93*** (5, 284)	.21	.52
Atypical/typical	4.64 (1.66)	5.48 (1.30)^{a,b}	5.21 (1.39)^{c,d}	5.42 (1.31)^{e,f}	4.54 (1.41)^{g}	3.35 (1.69)^{a,c,e,g}	3.73 (1.68)^{b,d,f}	18.27*** (5, 284)	.24	.56

Notes: Ratings on a scale from 1 to 7. Matching letters indicate significant mean differences (Scheffé Post-hoc test).

Table 5. Linear regression predicting scientific experts' perceived trustworthiness.

Predictors	Expertise (n = 280)		Integrity (n = 279)		Benevolence (n = 277)	
	β	95% CI of B	β	95% CI of B	β	95% CI of B
Constant		[−8.25, 20.79]		[−3.39, 30.73]		[−14.44, 23.23]
Stimuli						
TV interview vs. YouTube video	−.01	[−.28, .33]	−.02	[−.41, .31]	−.09	[−.61, .19]
Scientist's gender (male vs. female)	.19***	[.15, .58]	.02	[−.21, .29]	.02	[−.24, .32]
Scientist's age (old vs. young)	−.24**	[−.78, −.17]	−.08	[−.51, .20]	.01	[−.37, .41]
Emotional assessment						
Boring/entertaining	.34***	[.15, .30]	.25***	[.08, .26]	.20*	[.04, .25]
Incomprehensible/comprehensible	.17**	[.03, .18]	.19**	[.04, .21]	.14*	[.01, .20]
Atypical/typical	.33***	[.13, .26]	.16*	[.02, .18]	.19**	[.04, .21]
Viewers' attributes						
Trust in scientists	.10	[−.01, .29]	.01	[−.16, .19]	−.01	[−.20, .19]
Interest in science	.01	[−.11, .14]	.12*	[.01, .29]	.02	[−.13, .19]
Science TV use	−.02	[−.09, .06]	−.12*	[−.18, −.01]	−.06	[−.15, .05]
Science online video use	−.01	[−.10, .08]	−.04	[−.13, .08]	−.08	[−.18, .05]
Gender (2 = male)	−.09	[−.41, .03]	−.20***	[−.68, -.17]	−.08	[−.45, .11]
Age	.03	[.01, −.01]	.07	[.01, −.01]	−.01	[.01, −.01]
Education[1]	.04	[−.08, .16]	−.10	[−.27, .02]	−.22***	[−.45. −.14]
F total (df)	14.73*** (13, 267)		7.34*** (13, 266)		5.09*** (13, 264)	
Total R^2	.39		.23		.16	

Notes: Standardised β-values are reported, *p ≤ .05, **p ≤ .01, ***p ≤ .001. [1] No school degree = 1, Graduation from Secondary Education (Hauptschule) = 2, Graduation from Secondary Education (Realschule) = 3, Higher Secondary Education = 4, University Degree = 5, Doctoral Degree = 6.

scientific experts was shown to be the strongest positive predictor for expertise and one of the strongest for integrity as well as benevolence. As predicted in H2a and H2b, ratings of communicating scientific information comprehensibly and of being perceived as a typical scientist have positive effects on all dimensions of perceived trustworthiness. Despite theoretical suggestions that general trust in scientists is closely connected to perceived trustworthiness of specific experts, the small effect on expertise is not significant in our regression model. Therefore, and interestingly, the connection between the two concepts is not as strong as expected by H3. When comparing the correlations for the different video formats, we find small significant effects for videos in the TV interview setting (expertise: $r = .19$, $p \leq .01$; integrity: $r = .12$, $p \leq .05$; benevolence: $r = .11$, $p > .05$) and no effect for YouTube videos (expertise: $r = .04$, $p > .05$; integrity: $r = .04$, $p > .05$; benevolence: $r = –.07$, $p > .05$).

Lastly, the regression analyses show that some of the viewers' attributes, as well as socio-demographics, significantly predict the perceived trustworthiness of scientists: Contrary to previous research on general trust in science, female respondents perceive scientists' integrity significantly higher than male respondents. Also contrary to previous research on general trust in science, respondents with lower levels of educational attainment are more convinced that scientists act morally and responsibly. The higher people's educational attainments are, the less idealised or more critical their impression of scientific experts is. The analysis revealed no age effect. Additionally, interest in science only has a positive effect on whether scientific experts are perceived as honest and fair (integrity). A higher frequency of science TV use has the opposite effect.

5.3. Mediation Effects of Emotional Assessment

According to this study's third aim and research question, we want to explore whether emotional assessment variables are mediators of the stimulus effects (TV interview vs. YouTube video) on perceived trustworthiness. Thus, we want to shed light on the process of evaluating scientific experts' trustworthiness. We used Hayes' PROCESS macro (version 3.0, model 4) in SPSS with 10.000 bootstrap samples and added viewers' gender, age, and educational attainment as covariates. The covariates in the models revealed the same significant effects in perceived trustworthiness as in the linear regression analyses. Additionally, age has a tiny but significant positive effect on all emotional assessment variables.

The three models (Figure 2) revealed that sciencetubers were rated as significantly more entertaining

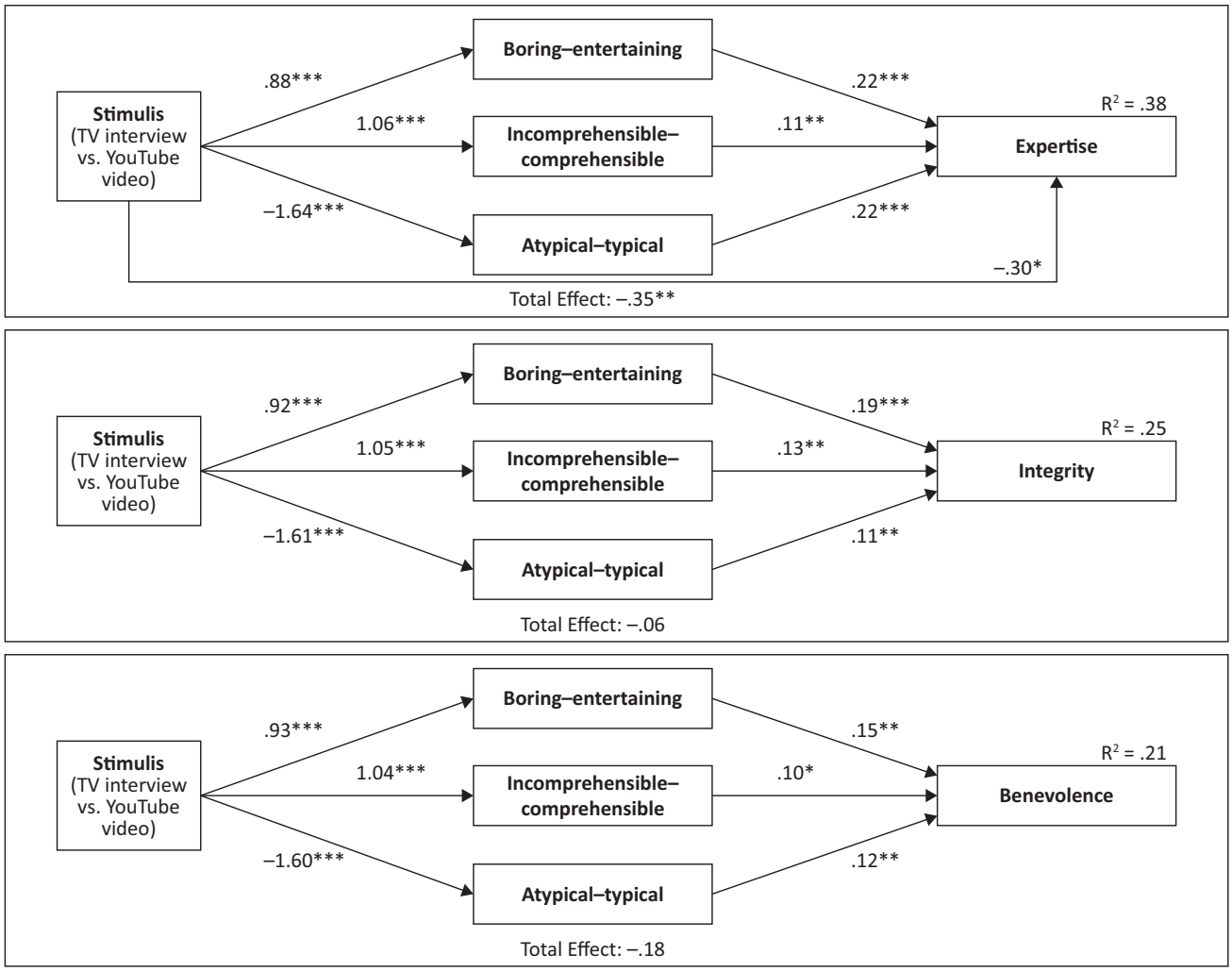

Figure 2. Mediation models for direct and indirect effects of stimulus on perceived trustworthiness. Notes: Unstandardised coefficients are reported, *p ≤ .05, **p ≤ .01, ***p ≤ .001.

($t(280) = 4.88$, $p < .001$) and more comprehensible ($t(280) = 5.58$, $p < .001$) than scientific experts appearing in TV interviews. They were regarded as being less typical scientists than scientists featured in TV interviews ($t(280) = -9.50$, $p < .001$).

We discovered significant negative direct effects by the stimulus variable on expertise ($t(277) = -2.41$, $p < .05$). The negative direct effect on integrity ($t(276) = -1.29$, $p = .20$) and benevolence ($t(277) = -1.55$, $p = .12$) are not significant.

Focusing on affective assessment and thereby on scientific experts' entertaining abilities, we found—similar to the single linear regression models in Section 5.2—significant positive effects on expertise ($t(277) = 5.66$, $p < .001$), integrity ($t(276) = 4.18$, $p < .001$), and benevolence ($t(274) = 3.07$, $p < .01$). The bootstrapped estimates of the indirect effects were small but significant for all three dimensions of perceived trustworthiness (expertise: $\beta = .20$, SE = .05, 95% CI [.10, .30]; integrity: $\beta = .17$, SE = .06, 95% CI [.07, .29]; benevolence: $\beta = .13$, SE = .06, 95% CI [.03, .25]).

Furthermore, the more comprehensible an expert is perceived as, the higher the rating of their expertise ($t(277) = 3.04$, $p < .01$), integrity ($t(276) = 2.99$, $p < .01$), and benevolence ($t(274) = 2.23$, $p < .05$). Similar to the mediation effects of perceived entertaining abilities, all indirect effects of the stimulus variable on perceived trustworthiness through comprehensibility were small but significant (expertise: $\beta = .12$, SE = .05, 95% CI [.04, .22]; integrity: $\beta = .13$, SE = .05, 95% CI [.04, .23]; benevolence: $\beta = .10$, SE = .05, 95% CI [.01, .20]). The second variable measuring cognitive assessment indicates, as expected, a different effect. While being assessed as a more typical scientist positively affects expertise ($t(276) = 7.02$, $p < .001$), integrity ($t(276) = 3.10$, $p < .01$), and benevolence ($t(274) = 2.91$, $p < .01$), the negative indirect effect by the stimulus variable on all dimensions of perceived trustworthiness are significant. The indirect effect of the stimulus on expertise is mediocre and thereby the strongest indirect effect ($\beta = -.37$, SE = .07, 95% CI [−.52, -.24]). The indirect effects on integrity ($\beta = -.18$, SE = .06, 95% CI [−.31, −.06]), and benevolence ($\beta = -.17$, SE = .07, 95% CI [−.29, −.06]) are small.

These results suggest that viewers emotionally assess scientific experts who appear in video content in order to evaluate their trustworthiness. As a result of the

rather strong negative indirect effect caused by the assumption that sciencetubers are regarded as being atypical scientists and the weaker positive indirect effects caused by their entertaining abilities and comprehensibility, the total indirect effects are not significant (expertise: $\beta = -.06$, SE = .01, 95% CI [−.26, .15]; integrity: $\beta = -.12$, SE = .01, 95% CI [−.07, .32]; benevolence: $\beta = .06$, SE = .01, 95% CI [−.13, .23]). However, in terms of total effects, only the negative effect by the sciencetuber stimuli on expertise remains significant ($t(280) = -2.81$, $p < .01$).

6. Limitations

The selection of stimuli must be critically addressed. Even though the real stimulus material was chosen to minimise variance, each stimulus differs. Our self-imposed restriction on having to have German-language physics videos of high production quality led to there being a very small number of eligible videos. As a result, we were only able to use two YouTube videos as opposed to four TV interviews, leading to a smaller sample size for the former. Similar restrictions applied to the TV interviews since we wanted them all to be from the same interview series in order to have a more comparable sample. However, the second stimulus video was somewhat outdated and had a lower image quality.

Further, not only did the video format vary but also the scientific experts between stimuli. While the scientific experts interviewed on TV were noticeably not trained in science communication, the sciencetubers were professional science communicators. Therefore, the sciencetubers could be considered more comparable to journalists or presenters on TV, and the results may indicate that the respondents did not perceive them as being real scientists. Three respondents who evaluated the expert in stimulus 5 and one respondent for stimulus 6 stated this perception in their answers to an additional open-ended question. There were no such comments regarding the experts who appeared in the TV interview setting. Although all stimuli were in the field of physics, the specific topics addressed varied slightly. We tried to consider scientific experts who varied in age and gender but finding sciencetubers of different ages was difficult. Thus, the age, besides different factors, may also have impacted the stimulus effects. The female physicists chosen as stimuli are on average younger than the male ones, but this is in part a reflection of the scientists featured in the interview series we drew from. Apart from that, two experts differed significantly from the others. The oldest expert in stimulus 2 stood out for the lowest means on diverse items. The expert in stimulus 6 is a rather well-known sciencetuber who now hosts a science show on German TV and is also the only expert shown who is not of European ethnicity.

Another limitation of this study is that the sample is highly educated, rather interested in science, and young which is why it cannot be assumed as representative for Germany. Especially the young age of respondents and higher contact with online science videos may have influenced more positive ratings of perceived trustworthiness for the sciencetubers.

Finally, the decision to use the three-fold construct of perceived trustworthiness has to be critically addressed. We used the METI scale as it was invented to measure perceived trustworthiness in scientific experts in online contexts which is practically the most specific instrument for our study. Gheorghiu (2017) also gives evidence towards a better model fit for measuring three dimensions over two in confirmatory factor analyses. However, more research is needed to compare different measures. Especially because we found hints towards two factors in an exploratory factor analysis.

7. Conclusion

The goal of this study was to extend trust and trustworthiness research in the field of science communication to consider the emotional assessments of scientific experts in emerging online video content.

An experimental online survey ($n = 155$) using six different video stimuli was conducted to explore the predictors of perceived trustworthiness and more specifically the role of video format and emotional assessment of scientific experts.

Firstly, the sciencetubers in this study were perceived as less competent but just as honest and benevolent as scientific experts who appeared in TV interviews. While the scientists interviewed on TV were regarded as typical scientists, sciencetubers stand out for their highly professional communication abilities. Content presented by scientific experts on YouTube videos was regarded as highly comprehensible and entertaining. As discussed in the limitations, these results may also be influenced by the fact that the studied sciencetubers are professional science communicators and may not have been perceived as scientists. Strictly controlling for this in the selection of stimulus material in future experimental research can diminish most of the limitations. Furthermore, viewers' expectations were not researched here, but they are important at the science-public-interface and in the mutual understanding of experts and laypeople (Bromme & Jucks, 2017). What the non-expert audience expects from the experts' communication thus affects how this is perceived (Taddicken & Wicke, 2019). This might have affected the perceptions of the sciencetubers. Expectations regarding the format of explainer videos on YouTube in contrast to TV interviews should be considered in future research.

Secondly, our results highlight the emotional assessment (entertaining, comprehensible, and typical) of scientific experts and thereby a first impression as an important predictor of perceived trustworthiness. Scientists' attributes connected to stereotypes about scientists, such as their gender and age only affect expertise—for gender, however, we found the opposite effect similar to

the findings of Jarreau et al. (2019). Female respondents also evaluated the scientific experts as having more integrity than male respondents and higher educational attainment was found to lead to lower perceived benevolence. General trust in scientists and specific trustworthiness were not significantly linked in our model. While we only found small significant correlations between the variables for scientific experts appearing in TV interviews, there were no correlations for sciencetubers—who may not have been perceived as being scientists. However, more research is needed to examine the relationship between trust and trustworthiness. While general trust in science is assumed to be a procedural variable but relatively stable over time, trustworthiness for specific experts is highly situational. Transfer effects between trust and trustworthiness seem to be more complex than linear, and mutually affecting. Trust in scientists as general beliefs may be more strongly affected by stereotypical views (e.g., ambivalent stereotype of scientists), whereas perceptions of specific individuals may be less stereotypical. In turn, repeated contact with 'real' scientists may help to diminish existing stereotypes. Longitudinal research is needed to explore the dynamics in greater detail.

Finally, by mediation analyses, we have detected that emotional assessment mediates the effects of the stimulus (TV vs. YouTube) on perceived trustworthiness. When audiences are exposed to scientific experts in videos, they emotionally assess them which helps them to evaluate their trustworthiness.

This study serves as a starting point for further discussion. It highlights the importance of considering emotions when studying trustworthiness. If audiences feel more entertained by, and/or understand scientific experts' explanations, this can have a positive effect on perceived trustworthiness. New online formats and young sciencetubers have to be acknowledged as a crucial part of current science communication to the public. They should be considered significantly more often in the academic discussion about how to build or retain trust in scientists and science in general.

Further, strictly controlled experiments are required to dig deeper into the numerous relationships and effects and to explore the processes of emotional assessment and how these affect the audiences' trustworthiness perception in greater detail. Future research should also consider including emotions that may appear at the different stages in the process of evaluating trustworthiness, such as: (a) the emotions expressed by scientists; and (b) the emotions evoked by the audiences.

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Conflict of Interests

The authors declare no conflicts of interest.

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Article

‘Fake News’ in Science Communication: Emotions and Strategies of Coping with Dissonance Online

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Abstract
In view of events such as the public denial of climate change research by well-known politicians, the effects of postfactual disinformation and emotionalisation are discussed for science. Here, so-called ‘fake news’ are of focus. These are considered problematic, particularly in a high-choice media environment as users tend to show selective behaviour. Much research has demonstrated this selective exposure approach, which has roots in the Theory of Cognitive Dissonance (Festinger, 1957). However, research on the processes of coping with dissonance is still considered sparse. In particular, communication scholars have overlooked emotional states and negotiations. This article analyses the affects that are aroused when users are confronted with opinion-challenging disinformation and how they (emotionally) cope by using different strategies for online information. For this, we used the context of climate change that is widely accepted in Germany. The innovative research design included pre- and post-survey research, stimulus exposure (denying ‘fake news’), observations, and retrospective interviews (n = 50). Through this, we find that perceptions and coping strategies vary individually and that overt behaviour, such as searching for counter-arguments, should be seen against the background of individual ideas and motivations, such as believing in an easy rejection of arguments. Confirming neuroscientific findings, participants felt relieved and satisfied once they were able to dissolve their dissonant state and negative arousal. Dissatisfaction and frustration were expressed if this had not been accomplished.

Keywords
cognitive dissonance; emotions; fake news; online disinformation; science communication; selective exposure

Issue
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1. Introduction: Science Information Online

Several problems and threats for individuals and society around the consumption of online information have been recently debated. In view of events such as the public denial of climate change research by well-known politicians, the effects of disinformation are discussed. However, disinformation should not be confused with misinformation. The latter is information that is incorrect, possibly given by accident, but not created with the intention of causing harm, whereas disinformation means intentionally false information that is often used for specific communication strategies, such as damaging the reputation of a person, social groups, organisations or countries (cf. Garrett, 2017). Among these are so-called ‘fake news.’ Although there is no universal understanding of ‘fake news,’ some aspects appear to be central: deliberately false claims that are supposed to imitate the style of conventional media reporting and to reach a certain public (Gelfert, 2018; Zimmermann & Kohring, 2018; see also Ethical Journalism Network, n.d.; First Draft, n.d.)

Facing the fact that we live in a high-choice media environment, their existence is considered problematic. It is assumed that users confirm their own opinions

many times over, regardless of whether they are scientifically founded or socially established (so-called confirmation bias). Expectations of 'filter bubbles' (Pariser, 2011), 'information cocoons' (Sunstein, 2018), or 'echo chambers' (Sunstein, 2001) raise concerns about narrow-minded online users and societal fragmentations and polarisations. However, at the same time—and this is often forgotten—it is highly likely that users will come into contact with online content that contradicts or challenges their own attitudes. The enormous diversity of opinions, values, and beliefs presented online allows for a much higher proximity to opposing opinions through users' social networks.

The effects of a high-choice media environment are mainly discussed over information about politics and public issues; however, the relevance of science information for society is increasingly acknowledged. Thus, Scheufele and Krause (2019) demand urgent research on the (mis/dis)information of scientific issues and analyses of science communication in new media environments.

This article aims to contribute to this goal by considering Festinger's (1957) Theory of Cognitive Dissonance (TCD), which can be seen as the root of research on selective exposure theory. A wide variety of empirical studies has proven the assumption that online users turn primarily to content that confirms their own attitudes (D'Alessio & Allen, 2007; Knobloch-Westerwick & Kleinman, 2011). Nevertheless, according to recent studies, users do not necessarily turn away from content that contradicts or challenges their attitudes (Garrett, 2017; Jang, 2014). However, research on the processes of coping with dissonance is still sparse.

Further, and this is quite new to research on cognitive dissonance and for the field of science communication, we will consider the emotional states and negotiations of online users. Online and social media are discussed as problematic due to their emotional-impulsive functional logic that favours the spread of polarising and pointed rhetoric (Eisenegger, 2017). This is related to the rational argument, discourse, and deliberation perspective of Habermas (1990) on public spheres and communication, which is widespread in scholarly discussion. However, recent concepts of 'affective publics' (Papacharissi, 2014) have argued over the relevance of considering affects because this allows focus on relational, processual, and performative aspects, and thus provides broader understanding (Lünenborg, 2019).

According to the common perspective on rationality and cognitive processes, prior studies in the field of dissonance research typically focus on cognitive negotiation whereby, according to the TCD, the emotional sensation after reception plays an important role. The emotional state of a human being can affect the accuracy of his or her beliefs. In recent experimental work, it was found that angry partisans who saw uncorrected political misinformation from their own party held less accurate beliefs than emotionally neutral partisans. This raises concerns that anger can facilitate belief in falsehoods (Scheufele & Krause, 2019; Weeks, 2015). Emotional states, and anger in particular, are assumed to interact with individual ideologies and the information environment—such as the presence or absence of correctives—to influence how people encounter (mis/dis)information. Thus, potentially exacerbating their beliefs in falsehoods and shaping how (mis/dis)information is assimilated into their own worldviews (Scheufele & Krause, 2019).

This study aims to shed light on questions over how people are emotionally affected by online disinformation and how they cope by using different strategies for online information.

2. Coping with Dissonance

In his TCD, Festinger (1957) assumes that people strive for inner psychological consistency. Cognitive dissonance describes a person's mental discomfort that is triggered by a situation in which one is confronted with facts that contradict his or her beliefs, ideals, and values. Basic hypotheses of the TCD (Festinger, 1957, p. 3) are:

1. The existence of dissonance, being psychologically uncomfortable, will motivate the person to try to reduce the dissonance and achieve consonance.
2. When dissonance is present, in addition to trying to reduce it, the person will actively avoid situations and information which would likely increase the dissonance.

Festinger assumes observable manifestations of these pressures (Festinger, 1957). It is important to acknowledge that the state of cognitive dissonance is an aversive motivational state of personal stress (Elliot & Devine, 1994; Harmon-Jones, Harmon-Jones, & Levy, 2015) and it causes negative affect (Harmon-Jones, 2000a). Getting into a dissonant state by being confronted with attitude-inconsistent cognitions initially produces a negative emotional reaction (Garrett, Carnahan, & Lynch, 2013). However, even though this imbalance is caused by a conflict on the cognitive level, experiencing this state encompasses the affective level, including a certain level of arousal. These may vary individually and can arise from the mere presence of a cognitive conflict or from a self-threat, such as the perception that one is poorly informed (Hart et al., 2009). Although cognitive discrepancy and the resulting negative emotions are interacting in the state of dissonance, one can analytically differentiate between behaviour that seeks to reduce the cognitive discrepancy and behaviour of coping with the negative emotional state (Harmon-Jones, 2000b). Surprisingly, although the idea that cognitive dissonance can create an unpleasant feeling is central to the TCD, this is mostly overlooked in research studies (Harmon-Jones, 2000a). Therefore, this study will focus on this emotional perspective.

Looking at information selection behaviour, the desire for cognitive balance was assumed to induce people

to expose themselves to certain types of media content in preference to others, which is well-known as selective exposure hypothesis (D'Alessio & Allen, 2007). In particular, the idea of confirmation-biased selective exposure has long been discussed (Knobloch-Westerwick & Kleinman, 2011). Where empirical studies have oftentimes confirmed the selective exposure towards congruent information, particularly regarding political issues, recent studies have not confirmed the systematic avoidance of incongruent information (Garrett, 2017; Jang, 2014).

However, most empirical research has been carried out on an individual's behaviour to avoid dissonance or incongruent information. Donsbach (2007) has criticised that previous research usually leaves open how people actually handle a situation when confronted with incongruent information, which mostly fails to take into account that dissonance only arises under these conditions. That is why this study will focus on how people cope with their state of dissonance. Individuals do not passively accept this negative state; instead, they engage in either counter-arguments or search for ways to discount or ignore the offending information (Festinger, 1957; Garrett et al., 2013). If the individual is successful in these efforts, and the contradiction between attitude and discrepant evidence is resolved, an individual will feel rewarded or relieved (Garrett et al., 2013). This was shown in a neuroscience study, where areas of the brain associated with pleasure were activated when the challenging information was successfully equilibrated to an emotionally stable judgment (Westen, Blagov, Harenski, Kilts, & Hamann, 2006, p. 1956). Thus, the negative emotional state triggered by counter-attitudinal exposure tends to be short-lived, and successful rejection of the challenge is emotionally rewarding (Garrett et al., 2013).

However, research on the emotional dimension of being confronted with counter-attitudinal information and becoming imbalanced is rare, and even more so is research on how individuals cope with their dissonance, particularly regarding emotional processes. This study focuses on these research questions in the context of 'fake news' exposure. Consequently, this study is guided by the following research questions:

RQ1: What affects do internet users have when confronted with opinion-challenging disinformation?

RQ2: How do they cope with their state of dissonance?

We will use the term 'affect' to cover the arousal and valence of emotions. Whereas (psychological) research has put much effort into theorising and differentiating emotions and affects, it is often criticised that distinctions between affect and emotion are untenable (in communication and media studies; Lünenborg & Maier, 2018). Thus, affect and emotion are often considered as synonymous (Lünenborg, Maier, & Töpper, 2018). Particularly in research on media use and effects, affect usually covers emotions and is discussed regarding aspects of (de)arousal or (de)activation and valence, such as varying degrees of positive-negative or pleasure–displeasure (Konijn, 2013, p. 190; Wirth, 2013, p. 229), as followed here.

Moreover, we will use the term of coping with dissonance instead of reducing. With this, we highlight interests in the processual perspective on individuals' behaviour and their ways of dealing with psychological discomfort (Diestel & Schmidt, 2011; Fogel, 2004).

For our research questions, the highly relevant public issue of climate change is an appropriate context as the phenomena of 'fake news'/mis- and disinformation, filter bubbles, and polarisations are widely discussed on this issue (Fisher, Waggle, & Leifeld, 2012; van der Linden, Leiserowitz, Rosenthal, & Maibach, 2017; Williams, McMurray, Kurz, & Hugo Lambert, 2015).

3. Methods

To explore emotional processes and coping strategies in more depth than in previous research, this study triangulates quantitative and qualitative methods in an innovative research design through the use of surveys, eye tracking, and a post-exposure walkthrough during retrospective interviews (see Figure 1).

In a laboratory setting, university students (n = 50, aged between 19 and 38 years [M = 23.2; SD = 3.5], mostly female [70%], see Supplementary File) were exposed to a stimulus: a YouTube clip titled "The big CO_2 lie explained in 3 minutes, simple and comprehensible," produced by kla.tv (short for Klagemauer TV [Wailing Wall TV]), that proclaims doubts about humans' responsibility for causing climate change (Kla.tv., 2014). For example, the so-called 'Oregon Petition' is presented, according to which scientific research has not proven that high amounts of CO_2 contribute to global warming. This petition was rejected by the National Academy of Sciences in the US (The National Academies of Sciences, Engineering, and Medicine, 1998). Moreover, the 'Heidelberg Appeal' is presented as a statement against man-made climate change, although the Heidelberg Appeal is "a quiet call for reason and a recognition of scientific progress as the solution to, not the cause of, the health and environmental problems that we face" (DeWeese, 2002). Kla.tv (n.d.) introduces itself with "Klagemauer TV entlarvt

Figure 1. Procedure of the study.

Verderben bringende Medienlügen und Lügenmedien!" ("Wailing Wall TV exposes spoiling media lies and lie media!"), indicating a conspiracy background.

Subsequently, the participants were given 10 minutes to perform an internet search that was not restricted to the issue of climate change. Standardised surveys were conducted before the lab stage (t_a: paper-based, about two weeks before), directly after 'fake news' exposure and before the online research (t_b: online), and after the online research (t_c: online). Here, we asked—inter alia—for climate change attitudes (t_a, t_c). As emotions are at the centre of the research, this study is mainly interested in affective attitude components. Therefore, we will analyse an individual's climate change problem awareness (reduced scale of Taddicken & Reif, 2016), first introduced by Taddicken (2013). For measuring the immediate state of dissonance, we conducted in t_b positive and negative affects by means of the German version (Breyer & Bluemke, 2016) of the widely used Positive and Negative Affect Schedule (PANAS) scale (Watson, Clark, & Tellegen, 1988). It is supplemented by three more items particularly interesting in this context. The online research phase was recorded through an eye tracking system. This recording was then used as a stimulus for a post-exposure walkthrough. Participants were asked at this stage to explain their choice of keywords and web pages. These retrospective interviews lasted between 11 and 30 minutes. Finally, a debriefing document was given to the participants. In this document, popular climate change denying arguments were briefly discussed using parts of the IPCC report (BMU, UBA, & German IPCC Coordination Unit, 2017).

To ensure that the stimulus was opinion-challenging for participants, we excluded those who did not fully believe in human-made climate change. The final sample size was n = 39.

The conducted survey data were used to calculate different statistical tests (principal component analysis [PCA], analysis of variance [ANOVA]). The transcripts of the interviews were analysed qualitatively using a deductive-inductive approach, starting with the methodology of Grounded Theory (Glaser & Strauss, 1999). Following the guidelines of Corbin and Strauss (1990), open coding was used first to identify conceptually perceptions, actions, and emotions. They were grouped together to form categories and subcategories. These were then related to different stages during the online research phase according to user-centred approaches of information seeking (Kuhlthau, 1991) and, moreover, to different stages of the process of coping with dissonances (Festinger, 1957).

4. Results

4.1. Research Question 1 on Affects

RQ1: What affects do internet users have when confronted with opinion-challenging disinformation?

To answer RQ1, we looked at the data of the PANAS scale first. Supplementary to the original 20 items were three items interesting in this context: 'confirmed' as a positive affect item and 'confused' and 'insecure' as negative affect items.

Overall, the participants were more negatively affected than positively, which is not surprising as the stimulus was opinion-challenging and of negative tone. What is interesting is the small difference between both affect dimensions and the general level of affect, which is below the middle of the five-point rating scale. The items 'irritable' and 'hostile' of the negative dimension show the highest scores of standard deviations, with answers ranging from 1 to 5, meaning that some participants felt very irritable or hostile while others did not. Thus, individual reactions to the stimulus varied widely (see Supplementary File).

To explore these differences more deeply, we calculated a PCA to further differentiate the emotional states of dissonance. Three different factors were identified: anger, alarm, and activation (see Table 1). In this solution, three of the original positive affect items were not included as their means and standard deviations were both very low.

The first factor explaining the highest proportion of variance is anger, with the highest loadings of feeling 'irritable,' 'hostile,' and 'upset.' The second factor is alarm, with being 'afraid,' 'nervous,' and 'insecure' loading the highest. Both factors are mixed between items of positive and negative affect of the original PANAS scale. The third factor, activation, is composed of only positive affect items, such as 'active,' 'attentive,' and 'alert.' The originally positive affect item 'strong' loads on anger, which indicates that participants felt angry but not weak or defensive. The originally positive affect items 'interested' and 'inspired' load on alarm, which indicates that the feeling of being alarmed by the disinformation also seems to have some elements of curiosity.

In general, the means indicate a medium to low affect level, even though being angry and feeling alarmed by the stimulus is higher than the feeling of being activated by the video (see Table 2).

From these data, we do not know why some participants felt angry, alarmed or activated, and it remains unclear what explicitly caused the affective arousal: the presented content, the format, or the provider. To explore this in more detail, the reconstructive interviews were analysed. The interviews were held in German. Selected citations were translated for this article.

Anger: This had the highest share in explained variances and it became clear that some individuals recognised the stimulus as disinformation and this caused avoidance:

> Because this is bullshit. So….Because I simply don't believe anything about it and just felt mucked about by the presentation alone and just don't want to listen to such right-winged nonsense. (P35)

Table 1. PCA of affect items.

Items	Anger	Alarm	Activation
irritable (n)	.868		
hostile (n)	.812		
upset (n)	.791		
ashamed (n)	.628		
strong (p)	.541		.449
confused *	.465	.427	
afraid (n)		.688	
nervous (n)		.687	
insecure *		.638	
jittery (n)		.609	
distressed (n)		.579	
interested (p)		.560	
inspired (p)		.502	.428
scared (n)		.500	
active (p)			.604
attentive (p)			.598
alert (p)	.443		.551
confirmed *			.512
determined (p)	.447		.497
guilty (n)			.455
enthusiastic (p)			
excited (p)			
proud (p)			
Eigenvalue	5.433	2.848	2.152
Explained variances	23.6%	12.4%	9.4%
Cronbach's Alpha	.820	.787	.723

Notes: Elbow criterion, varimax rotation, factors < .4 shown; explained variance 45.4%; p: positive, n: negative; * additional items.

Compared to the cognitive discrepancy, the affective intensity of the dissonance experience becomes particularly obvious here. The stimulus was seen as hostile content. In some cases, strong emotions were revealed, even anger against the study itself which forced the exposure:

> First of all, I think I should have been warned that the study might trigger certain emotions. Because I'm really a bit pissed off now…that people don't realise that this is actually total bullshit what they are saying. That makes me really aggressive. (P45)

Participants felt annoyed by the idea that other people could believe in the presented content. They showed superior feelings towards these third persons with 'the more impressionable minds' (known as third-person-effect; Davison, 1983, p. 1). This goes along with the finding that the affect item 'strong' belongs to this factor.

Alarm: Besides, participants were alarmed, and feelings of uncertainty were expressed. Some individuals felt irritated and insecure:

> Um, it surprised me, and I…err…would have said I didn't believe it, but it made me think a little. (P56)

Individuals revealed feelings of nervousness about their perceived insecurity:

> And somehow she [the moderator] spoke like that….I don't know….It was like: Is she telling the truth or not? I really wasn't sure after the video how much truth there is in that. (P29)

Table 2. Descriptives of the introduced affect dimensions.

Factors	Mean	Standard deviation	Minimum	Maximum
Anger	2.32	.801	1	4.13
Alarm	2.21	.649	1.33	4.22
Activation	2.03	.553	1.13	3.25

Note: n = 39.

Activation: States of activation were expressed as the motivation to seek for more information and to learn more about other perspectives on climate change:

> And then she [the moderator] also gave facts and percentages…and um, the video definitely made me want to check things again. Because I don't watch a video and believe this to be the truth, but I want to see both sides….And that's why, yeah, I got active and thought, I'll look myself what the net has to say about it. (P48)

Overall, the feeling of imbalance after stimulus exposure was 'only' medium to low; however, emotional responses were not only of a different kind, they were related to perceptions of different reference objects. Three different factors of affects were identified: anger, alarm, and activation. While overall anger was the dominant emotion, the feeling of insecurity and helplessness led to an alarmed state. Activated people mainly seemed curious about unknown and surprising arguments.

4.2. Research Question 2 on Coping

> RQ2: How do they cope with their state of dissonance?

According to Festinger's (1957, pp. 19–22) original theory, individuals can cope with their state of dissonance through different strategies: (1) by adding consonant conditions that reduce the overall level of inconsistency and includes active attempts to seek out new information; (2) by decreasing the importance of the elements involved in the dissonant relations; or (3) by changing one of the dissonance elements, either attitudes, values, opinions, or behaviours (Simon, Greenberg, & Brehm, 1995). Moreover, he assumes—when people are involuntarily confronted with information they would have normally avoided—(0) the "set up [of] quick defensive processes which prevent the new cognition from ever becoming firmly established" (Festinger, 1957, p. 136).

In this study, strategies (1) and (2) are the ones to favour from a normative perspective as these indicate 'fake news resistance'—the same for (0) quick defence—whereas (3) can be seen as democratically problematic.

Overall, participants used a variety of different keywords for their searches, but most often started with "Klimawandel" [climate change] or "Klimalüge" [lie about climate change].

4.2.1. (0) Quick Defence

It is plausible to assume that many of the participants used quick defensive processes to directly avoid the establishment of contra-anthropogenic climate change information. This might explain the relatively low level of dissonance of some individuals directly after exposure.

Throughout the interviews, participants used the expression of 'conspiracy' and 'conspiracy theory' several times and this often seemed to be connected to anger. One individual revealed this as a quick defence argument, but added that searching for counter-arguments was part of the coping strategy:

> I instantly classified her [the moderator] as a conspiracy theorist…so my first search…was to look at all these arguments….It's always the same what the climate change opponents say. Um. Just to look again: Is there perhaps something true about it? But, well…if you already call it a conspiracy theory then it's clear that you're just confirming your own knowledge. (P45)

4.2.2. (1) Adding Consonant Information

In line with this strategy, individuals add consonant conditions to reduce the overall level of inconsistency, which includes active attempts to seek out new and confirming information.

While Germans generally perceive themselves to be fairly knowledgeable about climate change (Taddicken, Kohout, & Hoppe, 2019), specific details in the clip—mainly the named 'Heidelberg Appeal' and the 'Oregon Petition'—caused a desire to seek more information. Here, the participants obviously felt activated:

> The researcher [the moderator] also talked about this…the Oregon…or so. And then I was really interested in how these numbers came about. (P27)

However, in this study participants mainly confirmed their attitudes with the help of reading already known information. This strategy was mainly confirming instead of discovering, which might have resulted from their affective state of anger. It is striking that participants were able to clearly recognise this strategy within their own behaviour and to explicitly express it:

> I wanted to confirm that the information that was shown is false and that my previous knowledge is right. (P58)

Nevertheless, their defence motivation was satisfied by their selection:

> Um, and I got exactly the information that interested me. So you can see that, like, 97 percent [who agree to anthropogenic climate change] is a very large majority, which then, like, which I didn't even know until then. That encouraged me again, like, to see that…there is not at all a fight in science, but that the situation is actually quite clear. (P31)

In sum, the search for concrete information aims to clarify and counter-argue the cited facts. This can be classified as a coping strategy with the aim to dissolve the state of dissonance by trying to overcome the cognitive discrepancy in the first place.

4.2.3. (2) Decrease Dissonant Elements

The coping strategy of confirming was often merged with the strategy of decreasing dissonant information:

> Well, I wanted to see what the opposing voices are actually about and above all I wanted to have a closer look at the proportion…because…I had the feeling that, um, there's a discrepancy. (P31)

In order to devalue dissonant elements, counter-information can be actively sought and considered as helpful when an individual believes he or she can easily refute the information (Frey, 1981). This strategy was clearly used by some subjects:

> I didn't want to hear any more opinions, I wanted to know what that Heidelberg Appeal or uprising or what it was called was….And then I was confirmed, so my opinion was confirmed, that climate change exists and that all these, apparently this Heidelberg Appeal thing is a conspiracy theory, too, in the end. And then I was actually satisfied with it. (P26)

Here, the refutation of dissonant information was used to cope with the dissonance instead of the naive avoidance of the given information. Confirmation that the presented information in the stimulus was not valuable produced a feeling of satisfaction and relief.

In contrast to those individuals who felt activated by the stimulus and interested to find out more about the contra-arguments, others were defensive and mainly or even only interested in discounting the stimulus:

> I have to say, I wasn't really interested in the climate thing. I didn't…I didn't feel like confirming that climate change is real. It didn't make me feel like it at all…because I knew there was such a thing and I was really only interested in what kind of source it was. (P12)

Here, the coping strategy is to confirm one's own view by searching for information to discount the source's credibility. For this aim, content from the clip provider on other public issues was screened, such as denial of the Holocaust, which caused intense indignation with a much higher level of emotional arousal. However, although the success of the discounting was not perceived as surprising it did cause a certain feeling of satisfaction.

Another feeling caused by the stimulus exposure was amusement:

> So, if I'd just seen it at home, I probably wouldn't have googled anything….At home I would have just thought: Ok, honestly, I would have just laughed it away. Maybe, and I think I also ticked [in the questionnaire] that I would share it. Maybe I'd even have shared it with somebody, like: "Hey, look how funny this is!" (P12)

This undermines the assumption that content—even with regard to public science issues—is more likely shared when it evokes surprise or disgust (Scheufele & Krause, 2019; Vosoughi, Roy, & Aral, 2018).

In sum, the participants used coping strategies to refute the stimulus content and discount its credibility. The subjects were less concerned with the (objective) negotiation of the cognitive discrepancy caused by any counter-information. Their main focus was coping with the negative emotional state of dissonance, with feelings of relief and satisfaction being disclosed if that succeeded.

4.2.4. (3) Changing Attitudes

Whereas the former coping strategies can lead to 'fake news resistance,' the coping strategy of changing one of the individual's dissonance elements indicates a problematic consequence: when individuals change to lower problem awareness. We first calculated repeated measures ANOVA. This determines that the means of the index of climate change problem awareness shows a statistically significant difference between the measurements ($F(2, 74) = 8.324$, $p = .001$). Looking at the single items, the means of three of the four items differed significantly between the three different data points. Thus, the stimulus exposure caused a significant decrease of problem awareness. Although this rallies at data point three, the means of problem awareness do not return to the initial level (see Table 3). We did not measure problem awareness after the reception of the debriefing document.

A power analysis was conducted with G*POWER (Faul, Erdfelder, Lang, & Buchner, 2007). The post-hoc test for sensitivity for the repeated measures ANOVA showed an effect size of $f = .36$ for 39 participants (α err prob $= .05$, power $= .80$), with Critical $F = 3.117$, indicating a medium to large effect (Cohen, 1988).

To investigate how many participants changed their affective attitude component problem awareness, we calculated the individual differences over the three data points to count the number of people with a decrease in problem awareness (see Table 4). Half of the participants showed a decrease of problem awareness after the stimulus reception (t_a–t_b). For almost half of the subjects (17 of 38), this effect persists until after the research period (albeit reduced, cf. level of differences).

This result was surprising because we assumed participants would be mainly resistant. Therefore, we explored this more deeply by analysing the retrospective interviews of people with a permanent decrease in problem awareness over the three data points. Different search intentions and behaviours were found in this group of participants.

It became clear that some individuals felt lost in their state of dissonance as they tried to seek out objective information, but were not sure over how to exactly find the information. Participant P04 is a good example: She wanted to "find out if this is really such an alleged lie" and was "trying to find anything scientific about it." She

Table 3. Repeated measurement of climate change problem awareness.

	t_a: before the exposure	t_b: directly after the exposure	t_c: after the internet research		
Item	Mean (SD)	Mean (SD)	Mean (SD)	F	p
Climate change problem awareness.	4.55 (.526)	4.34 (.696)	4.34 (.608)	8.324	.001
Climate change will have a major impact on humans' lives in the future.	4.77 (.427)	4.42 (.858)	4.72 (.510)	5.074	.009
Climate change is a threat to the Earth.	4.56 (.882)	4.26 (1.107)	4.33 (1.009)	6.000	.004
Climate change is one of the biggest challenges for humanity.	4.54 (.643)	4.32 (.739)	4.36 (.707)	2.156	.123
Climate change worries me.	4.26 (.938)	3.97 (.915)	3.97 (.932)	4.098	.021
Cronbach's Alpha	.655	.758	.728		

Notes: n = 38–39; differences calculated with repeated measures ANOVA; response scale from 1 ('do not agree at all') to 5 ('totally agree').

felt insecure about climate change, but also about how to search for the desired information: "I didn't really know how to approach the search" (P04). She often followed recommendations of the used search engine or other platforms, but was mostly dissatisfied with the search results. She glanced over several websites instead of reading some parts more carefully. She had the aim "to search neutrally," which led to an excessive demand and the feeling of helplessness. In the end, this participant still felt ambivalent about the issue (P04).

Another pattern was observed within this group. P08 is taken as an extreme case. She had the highest decrease of problem awareness of the whole sample (difference t_c to t_a = 2.0, t_b to t_a = 2.5 on the five-point-rating scale). She had no clear research strategy but presented a high level of curiosity. She sought out surprising information with a certain uniqueness and alternative positions to traditional news media. Generally, she expressed a high interest in conspiracy theories and felt bored by things already known:

> Hmm….Yeah, well, I'm really interested in conspiracy theories. I would have liked to read something about it somehow….Like where in a way something comes out that you would not have expected. Like what I have read now, it already sounded familiar to me, like what you always hear. (P08)

A high level of attraction of surprising information is clear here. This goes along with the findings of Vosoughi et al. (2018), who identified in their big Twitter study that false stories inspired fear, disgust, and surprise in replies, and suggested that these were more likely shared because they were more novel.

What P08 and P04 have in common is that they both felt insecure because they were unable to fulfil their information desires and finish the coping process. They were unable to dissolve their inner state of tension through the use of media. Where P08 did not feel uncomfortable with the situation, P04 felt dissatisfied. This difference might be caused by different personality traits, such as tolerance of uncertainty or need for cognition, and/or different motivations such as the level of accuracy (Hart et al., 2009).

In sum, different coping strategies following Festinger's original theory could be identified here, although these were sometimes merged. A key strategy was to confirm one's former opinion on the existence of anthropogenic climate change by re-reading already known information instead of searching for new evidence. This helped to overcome cognitive discrepancies. Another dominant strategy was to seek out information about specific details named in the stimulus clip. The retrospective interviews disclosed that it was often done with the aim to refute the claims, such as to discount the source's credibility. In this way they succeeded in dissolving the negative emotional state of dissonance. Quite unexpected, many subjects also used the strategy of changing their view—meaning their climate change problem awareness decreased—although this

Table 4. Changes in problem awareness in absolute numbers of participants.

Problem awareness	t_a–t_b	t_b–t_c	t_a–t_c
Constant	14	20	16
Increased	5	13	5
Decreased	19	5	17

Note: n = 38.

trend weakened after the internet research phase. We further investigated those with a stable decrease and found two different patterns: the feeling of frustration and helplessness due to a lack of media literacy, and a feeling of sensation and attraction of surprising information and alternative worldviews.

5. Limitations

Some methodological shortcomings must be considered. First, the participants were students and thus the sample is younger, more educated, and more trained in internet usage than the German average. This might explain the relatively high level of reflected self-assessments even though this helped to gain deeper insights. As the stimulus exposure and internet research was carried out in the lab questions of external validity may arise. However, the lab was designed to be as comfortable as possible and the time given for the research process was relatively long in order to provide the most natural surroundings possible. Although we conducted post-exposure walk-through interviews and were able to combine overt behaviour with retrospective self-assessments, we were not able to conduct unconscious behaviour and may have forced ex post sense-making processes. Finally, we were not fully successful in provoking the feeling of dissonance. On the one hand this is a clear limitation of our analyses, which ties in with a former critique of cognitive dissonance research (Donsbach, 2007) and should be considered with more attention in future studies. On the other hand, it is also a major finding of this study to confirm that climate change is a non-quested public issue in Germany (BMU & UBA, 2019; Engels, Hüther, Schäfer, & Held, 2013). It would be interesting to repeat the study with other science issues that have not been on the public agenda for so long and are perceived to be more ambivalent. Finally, some ethical concerns must be considered. Although the debriefing was an important component of method design, we did not measure its effect. Some participants showed a relatively strong emotional involvement during the exposure, but this was resolved in subsequent interviews.

6. Conclusion

With this study, we aimed to explore what affects internet users have when confronted with opinion-challenging disinformation and how they cope with their state of dissonance during an internet search. With this, we turned the usual research questions related to dissonance avoidance and confirmation biased-selection behaviour around. While prior research has often analysed how people perceive online disinformation to confirm their attitudes, the question of how users react when being confronted with opinion-challenging disinformation has been overlooked. As this is likely to happen in an online environment that can be called "dissonant public spheres" (Pfetsch, Löblich, & Eilders, 2018), this is highly relevant. Whether or not users are 'fake news resistant,' meaning that online disinformation does not become affective in their opinion-formation processes, is seen to be a major societal challenge in the near future (Garrett, 2017).

Here, we aimed to focus on affects during exposure and coping behaviours. For this, we used an innovative, multidimensional research design which proved to be useful. It became clear that affective arousals as well as coping strategies varied individually and that overt behaviour has to be regarded against the background of individual ideas and motivations: for example, that searching for counter-arguments might be motivated by believing in an easy refutation of them. Confirming neuroscientific findings, we found that individuals felt relieved and satisfied after being able to dissolve their dissonant state and negative arousal. We also found dissatisfaction and frustration if this had not succeeded. It seems important over whether individuals were able to complete their coping process or not. Thus, unfinished coping processes might be an explanation for disenchantment with the media as well as with scientific elites. The high relevance of an adequate level of media and internet literacy is highlighted by this finding.

We were not able to analyse the effects of the disinformation stimulus in more detail in this article. However, the (short-lived) decrease of the affective attitude of problem awareness urges further analyses. Where some individuals seemed to be 'fake news resistant', others were not. Individual characteristics, such as curiosity and openness towards alternative ideas, should be investigated more deeply in this context. Further research on different typologies will be helpful when thinking about how to counteract campaigns of (mis/dis)information on science issues (Iyengar & Massey, 2019).

In addition, it seems worthwhile to analyse the relationship between the various coping strategies and selection behaviour. Thus, identifying the information sources primarily used to confirm previous opinion and which ones are used to find additional—and devaluating—information about the content provider. This would also include the search terms used and how relevant they are, as well as search engine hit lists for the selection of websites. For example, is information from NGOs systematically avoided and traditional journalistic information preferred? What role does social media play (Huber, Barnidge, Gil de Zúñiga, & Liu, 2019)? These and similar questions should be answered in the future.

This study has shown how important future in-depth research is to identifying individual processes of coping with affective arousal when being confronted with disinformation on science issues.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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Article

What Remains in Mind? Effectiveness and Efficiency of Explainers at Conveying Information

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Abstract
Whether and to what extent mass media contribute to the acquisition of knowledge depends fundamentally on the senses addressed by a particular medium. However, there is a lack of current research investigating the effectiveness and efficiency of (new) media, like scrollytelling and explainer videos, at conveying information, compared to established formats like text and audio. To fill this research gap, I conducted an experimental online survey (N = 381) with medium as the independent variable (explainer text vs. audio vs. video vs. scrollytelling) and the recall of information as the dependent variable. The subjects were presented with a popular scientific presentation on the environmental consequences of meat consumption in order to examine a socially relevant, controversial topic and to explore the possible consequences of dissonance on recalling information. As the present study demonstrates, the traditionally lower reputation of moving images in regard to the effectiveness of information transfer is not always justified. Rather, the results show that scrollytelling and video lead to a significantly more extensive recall than audio and in part text media. However, when considering exposure time, text turns out to be the most efficient medium. The dissonance perceived by the participants did not have any significant influence on their recall of information.

Keywords
dissonance; emotions; experiment; explainer video; intermedia comparison; recalling information; science communication; scrollytelling

Issue
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1. Introduction: The Rise of Digital Video and Audio for Knowledge Acquisition

With the emergence of digital platforms, audio and audio-visual content is gaining popularity in the dissemination and acquisition of knowledge (Schneider, Weinmann, Roth, Knop, & Vorderer, 2016) at the expense of text-based formats. Therefore, in the tradition of media theorist Walter Ong (1991), there already is talk of a "return to orality" (Kaeser, 2016) or a "post-text future" (Manjoo, 2018) with YouTube as digital lecture hall. Accordingly, out of the 86% of 12 to 19-year-olds in Germany who use YouTube, a quarter expect to expand their knowledge. Almost half of the pupils describe YouTube as important or even very important for school matters (Jebe, Konietzko, Lichtschlag, & Liebau, 2019). 13% use so-called explainer videos about school topics at least several times a week (Feierabend, Plankenhorn, & Rathgeb, 2017). Altogether, explainer videos have already been watched by about 70% of the population in Germany, making their use much more widespread than in the United States (Krämer & Böhrs, 2017). Such explainers can be defined as "movies from self-production…which explain how to do something or how something works or in which abstract concepts and contexts are explained" (Wolf, 2015, p. 1). In this context, news explainers are used, for instance, to counteract disinformation (Graves & Cherubini, 2016) or to

provide background information about occasionally controversial issues (Spilioti, 2018) in increasingly complex, popularized high-choice news environments (Umbricht & Esser, 2016).

The unmistakable trend towards video is also driven by the economic interests of information intermediaries, as videos are easier to monetize than other formats (Kalogeropoulos, Cherubini, & Newman, 2016). So, publishers are increasingly complementing their text offerings with online videos (Bock, 2016). Newman concludes that the "video-enabled internet is changing the formats and style of digital content, providing competition for, but not replacing text" (2017, p. 20). Altogether, a proliferation of digital knowledge transfer formats can be observed, which is reflected in the heterogeneity of usage patterns (e.g., Costera Meijer & Groot Kormelink, 2015).

The question thus arises as to what consequences these developments will have for informing people. There is no doubt of a positive relation between media use and the acquisition of socially relevant knowledge (Delli Carpini & Keeter, 1996; Eveland & Schmitt, 2015). Yet, clearly, there are "some variations across media channels and types of political learning" (Dimitrova, Shehata, Strömbäck, & Nord, 2014, p. 98). Lang traces these variations primarily back to differences among perceptual channels, temporal constraints, learned signals, and the orientation-eliciting structural features of the various media, which perform an "extremely important role in the automatic allocation of resources" (2006, S63), like attention. In this respect, it is necessary to distinguish between effectiveness and efficiency of information transfer. Effectiveness is understood as learning output, and efficiency as the ratio between input (time spent to consume a specific content) and output (information recall) (Krämer & Böhrs, 2017).

Which medium is the most effective and which the most efficient at conveying (political or scientific) information is of essential importance not only in the pedagogical context, but also for deliberative discourse and decision-making in democracies that depend on well-founded judgements. This is especially true in times of an erosion of a shared knowledge base and the questioning of epistemic authorities (Neuberger et al., 2019). Consequently, Holbert emphasizes, that "perhaps *the* central question for the discipline concerns how media aid citizens in becoming informed voters" (2005, p. 511), or, as Baron puts it, "we should be figuring out the right curricular balance of video, audio, and textual materials" (2017, p. 19).

The developments are also relevant because videos are claimed to possess a higher suggestive power than other formats. In turn, the affective reaction to their content, specifically the induced amount of dissonance, may be an important factor when investigating the recall of information provided by explainers. After all, emotions and cognitions interact closely, and emotions help learners to prioritize information as they process it (Brosch, Scherer, Grandjean, & Sander, 2013; Forgas, 1995; Tyng, Amin, Saad, & Malik, 2017). Therefore, this study aims to investigate the effects of the medium itself and of emotions on recalling information provided by explainers. To pursue this goal, I first explain more about why medium and emotions matter for learning processes and then present the results of my experimental survey.

2. The Power of the Medium

Early research in communication science in this context predominantly concerned the memory of *news*. It mainly showed that individuals remember stimulus material received through print media more extensively than identical material received through broadcasting media (Facorro & DeFleur, 1993; Wilson, 1974). According to Stauffer, Frost, and Rybolt (1981), memory of news is worst for audio formats. In line with that, Daniel and Woody (2010) examined the retention of a 22-minute podcast in comparison to the corresponding text. Like Green (1981), they found that listeners performed more poorly than readers did in completing a quiz about the article.

The "primacy of print" (Furnham & Gunter, 1989, p. 309), or, in the words of Jacoby, Hoyer, and Zimmer, the "superiority of the medium" (1983, p. 212) has been repeatedly stated in experiments, particularly those of the research group around Furnham and Gunter (Furnham & Gunter, 1985, 1987; Gunter & Furnham, 1986). Besides their research on news, they also examined popular scientific contributions, coming to similar conclusions: Print leads to the best recall scores, followed by audio-visual, with audio-only being last (Furnham, Gunter, & Green, 1990). They and other researchers attribute this phenomenon mainly to the fact that text offers its readers greater cognitive control, since processing speed can be freely determined. Videos and audios, on the other hand, are played at a predetermined reception time, which may overload or under-engage recipients (Eveland, Seo, & Marton, 2002; Green, 1981; Lang, 2006). While audios and videos organize "in time" (Noelle-Neumann, 1977, p. 92), text offers orientation in space. Nevertheless, this text feature can stand in the way of an integrated knowledge acquisition process, as recipients can fly over or skip passages (Dalrymple & Scheufele, 2007).

Walma van der Molen and van der Voort (2000) heralded kind of an epistemological turn in the intermedia study of information recall. In their experiment, they found that both adult and child viewers of children's TV news stories recalled more information than readers of the corresponding print news. When, on the other hand, adults received news made for adults (rather than prepared for children), they remembered the content conveyed in the print article better. The researchers argued that the latter TV news stories showed a low degree of redundancy between the image and audio track, i.e., a small amount of semantic overlap between the verbal and visual content. Instead, "standard news pictures"

and "talking head-only items" dominated; these have only a limited supplementary information value because they convey "little meaning and are often at best only partially related to the spoken commentary" (p. 134). The authors expected that the images distract the recipients from the spoken text as the carrier of the main information (see also Sundar, 2000). However, as previous research on so-called cue summation demonstrated, image and audio should not be completely redundant either. Otherwise the recipients are not offered any additional learning cues that facilitate information retrieval (Severin, 1967). If at least 40 to 50% of verbal information has a semantic reference to its visualization, TV can exercise a recall advantage over print, according to Walma van der Molen and Klijn (2004). In this respect, the recipients' limited capacity for information processing should be taken into account. If the information density of a contribution is too high, verbal and visual information might compete for the recipient's limited attention (Lang, 2006).

3. Studying Medium Effects in the Context of Explainers

Research on the effectiveness and efficiency of different media at conveying information has scarcely begun to be transferred to the digital age so far (Powell, Boomgaarden, De Swert, & de Vreese, 2018). Not only do digital videos and audios allow for more cognitive control today than they did during the period of the studies described above, new hybrid formats such as scrollytelling have entered the market. Scrollytelling refers to digital storytelling formats that unfold as you scroll. Thereby multimedia elements like photos, videos, audio, graphics or animations complement text elements (Godulla & Wolf, 2018). Furthermore, by traditionally focusing on *news*, communication science neglected the emergence as well as the effects of popular (science) formats like the explainer videos mentioned above. Explainer videos are characterized by an informal style of presentation as well as a higher degree of narration and didactics than documentary films. Not least, they feature simple language, as well as a complementarity of spoken word and image (Krämer & Böhrs, 2017). For example, the audio track may be illustrated by the visualization of numbers and quantities, and by graphics and theme pictures (Lauter, 2018). It can thus be assumed that explainer videos usually contain a greater amount of semantically related (i.e. redundant) audio-visual information than news stories. This is why I hypothesized that:

> H1a: Subjects exposed to an explainer video will recall significantly more facts than those exposed to the corresponding text.

There is strong research evidence that audio leads to the poorest recall performance. In contrast to video, audio lacks additional retrieval cues, in contrast to text, the rate at which audio information is presented is not determined by the recipient (Daniel & Woody, 2010; Furnham et al., 1990). Therefore, I proposed that:

> H1b: Subjects exposed to an audio contribution will recall significantly fewer facts than those exposed to the corresponding video, text and scrollytelling.

As a hybrid medium, scrollytelling contains textual and audio-visual passages, therefore sharing some of the advantages and disadvantages of both text and video. Consequently, I supposed that:

> H1c: Subjects exposed to scrollytelling will recall significantly fewer facts than those exposed to the corresponding video, but more facts than those exposed to text and audio.

Many intermedia studies dealing with information acquisition have equated exposure time (e.g., Eveland et al., 2002; Furnham et al., 1990; Furnham, Proctor, & Gunter, 1988). However, it can be presumed that the uptake of information occurs at different rates (Furnham et al., 1990). Allowing subjects to self-regulate their exposure time makes it possible to distinguish between effectiveness and efficiency of different media in transferring information. Efficiency is thus derived by weighting the recalled information (= effectiveness) with the respective exposure time (Krämer & Böhrs, 2017).

In digital environments, reading is characterized by a quick, selective scanning of content (Ackerman & Goldsmith, 2011; Baron, 2017; Mangen, Walgermo, & Brønnick, 2013). Audio-visual formats support this reception mode only to a limited extent. This is why I expected that:

> H2: Text is a more efficient format than audio, video and scrollytelling for recalling information.

Furthermore, their larger proportion of redundant audio-visual information makes explainer videos particularly suitable for investigating whether the alleged advantage of video over other media really is due to its semantic overlap, which would be a direct effect of the medium on recalling information. There is considerable evidence to propose an alternative explanation: Due to their vividness, pictorial formats capture recipient's attention comparatively longer than non-pictorial formats (Eveland et al., 2002; Goldberg et al., 2019), which in turns leads to greater recall (Chun & Turk-Browne, 2007). This would be an indirect effect of the medium on information recall. Effects of the different formats would be mediated by exposure time (see also Singer Trakhman, Alexander, & Berkowitz, 2019). Congruently, then, I hypothesized that:

> H3: The assumed higher recall values among the recipients of video are an indirect effect due to higher exposure time.

On the content level, explainers typically tackle socially relevant, complex and at times controversial issues like migration, embryonic stem cell research and global warming. Thus, it is likely that some of their expressed statements will cause cognitive dissonance among some recipients (Hart & Nisbet, 2012). Dissonant evidence is "information that challenges one's ideological worldview or set of cultural values" (Nisbet, Cooper, & Garrett, 2015, p. 37) and that may even lead to questioning one's identity (Kahan, 2013). However, according to the theory of cognitive dissonance (TCD), individuals seek consistency among their cognitions, meaning, among other things, that their attitudes, values and intentions should not contradict each other (Festinger, 2001). Dissonance is perceived as an aversive, unpleasant motivational state and as a result, exposure to dissonant messages may lead to negative metacognitive affective experiences (Harmon-Jones, 2000; Nisbet et al., 2015). Consequently, individuals partly try from the onset to avoid dissonant content, and if this is not possible or expedient, they try to reduce cognitive dissonance, for example by altering one of the inconsistent elements, like their attitude or behavior (Festinger, 2001; Jang, 2014).

The present study focuses on recipients' concrete emotional reactions and its consequences for information recall once they are exposed to potentially dissonant material. Once more because of their vividness, visual stimuli have been hypothesized to be psychologically more activating than pure text, and seem to be processed more emotionally than non-visual stimuli (Geise & Baden, 2015; Powell et al., 2015, 2018, 2019). I therefore concluded that:

> H4: Video and scrollytelling induce stronger feelings of dissonance than text and audio.

Strong emotions at the time of perception are said to promote encoding and recall of semantic information. For example, Doerksen and Shimamura (2001) found evidence that the use of emotional words leads to an increased allocation of attention (see also Kensinger & Corkin, 2003; Lang, 2017). However, it is quite ambiguous to what extent the (positive or negative) valence of emotions promotes or inhibits learning (Heidig, Müller, & Reichelt, 2015; Lang, Sanders-Jackson, Wang, & Rubenking, 2013; Tyng et al., 2017). According to Forgas, negative affect "recruits more careful and substantive processing styles" (1995, p. 50) because it has an alert function. Pekrun, Goetz, Titz, and Perry (2002) differentiated further between negative activating emotions (like anger, anxiety, and shame) and deactivating emotions (such as hopelessness), depending on whether they increase or decrease motivation to process information. Weeks (2015) observed that—rather than a general negative affect—it is anger that facilitates reasoning in the direction of one's own attitudes or beliefs (known as motivated reasoning). Anxious individuals, on the contrary, process the content to which they are exposed more elaborately, as anxiety unfolds in reaction to a threatening external stimulus.

Relatively little research has examined the concrete, typically short-lived emotional reactions accompanying thought generation during the reception of dissonant material. So far, psychological studies have found feelings of discomfort and stress (van Veen, Krug, Schooler, & Carter, 2009), tension, anger and irritation (Zuwerink & Devine, 1996) as well as anxiety, hostility and depression (Russell & Jones, 1980) to be associated with dissonance. Taddicken and Wolff (2020, in this thematic issue) showed that individuals exhibit an alarmed state grounded in feelings of insecurity and helplessness when confronted with opinion-challenging disinformation about climate change. Moreover, individuals expressed a state of activation, indicating they were attentive and curious. The dominant emotion, however, was anger. In general, the different emotions evoked by dissonant messages might affect processing of information partly in opposite directions. As anger seems to be a determining element of dissonance, it is conceivable that individuals confronted with dissonant messages may turn away from content during reception, or selectively recall or forget information in order to resolve the uncomfortable state as an expression of motivated reasoning (Lind, Visentini, Mäntylä, & Del Missier, 2017; Russell & Jones, 1980; see also Taber & Lodge, 2006). Therefore, I hypothesized:

> H5: Feelings of dissonance negatively moderate the relation between the medium and exposure time as well as between the medium and the recall of information.

4. Methods

4.1. Participants

The data for this study were collected in an experimental online survey of internet users in Germany from June 20, 2019, to July 3, 2019. Participants were mainly recruited via social network sites, including Facebook groups that deal with the topic of the stimulus material. Randomly assigned to the four experimental groups, 436 participants completed the questionnaire. 55 cases were excluded because of completing the questionnaire too quickly or spending a disproportionately large or short amount of time on the website with the respective stimulus. I cleaned the dataset of cases that violated Leiner's (2019) quality parameter 'relative speed index' (≤ 2.0), indicating that the participants did not take the survey seriously. Furthermore, I excluded extreme outliers that differed by more than three standard deviations from the respective mean exposure time. As a result, the sample for data analyses consisted of 381 participants (75% female), whose age ranged from 16 to 82 years ($M = 34$; $SD = 15$). 75% had achieved a high school diploma.

4.2. Procedure

First, the participants' topic-specific prior attitude and prior knowledge were measured. Next, participants were randomly assigned to one of four medium conditions (text, audio, video, scrollytelling). An analysis of variance (ANOVA) confirmed that randomization to the experimental conditions was successful. No significant differences were observed between the four experimental groups in terms of age, gender, formal education level and media use (all $p > 0.05$; see Table 1). Afterward, the participants' feelings of dissonance and factual knowledge were surveyed. In order to capture as natural a usage behavior as possible, the knowledge test was not announced in advance, and no learning instructions were given. Respondents were then asked to provide information on their media use and socio-demographics. The questionnaire was completed by a debriefing, which informed the respondents about the nature and purpose of the experiment.

4.3. Materials

Because I decided out of practical considerations to use a pre-existing video, I formulated several requirements that the video had to meet in order to be considered suitable:

1. It must contain neither a brand logo nor familiar testimonials, so (at least the obvious) effects of brand familiarity could be excluded.
2. It had to be long enough to convey a sufficient number of facts, but not too long in order to avoid fatigue.
3. It had to be scalable to text, audio and scrollytelling without sacrificing authenticity, and its audio track had to be comprehensible without the accompanying pictures.
4. It had to convey facts that were unfamiliar to the participants, so that their recall of information could be traced back to the stimulus.
5. Its content had to be topical and enduring.
6. Its content had to be controversial in order to generate sufficient variance in feelings of dissonance.
7. Its audio and image track had to exert a sufficient degree of semantic overlap.

The starting point for the four experimental stimuli was hence a popular scientific video from 2014 (https://edeos.org/projekte/fleisch-und-nachhaltigkeit). It is entertainingly packaged, animated, enriched with graphics and deals with the global ecological impact and sustainability aspects of industrial meat production and consumption. The issue seems appropriate to provoke feelings of dissonance. Non-vegetarians may perceive the message as a potential threat to their lifestyle, which may cause anger (Piazza et al., 2015). In order not to fatigue the participants, I reduced the original length of the video from 7:38 minutes to 5:24 minutes. The equally shortened transcript of the video with a length of 827 words (including instructions) served as the plain text condition. I modified some of the wording that would have seemed untypical for a text contribution. The audio clip consisted of the audio track of the shortened explainer video. The scrollytelling contribution was created using the digital storytelling tool Pageflow. It consisted of a 529-word text interrupted by an information graphic and three video clips of 11, 36 and 19 seconds. Its first page provided instruction as how to navigate the scrollytelling. The amount of semantic information contained in the four forms of media was nearly identical; the passages with slightly different formulations were not covered in the questionnaire (see Supplementary File for a list of the stimuli).

Table 1. Summary of mean comparisons, standard deviations and F-values.

	Text (N = 84)	Audio (N = 100)	Scrollytelling (N = 83)	Video (N = 95)	F
Mediator					
Exposure time	4.62 (2.54)	5.25 (1.21)	5.94 (2.25)	5.59 (1.55)	7.47**
Moderator					
Feeling of dissonance	3.38 (1.20)	3.39 (0.93)	3.38 (1.15)	3.52 (1.17)	.76
Covariates					
Age	35.66 (16.55)	33.86 (15.55)	34.57 (15.10)	33.58 (14.88)	.32
Education	4.94 (1.19)	4.91 (1.07)	4.98 (1.15)	4.88 (1.17)	.13
Prior knowledge	4.60 (1.44)	4.72 (1.37)	4.71 (1.35)	4.79 (1.36)	.31
Prior attitude	5.58 (1.50)	5.80 (1.11)	5.76 (1.10)	5.62 (1.05)	.77
Media use	4.80 (1.14)	4.71 (1.25)	4.48 (1.29)	4.58 (1.30)	1.14

Notes: Cell entries are means, standard deviations in brackets. Covariates: age, formal education level, media use, prior knowledge, prior attitude. ** $p < .01$.

4.4. Measures

4.4.1. Dependent Variables

I assessed *information recall* via seven multiple-choice and three cued recall questions referring to the stimulus material (e.g., E.-J. Lee & Y. W. Kim, 2016). To avoid guesswork, participants had the option to select "do not know" (Taddicken, Reif, & Hoppe, 2018). The questions did not address information that was conveyed solely verbally in the original video. Correct answers were rated with one point, partly correct answers with half a point (only for cued recall questions), and wrong answers with zero points (for a similar approach see Früh, 1980). Thereupon an index was formed from the arithmetic mean of the evaluated responses, ranging from zero to one (M = .63; SD = .21). The factual questions and the operationalization of the following variables are presented in Table S1 in the Supplementary File.

4.4.2. Mediator and Moderator

The *exposure time* (M = 5.32 min.; SD = 1.98 min.) was automatically assessed by the survey tool SoSci. The measurement of the assumed moderator *feeling of dissonance* (M = 3.42; SD = 1.11; Cronbach's α = .72) consisted of eight items oriented toward Breyer and Bluemke's (2016) positive and negative affect schedule (for an overview of measures of affect dimensions see Boyle, Helmes, Matthews, & Izard, 2015). I calculated a principle factor analysis to gain a deeper understanding of the feelings of dissonance that have only been minimally researched so far. The analysis revealed three potential factors (as much as were identified in the study of Taddicken & Wolff, 2020): Feelings of guilt, activation and anger (see Table 2). The first factor includes negative feelings of guilt, fear, insecurity and shame, the second comprises motivation and confirmation. As the factor 'anger' is composed of only one item, it cannot be regarded as an independent factor here. The rotation sums of squared loadings rather indicate a two-factor solution. Moreover, the item 'offended' cross-loads with .34 on factor 1 and with .18 on factor 3.

4.4.3. Covariates

I decided against the assessment of *prior knowledge* via a selection of factual questions (e.g., Greussing & Boomgaarden, 2019; E.-J. Lee & Y. W. Kim, 2016), because this approach may merely reflect a rather arbitrary fraction of the prior knowledge and the questionnaire may be too long and demanding. Moreover, measuring prior knowledge via such a quiz might have alerted the participants to the study's purpose. Instead, participants were asked to self-assess their knowledge on the topic 'environmental consequences of meat consumption' on a 7-point single item scale (M = 4.71; SD = 1.38).

The operationalization of *prior attitude* (M = 5.69 on a 7-point item scale; SD = 1.19, Cronbach's α = .82) encompasses the dimensions of problem awareness and behavioral intention. As a conative component, the latter comprises the willingness to assume responsibility (Taddicken, 2013). Additionally, I controlled for the participants' demographics (gender, age, and formal education level) as well as their media use (consisting of television, radio, newspaper and internet use) (e.g., Greussing & Boomgaarden, 2019).

5. Results

Zero-order correlations between all variables of interest are presented in Table S2 in the Supplementary File. To address H1a–H1c, I conducted an ANOVA. It proved that the medium exerted a significant influence on the recall

Table 2. Principle axis factoring of affect items.

	Factor		
Items	Feelings of guilt	Activation	Anger
guilty	.774		
scared	.684		
insecure	.653		
ashamed	.689		
offended			
confirmed		.866	
motivated*		.677	
upset*			.680
Initial eigenvalue	2.91	1.60	1.01
Explained variance before rotation	36.32%	20.02%	12.56%
Rotation sum of squared loadings	2.30	1.41	.75
Explained variance after rotation	28.57%	17.54%	09.85%
Cronbach's α	.785	.724	

Notes: Kaiser-Guttman criterion and parallel analysis, direct oblimin rotation, factors loading > .4 shown. Explained variance 68.92% (after rotation 55.96%). * positive affect.

Table 3. Contrast analyses of information recall.

	Video	Audio	Text
Video			
Audio	−.07**		
Text	−.04	.03	
Scrollytelling	−.01	.06*	.03

Notes: Cell entries show difference between the mean values of the respective groups. * $p < .05$, ** $p < .01$.

of information ($F(3, 358) = 2.87$, $p < .05$, partial $\eta^2 = .02$, $n = 362$). Contrast analyses (see Table 3) demonstrated that video did not lead to significantly higher recall levels than text ($p = .13$), rejecting H1a. Subjects exposed to the audio contribution recalled significantly fewer facts than those exposed to the corresponding video ($p = .007$) and scrollytelling ($p = .03$). Contrary to expectation, there was no significant difference between the effectiveness of audio and text in terms of successfully transferring information ($p = .27$), thus H1b may only be partly accepted. The reception of scrollytelling resulted in recall levels similar to those of subjects who watched the corresponding video (see Table 3; $p = .65$). Hence, recipients of the scrollytelling were able to recall significantly more information than those of the audio contribution ($p = .03$). Recipients of scrollytelling did not recall significantly more facts than the recipients of text ($p = .31$). H1c is therefore rejected.

As presumed in H2, the effectiveness of information transfer should be distinguished from efficiency. As Welch's ANOVA confirms, exposure time differs significantly across the different media forms: Welch's $F(3, 195.56) = 5.78$, $p < .01$. Subjects were exposed for a significantly longer time to video and scrollytelling than to text. Not surprisingly, depending on the medium, significant differences can be observed regarding the product of information recall and the indexed exposure time (see Table 4), with Welch's $F(3, 206.24) = 4.07$, $p < .01$. Bonferroni post hoc tests reveal that text conveys significantly more information than audio, video and scrollytelling in the same amount of time, confirming H2.

H3 posed that the assumed higher recall values among the recipients of video result from an indirect effect due to higher exposure time. Mediation analysis enables potential indirect effects through exposure time to be separated from the direct effects of the inherent capacities of the respective media (Singer Trakhman et al., 2019), and therefore allows to distinguish between those two rival explanations. I conducted mediation analysis using model 4 of the SPSS PROCESS (Hayes, 2012) macro version 3.3. Because the predictor (i.e., the medium) is multi-categorical, I coded dummy variables with video as the reference category. Again, socio-demographics, media use, prior attitude and prior knowledge were included as covariates. Confidence intervals that do not include zero indicate significance for statistical inference of mediated effects. Except for audio, neither a total nor a direct effect of the medium on information recall could be observed in relation to video (all $p > .05$). Yet, according to Hayes (2018), a total effect is not a prerequisite to indirect effects. Besides, less power is required to detect indirect effects compared to comparably sized total effects (Kenny & Judd, 2014). Mediation analysis confirms H3 in the sense that a negative indirect effect of different media via exposure time was observed when comparing video and text ($ab_{text} = -.034$, 95% CI = [−.069, −.011]). No indirect effects exist when comparing video and audio ($ab_{audio} = -.012$, 95% CI = [−.029, .001]) or video and scrollytelling ($ab_{scrollytelling} = .01$, 95% CI = [−.01, .032]). Thus, the relatively higher recall values associated with video compared to text may be explained by longer exposure time. However, this indirect effect seems to be cancelled out by another, unknown variable (MacKinnon, Krull, & Lockwood, 2000), which is already indicated by the absence of a total effect of text on recall in comparison to video.

Moving to the hypothesized interaction between medium and emotions, as can be seen in Table 5, the lev-

Table 4. Information transfer effectiveness and efficiency.

	a	b	c	d	
	Information recall (= effectiveness)	Exposure time (in s.)	Exposure time index	a*c	Information transfer efficiency
Video	.66 (.21)	335 (96)	.82	.54	89
Audio	.59 (.20)	312 (76)	.88	.52	84
Text	.61 (.24)	275 (151)	1	.61	100
Scrollytelling	.65 (2.0)	355 (134)	.78	.51	81

Notes: Cell a–b entries are means with standard deviations in brackets. The exposure time index is based on the lowest mean exposure time. Information transfer efficiency is the indexed product of effectiveness and exposure time index, with value 100 for most efficient medium.

Table 5. Feeling of dissonance and its factors.

	Text (N = 89)	Audio (N = 101)	Scrollytelling (N = 85)	Video (N = 102–103)	F
Feeling of dissonance	3.38 (1.20)	3.39 (0.93)	3.38 (1.15)	3.52 (1.17)	.39
Feelings of guilt	3.25 (1.59)	3.25 (1.52)	3.13 (1.52)	3.54 (1.47)	1.26
Activation	4.39 (1.82)	4.74 (1.60)	4.77 (1.56)	4.44 (1.83)	1.23
Anger	3.08 (2.14)	2.78 (2.03)	2.99 (2.16)	2.97 (2.09)	.34

Notes: Cell entries are means, standard deviations in brackets.

els of feelings of dissonance did not differ significantly between the four media, which is why H4 is rejected. The distribution of the two items 'offended' and 'upset' thereby is skewed to the right, i.e. the majority of respondents felt neither offended nor upset by the reception of the contribution.

With regard to H5, which proposed that recalling information is affected by the feeling of dissonance, either by reducing exposure or by selective recall of information, I executed a moderated mediation analysis using model 8 with video as the reference category and the (manually standardized) feeling of dissonance as the moderator (see Figure 1). As we already noticed in Table 5, the means of the feeling of dissonance and its previously identified factors hardly differ between the treatment groups. Therefore, not surprisingly, no significant interaction effects of the different media and the feeling of dissonance on exposure time or information recall could be observed. This means that path a and c do not significantly differ along the different levels of the moderator (Hayes, 2015). Interaction effects were also examined separately for each of the three identified factors of dissonance perception and were not confirmed. H5 consequently is rejected. Participants neither turned away from the medium when experienced as dissonant (as their exposure time was not shorter compared to those who did not express feelings of dissonance), nor did they seem to selectively remember or forget dissonant information.

6. Discussion

Audio-visual formats have not enjoyed a good reputation in the past, when it comes to recalling information. Bock

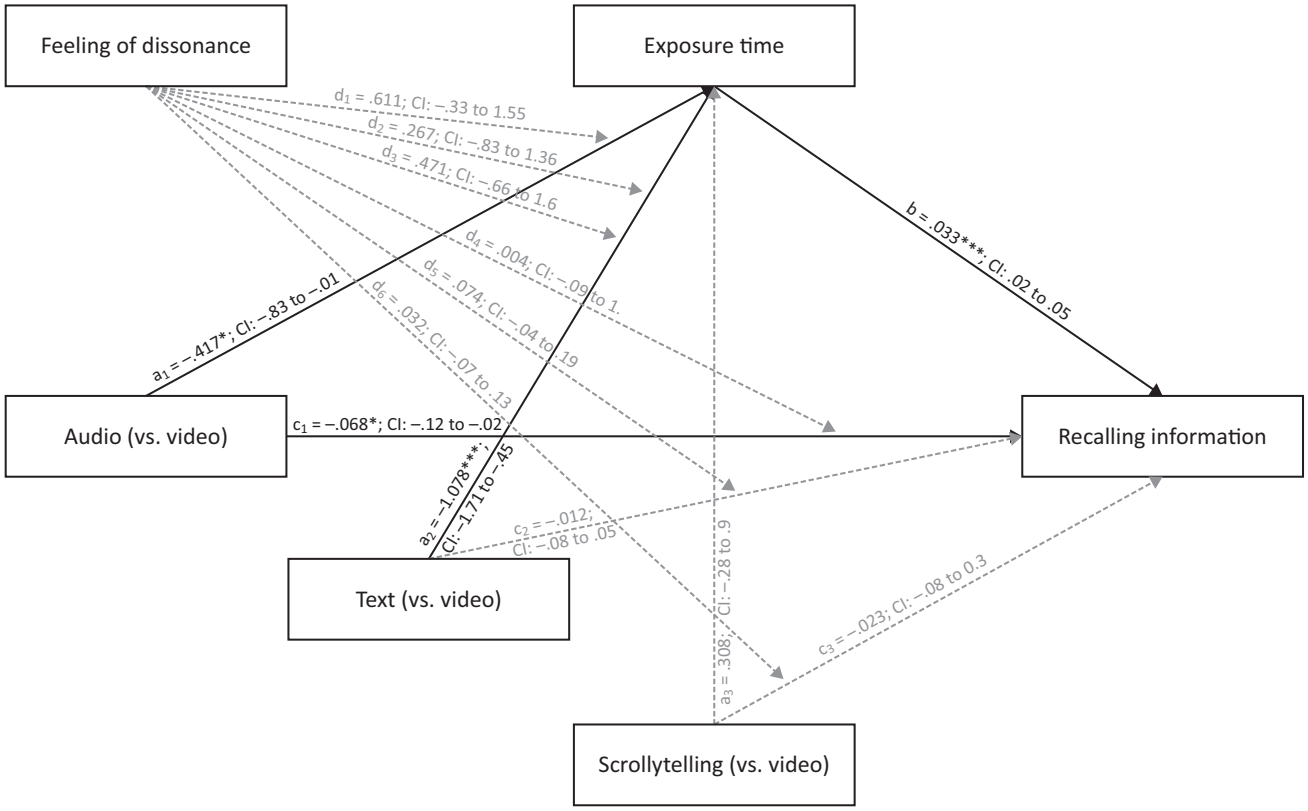

Figure 1. Moderated mediation model. Notes: Numbers represent path coefficients calculated via bootstrapping with 5,000 bootstrap samples and 95% bias-corrected confidence intervals. Video serves as the reference category. Solid lines indicate significant paths. * $p < .05$, ** $p < .01$, *** $p < .001$.

(2016) argues that behind this criticism lies a historical cultural evaluation of word over picture, both on the part of the audience and the producers.

The devaluation of moving images is not always justified, however, as the present article demonstrates. The media formats do not differ substantially with regard to the recipients' level of information recall. Multimodal media like video and scrollytelling, at least when characterized by a certain degree of semantic overlap among the audio and visual tracks, seem to be as effective as text in promoting the transfer at least of certain information. In contrast, audio, as a single-channel medium, leads to the lowest levels of information recall. Despite similar exposure time, audio and video lead to different recall values; this result indicates a direct effect of medium on the recall of information. This is in line with previous research and the theoretical framework of cue summation, arguing for the learning benefits of an increasing number of retrieval cues.

However, in comparison to text, explainer videos and scrollytelling do not lead to equal information recall *per se*, but rather seem to convey information also through their ability to bind attention for longer durations. So one central question in science communication is how long individuals can be motivated for reception. Apparently, feelings of dissonance do not play a central role here: Neither they nor their factors significantly influenced exposure time. Perhaps individuals perceived a lack of action implication (Harmon-Jones, Harmon-Jones, & Levy, 2015) or incentive to learn (Pekrun et al., 2002). Alternatively, as indicated by the low means of the 'anger'-reflecting item (see Table 5), they did not feel ("sufficiently") threatened or offended by the explainer to follow motivated reasoning. In any case, the absence of (short-term) effects of dissonance on recall is good news for explainers aiming to rationalize the deliberative discourse. The often invoked suggestive power of moving images should thereby not be overemphasized. Videos did not trigger stronger dissonant feelings than the other formats examined. Similarly, Powell et al. showed that "vivid news videos did not evoke a strong emotional response" (2018, p. 591; see also MacKay & Ahmetzanov, 2005).

Video nevertheless may be the more effective medium, while text is the more efficient, which may be traced back to the fact that text still allows individuals for the most differentiated information selection. This is reflected in user preferences for online news: About two-thirds of the adult online users surveyed in the 2019 Reuters Institute Digital News Report prefer news in text form to video form. Affinity for text is justified by the ease and rapidity of reading (Kalogeropoulos, 2019). The relatively low information transfer efficiency of scrollytelling may partly be explained by the rather unconventional click-through process.

From a methodological point of view, this study highlights the importance of considering exposure time as a factor of attention and recalling information. A free allocation of exposure time corresponds to natural usage behavior (Ackerman & Goldsmith, 2011). On the other hand, to move on to the limitations of the study, unlimited exposure time may simultaneously confound the results. As a solution, Jacoby et al. (1983) proposed dividing participants into one group without and one group with an exposure time limit. Accordingly, Ackerman and Goldsmith (2011) conducted two experiments regarding text learning from printed hardcopy versus from computer screen, one with fixed and the other with self-regulated study-time. They demonstrated that no differences in test performance occurred under the fixed study time condition. Under the self-paced study condition, worse performance was observed on screen than on paper. Because it was impossible to manipulate the mediator in this study, I can make only limited assumptions about the causal chain of the indirect effect.

In contrast to many previous studies (for an overview see Brosius, 1995, pp. 36–37), the majority of the subjects answered the quiz largely correctly (see Table S3 in the Supplementary File)—a fact that may not only be traced back to guessing, but also to the difficulty level of the questions. It might not have been sufficiently exhaustive, which could be investigated in future studies applying item response theory (IRT) models. Moreover, exposure to the stimulus was forced in this study. Under natural circumstances, it would be feasible that recipients whose attitudes are opposed to the issue of the contribution would not even pay attention to it (e.g., Dylko et al., 2017). However, contact with dissonant information may happen incidentally due to social interaction, or intentionally to sharpen one's own argument (Festinger, 2001; J. K. Lee & E. Kim, 2017) and therefore is quite likely especially in today's media environment (Taddicken & Wolff, 2020). Actually, the challenging nature of dissonant information may make it all the more conspicuous and thought-provoking to recipients, so that they remember it just as much as or better than consonant information (Wicks, 1995).

Consequently, future research should consider the *quality* of exposure. As with all online experiments, I had no control over how intensively the participants received the respective contribution. With the formula "television is easy, print is tough", Salomon (1984) proposed that the processing of audio-visual stimuli is automated and therefore unconscious and non-reflective (and more emotional). Text is said to require and to foster higher processing energy than (audio-)visual materials (Eveland et al., 2002; Geise & Baden, 2015; Lang, 2006; Powell et al., 2015, 2018, 2019). However, to quote Grabe, Lang, and Zhao, "Television viewing, although it 'feels' simple, is in fact a complex and difficult cognitive task" (2003, p. 390).

The research evidence regarding scrollytelling is even more ambiguous: On the one side, scrollytelling's multimedia elements may cause sensory overload or cue distraction which can hinder information processing (Sundar, 2000). On the other side, interactivity such as

scrolling through the story may enhance elaboration and learning (Xu & Sundar, 2016). Further, the narrative flow, ergo the consecutive presentation of text passages and video sequences in scrollytelling, may impede distractions, interferences or cognitive overload (Pincus, Wojcieszak, & Boomgarden, 2017; see also Lang, 2006). Future research should therefore take into account the degree of elaboration in the reception of (popular) scientific content. It seems plausible that elaboration cancels out the indirect effect of exposure time observed in the mediation analysis to a certain degree.

A further limitation that is typical in the context of online experiments is, besides a lack of sample representativeness and the capacity to address only short-term information recall rather than knowledge, the one stimulus only-procedure. Because effects are topic-related, they are difficult to generalize (Reeves, Yeykelis, & Cummings, 2016). Therefore, similar research dealing with other, potentially dissonance-provoking stimuli is necessary, especially since the levels of dissonant feelings were quite moderate and there may therefore have been a lack of variance in the moderation model. It cannot be ruled out that long-term effects of dissonance on knowledge may occur. Finally, yet importantly, increased attention in the experimental context can be assumed. Individuals are likely to multitask, especially when consuming audio-visual content (Eveland et al., 2002). In digital contexts, this even applies to reading (Baron, 2017).

Despite these constraints, in relation to audio, new formats like explainer videos and scrollytelling are promising media for imparting information. In terms of accommodating people with less developed reading literacy and information processing skills (Grabe, Kamhawi, & Yegiyan, 2009; Kleinnijenhuis, 1991), audio-visual formats can serve as a "knowledge leveler" (Neuman, 1976, p. 122; see also Hollander, 2014). Future experimental research should therefore further address the characteristics of audio-visual and hybrid formats that facilitate recalling information, such as subtitling (especially in the context of videos embedded in social media), and the optimal ratio of video and text passages.

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Conflict of Interests

The author declares no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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