Science Communication and Trust

Edited by
Antoinette Fage-Butler ·
Loni Ledderer · Kristian H. Nielsen

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Introduction

Antoinette Fage-Butler, Loni Ledderer,
and Kristian H. Nielsen

The Background to This Volume

This edited volume represents one of the main outputs of the research project called "(Mis)trust of Scientific Expertise" (MSE) that received funding from Aarhus University Research Foundation in Denmark at the end of 2019. It presents international scholarship that probes various aspects of public trust in science communication, exemplifying a range of different methods and reflecting multidisciplinary engagements with the book's theme: science communication and trust.

When we established our research project, public mistrust of science was increasingly thematised by the media as a matter of concern and had

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garnered growing academic attention (Gawande, 2016; Oreskes, 2019; Tsipursky, 2018; Woods, 2019). This attention to mistrust reflected disquiet about an apparent general crisis of societal trust (Blöbaum, 2021). With populism gaining in popularity around the world, concerns were expressed that populist ideologies could negatively impact both scientific credibility and democracy (Collins et al., 2019), as scientific expertise is often considered a cornerstone of democracy, underpinning governance, security and stability (Turner, 2013). Concerns were also expressed about how the relatively unregulated and open spaces facilitated by social media might negatively impact the credibility of science (Weingart & Guenther, 2016). Surveys, however, show that the levels of public trust in science have remained relatively robust (Cologna et al., 2025; National Science Foundation, 2024).

The overarching aim of our research project was to investigate the phenomena of public trust and mistrust as they applied in the context of communication about scientific topics. We chose to explore two cases that had previously been associated with public mistrust: the MMR vaccine and climate science. Trust has long been an object of interest particularly in the social sciences (Hardin, 2002, 2006; Misztal, 1996; Sztompka, 1999) as trust—or "confidence under more or less complex conditions" (Simmel, 1950, p. 318)—provides "important synthetic forces within society" (Simmel, 1950, p. 318). These support cooperative behaviours (Castelfranchi & Falcone, 2010) and solidarity (Misztal, 1996), reduce complexity (Giddens, 1990; Luhmann, 1979) and have been considered a form of social capital associated with economic prosperity (Fukuyama, 1996; Putnam et al., 1993) and well-being (Fukuyama, 1996). Mistrust, on the other hand, has often been depicted as a "social acid" (Carey, 2017, p. 2) that not only hinders such outcomes, but can lead to the opposite effects. In previous research, trust and mistrust have often been investigated as attitudinal phenomena (Dixson et al., 2022). Our research project set out to address the relative lack of research engagement with trust and mistrust of science as cultural and discursive phenomena, focusing on public (mis)trust of climate science communication and vaccine science communication. We wanted, among other things, to explore how (mis)trust of science was evident at the level of language, as both trust and mistrust could be communicated and spread in online contexts. As Blöbaum (2021) asserts, "through communication, trust can be established and maintained. Trust is a social phenomenon linked to communication" (p. 4).

The project group met at the start of 2020 and began making plans for future activities. But the world changed abruptly as the SARS-CoV-2 virus spread around the world, forcing an unsolicited "metamorphosis" (Latour, 2021). News reports of the COVID-19 pandemic showed hard-pressed hospitals, overworked medical staff and patients on ventilators, and the ravages of the virus were poignantly evident in reports of increasing numbers of deaths of those who had succumbed to the disease. At press conferences, heads of state around the world announced governmental responses to the public health crisis. To avoid spreading the disease, citizens needed to heavily curtail their usual social engagements, and that meant, for example, working from home, where possible.

This new and potentially deadly coronavirus provided a case for observing our phenomenon of interest—public (mis)trust of scientific expertise—during an unfolding global public health crisis. With the outbreak of the pandemic, populations around the world were reminded by national politicians and the World Health Organization to "trust the science" (Fage-Butler, 2024), while scientists spoke more cautiously about their evolving "best-for-now" knowledge of the pandemic (Fage-Butler, 2023). Interestingly, people's trust in science increased globally during the pandemic (Wellcome Global Monitor, 2020). Our research group had already planned to examine public trust of the MMR vaccine, but the public health response to the COVID-19 pandemic involved new approaches to vaccinology (i.e., mRNA technology). Would the public trust the science behind these new vaccines? We are currently pursuing this question in a literature review on public trust in COVID-19 vaccines. The need for public trust of the new vaccines prompted questions about the intricate trust links between members of the public and scientific institutions/governments, the importance of scientific and other forms of knowledge, as well as the role of societal and individual values in trust relations (Fage-Butler, 2022).

Climate change, our second project theme, was also impacted by the pandemic: lockdowns had resulted in lower levels of carbon emissions, as many industries reduced or suspended production (United Nations, 2021) and there were fewer workers commuting. Hopes were expressed that the broad adherence shown by the public towards the public health COVID-19 recommendations might mean that the climate change crisis, an evidently intractable "wicked problem" (Lazarus, 2009; Levin et al., 2012) for many decades, could be addressed in a similar fashion. Was it possible to achieve the global political resolve that was needed to address the climate crisis, and could alternative behaviours and practices than those that had brought about climate change be adopted by societies at large? We explored public trust in climate science in a literature review using a systematic meta-narrative methodology (Fage-Butler et al., 2022a). Another investigation conducted by the research project group included empirical research that employed qualitative framing analysis and computational analysis of mistrust relating to the MMR vaccine in Danish newspaper articles, using references to the Wakefield controversy as a proxy for expressions referring to mistrust of the vaccine (Fage-Butler et al., 2022b).

A significant milestone for the MSE research group was the online conference called "Scientific Expertise, Communication and Trust" (SECAT) that we held in September 2022. Over 100 participants from around the world attended the conference, facilitated by the development of video conferencing technology that had come into its own during the pandemic. In our call for papers, we emphasised our intention to establish an international and sustainable conference that highlighted the many disciplines engaging with the themes of the conference (scientific expertise, communication and trust), and that showcased different methods and theoretical approaches. The 22 contributed chapters in this volume represent just under half of the papers from the conference.

Our desire to present the disciplinary, theoretical and methodological diversity evident among researchers exploring the themes of science communication and trust reflected the project's original emphasis on trust and mistrust as cultural phenomena. However, as time went by, we found that context was just as much if not perhaps an even more valuable concept to the exploration of trust and mistrust as they pertain to science communication, no doubt because trust is always relational and thus always involves a context for those relations (Hardin, 2002, pp. xx–xxi). The COVID-19 pandemic that unfolded simultaneously with our project epitomised the importance of context. Public trust (and mistrust) in scientific authorities during the pandemic reflected the existing and evolving relations between members of the public and the scientific and political institutions that advocated public health measures. Similarly, the ways in which politicians communicated with publics reflected nations' historical contexts and were charged with sociocultural norms (Bjørkdahl et al., 2021; Fage-Butler, 2024; Lilleker et al., 2021). Social media provided their own contexts and affordances for communication that could impact trust relations during the pandemic (Johnson et al., 2020; WHO, 2020). Moreover, people's individual contexts, histories and life situations played a significant role in whether they adopted the recommended public health measures or not (Jønsson et al., 2022, in review). Sociodemographics clearly mattered to pandemic behaviours (Belot et al., 2021) just as they also were reflected in trust levels towards public health recommendations during the pandemic (Evans & Hargittai, 2020).

Our project's growing concern with context meant that complexity became an integral aspect of our research inquiry—and we reflected this in a small but significant alteration to the project's title. The original title of our project was "Mistrust of Scientific Expertise"; this changed around halfway through the project to the homonymic "(Mis)trust of Scientific Expertise" to suggest more complex and ambivalent relations between trust and mistrust, where, for example, an individual may hold coexisting positions on trust and mistrust on a scientific topic, or where understanding scientific expertise itself requires a delicate balancing of mistrust and trust. The orthographic change also helped to signify that our concern was not (and had not been) a normative agenda to "fix the problem" of mistrust, but rather to understand it as a societal phenomenon. Our aims were explorative, as we wished to capture some of the complexity of (mis)trust in the context of science communication, on the basis that the devil is indeed in the details.

A word now about the other half of the title of our book: science communication. The field of science communication has in recent years "attracted continuously growing attention" (Bucchi & Trench, 2021a, p. 1). It is often appealed to as a way (or the way) of addressing societal problems from a technocratic point of view, which Bucchi (2009) explored critically, as technocratic science communication tends to presume lack of knowledge on the part of both the public and politicians. Understandings of science communication have undergone radical changes over the years. Where once science communication had been considered (and to some extent still is considered) a means of providing "quick fixes and solutions" (Bucchi & Trench, 2021b, p. 9) to problems in society, Bucchi and Trench (2021b) propose that science communication would be better understood as "the social conversation around science" (p. 1), where communication is multi-way and inclusive. In line with this, science communication (both as a field and a practice) is evolving beyond a reliance on deficit models of communication. It shows growing acknowledgement of the importance of communicating with and between disparate publics (Bucchi & Trench, 2021a, 2021b), and it increasingly recognises the benefits of adopting participatory approaches that acknowledge the role of values (Entradas et al., 2023; Irwin, 2021; Phillips et al., 2012). Davies and Horst (2016) assert that "[s]cience communication is not simply about making difficult things more simple" (p. 2); instead, it should be examined as a fundamental societal aspect and activity, both impacting and being impacted by culture. Our volume with its focus on context, culture and complexity subscribes to such understandings of science communication. Empirical chapters showcase various speakers and settings, showing how trust features in science communication, while theoretical chapters unpack various conceptual aspects of trust as it relates to the contexts of science communication.

Our Aims with the Book

With its combined focus on science communication and trust, our volume appears to be the first of its kind. Situated at the confluence of the three thematic areas of scientific expertise, communication and trust, it brings a concerted focus on what is being communicated (scientific expertise), how it is being conveyed (communication), and what effects it may have on attitudes and behaviours or what antecedents may impact public perceptions of trustworthiness. Besides exploring these content areas, it aims to do the following: present some of the rich variety characterising research on science communication and trust, probe the vital role of context, showcase the work of international scholars, and demonstrate the strength of multidisciplinary approaches.

Some of the chapters explore what are called "wicked problems" (Auld et al., 2021; Lazarus, 2009; Rittel & Webber, 1973; Wohlgezogen et al., 2020), i.e., problems for policymakers that are "complex, intractable and value-laden" (Fage-Butler, 2024, p. 37) such as vaccine uptake, managing the COVID-19 pandemic and tackling climate change (e.g., Auld et al., 2021; Hohaus, 2022). Understanding the nature of wicked problems has been and still is a major challenge for problem-solving (Rittel & Webber, 1973). A core obstacle in effectively addressing such wicked problems lies in the exchange, reception and assimilation of knowledge among diverse people (Weber & Khademian, 2008). However, knowledge sharing between scientific authorities and the public and creating and integrating common understandings are considered key to building both collaborative capacity and trust (Entradas et al., 2023). Thus, transdisciplinary research (Pohl et al., 2017) that involves multiple stakeholders including publics has been recommended for wicked problems and for challenging problems of a socio-scientific nature—where science and values are embroiled—or what Funtowicz and Ravetz (1994) call "post-normal science".

Context may be understood as a kind of frame that is created and recreated around an event, as circumstances that set the scene for an event, utterance, or idea and thereby establish the frame for how it can be understood and assessed (Goodwin & Duranti, 1992). Context is evident in how people engage and interact in social activities in specific settings, including communicative ones. The phenomena of scientific expertise, communication and trust are global, but, as this book illustrates, context is essential when investigating them. Considering context allows for a more nuanced analysis of how elements interact and vary across different cultural, social and political landscapes. Without this consideration, research may overlook key factors that influence public perception and engagement with science, leading to incomplete or skewed conclusions.

Reflecting the central importance of context in this book are the contributions of international scholars, mainly working in Europe, the USA, and Australasia; a few of the contributors have backgrounds or affiliations that extend the international scope represented in the book to Africa and South America. A number of the empirical chapters include a national focus, exploring science communication as it unfolds in the politico-cultural context of the nation state.

Addressing the areas of scientific expertise, communication, and trust is challenging and demands the perspectives of various disciplines. Reflecting this reality, the volume adopts a multidisciplinary approach, including research from disciplines such as media studies, journalism, rhetoric, philosophy, psychology and science communication. The authors contributing to the volume also present a range of methods including surveys, experiments, literature analyses, and discourse analysis, that cut across the quantitative and qualitative divide and facilitate more comprehensive analysis. It is hoped that the methodological heterogeneity represented in the chapters may inspire other scholars working in the field.

Overview of the Content of the Book

Summary of Chapters in Part I: Trustworthy Science Communicators

Trustworthiness is often seen as more important than trust in science communication, as trust can be misplaced if the person or authority one trusts is untrustworthy (Hardin, 2006; O'Neill, 2002). The chapters in Part I attend to the thematic area of trustworthy science communicators, reflecting various empirical, theoretical and methodological concerns.

In Chapter 2, Pamela Pietrucci and Frederik Appel Olsen conceptualise the ethos of science as a source of trust. With reference to public communication before and after the COVID-19 pandemic, they characterise the ethos of the "scientist citizen", elaborating on the idea of scientist citizenship with "scientist activism" which involves more radical rhetorical means of engaging the public. The authors argue for the need to conceptualise an integrated ethos for scientific experts that straddles both scientist citizenship and scientist activism. They conclude by encouraging public experts to cultivate deeper awareness of the rhetorical contexts in which they go public to cultivate meaningful agency in times of crisis.

Chapter 3 by Inês Nepomuceno Navalhas is concerned with public trust in scientists and analyses data from a survey conducted in Portugal with engineering and science students and teachers to understand who they trust as an information source. The results show that both groups, despite age and career differences, largely trust scientists at universities, public research institutions and companies. The author argues that science communication might help to build relations of trust between scientists and the public.

In Chapter 4, Alberta Giorgi and Hande Eslen-Ziya highlight the centrality of emotions in contemporary epistemic conflicts, emphasising their impact on subjectivity and collective identities. The authors discuss, for example, how emotions are moderated within online groups, and the impact of societal structures on emotional expression. By exploring these complexities, researchers can gain deeper understanding of intricate post-truth dynamics. The authors argue that exploring how conventionalised "feeling rules" towards science are established in online epistemic conflicts can advance understandings of transformations of epistemic trust as well as the social and political implications of these transformations.

In Chapter 5, Jessica Gall Myrick and Helena Bilandzic explore scientific information in times of crisis. During a crisis such as the COVID-19 pandemic, audiences seek information from trusted individuals to reduce anxiety. Celebrity scientists can develop a special connection with audiences and provide social and emotional support to the public beyond their expert role. The authors propose that trust in science is to some extent fuelled by scientists who appear in public. Celebrity scientists have the potential to personalise facts and humanise science, provided that the public knows and trusts them.

In Chapter 6, Kaija Biermann presents an analytical framework for examining scientists' communicative roles in digital communication environments that includes the key concept of "journalistic role" which combines subjective and more socially structured perspectives on roles. She illustrates the framework with results from a case study, concluding that the extent to which scientists function as embodiments of trustworthy scientific knowledge ultimately depends on the communicative roles they adopt, hence the value of further research on their roles in online public arenas.

In Chapter 7, Janiv Gabbai-Müller and Alexandra R. Kratschmer investigate scientists from science-denialist communities who are presented as martyr-like heroes, going against the scientific establishment to uncover inconvenient truths. The authors use data from news websites, blogs and social media, and analyse science-denialist narratives, defining the "dissentient expert" as a recurrent martyr-like protagonist with a denialist agenda. The narrative typically follows a script where a brilliant expert detects that the scientific establishment is holding back essential information from the public to promote its interests. The authors suggest that insights from the chapter on narratives and archetypes could bolster science communication.

Summary of Chapters in Part II: Trust and the Contexts of Science Communication

The chapters in Part II attend to the question of trust as it relates to the field and practice of science communication. Disciplinary issues and other contextual matters relating to trust in science communication are discussed.

In Chapter 8, Will Rifkin, Nic Badullovich, Lisa Bailey, Heather Bray, Martin Espig, Alison Kershaw, Nancy Longnecker, Jennifer Manyweathers and Matthew S. Nurse present Irwin's (2021) theory of third-order thinking about science communication which draws attention to messiness, multi-lateral epistemic asymmetries and reflexivity, and they demonstrate how it resonates with their experiences as science communication practitioners. In this approach to science communication, instead of translating scientific information for audiences to ensure that they trust scientific experts, science communicators should focus on participatory practices, dialogue and critical self-reflection. The authors recommend further engagement with and development of third-order thinking to address the wicked problems facing societies.

In Chapter 9, Tobias Kreutzer, defining science broadly in the German tradition of *Wissenschaft*, notes that insufficient attention has been paid to the issue of academic disciplines in discussions of trust in science. Science is indeed not monolithic but consists of fragmented sites of knowledge production (disciplines) with different trust expectations towards the various disciplines. Kreutzer sees a special role for science studies and the social sciences in supporting discipline-specific reflexivity, with implications for public trust in science communication.

In Chapter 10, Brandi Morris highlights the value of stories in risk communication for gaining public trust. With biology as her point of departure, she argues that people are cognitively wired for stories, rather than abstract thinking. As such, risk communicators would benefit from going beyond purely informational frames and integrating stories in their communicative repertoire as they may bring about affective engagement, leading to the public realising the behavioural goals of risk communicators. She calls for further research to explore more fully the impact of story elements on public trust in science communication.

In Chapter 11, Adalberto Fernandes unpacks trust's complex relationship with knowledge, contrasting radical trust (trusting implicitly, without recourse to knowledge) with calls from science communicators to trust science on the basis that we (the public) may know, even imprecisely, that scientific practices are trustworthy (semi-trust). However, Fernandes argues that radical trust may still prevail in the context of science communication if members of the public themselves choose to radically trust scientists instead of seeking to engage with the science, or if their chances of engaging in semi-trust (consciously trusting) are negatively impacted due to socioeconomic disadvantage.

In Chapter 12, Sanna Kivimäki and Arko Olesk explore how (national) language policies shape science communication in Estonia and Finland. They argue that language is central to science communication and is a matter of particular interest in multilingual societies and contexts where language choice is influenced by political and cultural concerns. The authors discuss the implications that linguistic choices have for public trust in science communication and urge a more language-sensitive research agenda on science communication, diversity and trust.

In Chapter 13, Adán Lerma-Mayer highlights the challenges to public trust posed by online contexts of science communication. The author presents a three-pronged model of dialogic communication to address challenges such as those posed by the epistemically weak online context for communication, lack of trust in science, and biases. The model seeks to address cognitive, sociocultural and technological biases and reflects awareness of the need for relationship-building, also considered key to trust in science communication.

In Chapter 14, Claire Roney and Edoardo Anziano conduct a quantitative content analysis of construal levels (degrees of concreteness/abstractness) in journalists' representation of glyphosate, the chemical in the Monsanto weedkiller Roundup, in digital news articles in English from international outlets in Germany and France, after studies revealed its carcinogenic effects. They conclude that mixed construals seemed to indicate a missed opportunity for journalists to concretise glyphosate, and they recommend follow-up studies, including exploring the impact of journalists' use of construals on public trust in science communication.

In Chapter 15, Michael A. Poerio and Erik Stengler explore a prevalent trope—namely, science agencies as antagonists, associated with unethical conduct—in seven science-fiction films. Their analysis reveals themes, character types and narrative choices associated with this trope. Given the potential impact of such cultural representations on public trust in science communication, the authors recommend a future research programme that explores science-fiction's role in shaping the relationship between science and society.

Summary of Chapters in Part III: Trust in Science Communication

The chapters in Part III centre on trust. They collectively emphasise the complexity and multifaceted nature of trust in science communication, exploring how various factors such as media representation, personal epistemologies and communication strategies influence public trust in science communication.

Chapter 16 by Brian Trench critiques the binary perspective of trust versus mistrust in science communication, proposing a nuanced view that includes total trust, conditional trust, selective mistrust, and determined distrust. Using literature review and analysis, Trench highlights that trust in science is influenced by various factors and contexts, urging science communicators to adopt differentiated approaches. He emphasises the role of personal epistemologies in shaping attitudes towards science, highlighting that trust in scientific expertise is nuanced and context-dependent. This work contributes to a more nuanced understanding of public engagement with science and the complexity of trust in scientific communication.

Chapter 17 by Dan Santos, Joan Leach and Rachel A. Ankeny investigates how the valuation of resources influences trust, sharing and communication among stem cell researchers in Australia. Through 46 interviews, the authors reveal that ethical considerations, donor consent, and concerns about resource handling affected the researchers' willingness to share stem cell lines and data. The interviews show that openness in scientific research is complex and nuanced, shaped by various factors including ethical considerations, donor consent, and the nature of collaboration. They highlight the importance of understanding the socio-material aspects of science communication and how resources in scientific fields play a crucial role in enabling or hindering openness and collaboration.

Chapter 18 by Bianca Nowak, Yannic Meier and Nicole Krämer explores the complexities of defining and measuring trust and distrust in science, highlighting the need for precise conceptualisation and differentiation between trust and distrust. Key findings suggest trust and distrust may be distinct constructs with different cognitive and emotional bases.

The authors call for renewed attention to conceptual clarity and methodological stringency when studying public trust and mistrust in science communication in future empirical research.

Chapter 19 by Justin T. Schröder explores how media representation of female and male scientists may influence public trust in science. Using a qualitative content analysis of 158 science media pieces from Germany, Schröder identifies 1,329 trust cues aligned with five trust dimensions: expertise, integrity, benevolence, transparency, and dialogue. He discovers both similarities and differences in the use of these cues for female and male scientists. Notably, the study finds that media sources predominantly attribute trust cues to male scientists, revealing potential gender biases in science media coverage. Ultimately, the results suggest that trust is mediated differently for female and male scientists.

Chapter 20 by Anne Reif, Justin T. Schröder, Lars Guenther, Monika Taddicken, and Peter Weingart aims to identify and compare groups of online users in South Africa and Germany based on their trust in science and use of various science communication channels. Using latent profile analyses with data from online surveys, the authors find four main trust groups in both countries, with Germany having an additional "untrusting" group. Results indicate that higher trust correlates with more frequent science communication exposure. The authors emphasise the importance of culturally tailored science communication strategies.

Chapter 21 by Jussara Rowland, João Estevens, and Ana Delicado investigates how personal epistemologies shape trust in scientific expertise across four topics: climate change, vaccines, complementary and alternative medicine, and GMOs. Deriving vignettes from 102 participants who participated in group discussions as part of a public consultation in Portugal, the authors find that trust and interpretations of scientific evidence are influenced by individual backgrounds, experiences and domain-specific contexts. They conclude that science communication must account for these nuanced, topic-dependent perspectives to effectively build public trust in science.

Chapter 22 by Alexandra Regina Kratschmer, Ana Paulla Braga Mattos, Byurakn Ishkhanyan, Rebekah Brita Baglini and Marie Louise Tørring investigates parents' trust in childhood vaccines in Armenia, Brazil, Denmark and Italy, analysing their explanations for trust scores.

Using a linguistic-rhetorical approach, the authors identify similar patterns across countries, correlating high and low trust with minimal elaboration and detailed justifications with medium trust. Their findings align with established trust constructs—unquestioned confidence, justified trust and active distrust. The study indicates that science communication should address complex arguments to build trust, considering the varying sociopolitical contexts.

Chapter 23 by Harry J. Witchel, Christopher I. Jones, Carina E. I. Westling, Alessia Nicotra, Bruno Maag and Hugo D. Critchley aims to explore the impact of spelling errors and online "shouting" (capitalisation) on trustworthiness judgments in online health information. Using a series of online experiments, participants rated the trustworthiness of text excerpts with varying degrees of typographic errors/forms. Results showed that both spelling errors and shouting text independently reduced trustworthiness, with combined unconventionalities leading to additive penalties. The study concludes that trust judgements are additive rather than based on simple heuristics, supporting a cost-benefit model for trust assessment.

Who Is This Book For?

The primary audience for this book encompasses researchers, students and academics involved in the fields of Science Communication, Science and Technology Studies (STS), Risk Communication, Environmental Communication and Health Communication. These fields are inherently interdisciplinary, drawing from disciplines such as sociology, psychology, communication studies and public policy, making the book relevant for a wide range of scholarly inquiries and practical applications.

We expect that researchers and academics will appreciate this book. It provides comprehensive insights into the dynamics of trust in science communication, a critical area of study given current concerns about misinformation and scepticism towards scientific expertise. The detailed analyses and interdisciplinary approaches presented in the chapters could prove invaluable to those conducting research on public understanding of science, risk communication, and the role of media in shaping public perceptions of scientific issues. By exploring factors that influence trust in science, from media representation and personal epistemologies to the impact of linguistic choices and digital communication platforms, we believe the book offers a nuanced perspective that is crucial for advanced academic research and theory development.

We also see the book as being highly relevant for students enrolled in science communication courses and programs. Institutions across the world offer specialised programs in science communication, and they might find this book particularly useful. It can serve both as a primary text and as a supplemental resource for courses covering topics such as science, environmental, and health communication, media and information studies, or STS. The book's interdisciplinary nature and practical case studies will help students understand the complexities of both trust and science communication and develop the approaches needed to effectively enable "the social conversation around science" (Bucchi & Trench, 2021b, p. 1)

Practitioners working in science communication, including those involved in public relations for scientific organisations, science museums and media outlets, constitute another important audience for this book. The insights into how different communication strategies can build or undermine public trust in science are directly applicable to their work. Organisations and networks such as the Public Communication of Science and Technology (PCST) Network, Wissenschaft im Dialog, the World Federation of Science Journalists, and the Association of Science Communicators can benefit from the research findings and recommendations provided in this book. These practitioners can use the book to inform their communication strategies, ensuring they are effective in enhancing public understanding and trust in science.

Other audiences for this book include various academic associations and professional bodies that focus on science communication and public engagement. Most scientific organisations need to communicate to wider audiences or deal with the intersection of science and public policy. The book's exploration of trust dynamics in science communication can provide important insights for policy development and advocacy.

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Part I

Trustworthy Science Communicators

2

From Science Citizenship to Science Activism: Reconceptualising the Ethos of Expertise for the Crises of Our Times

Pamela Pietrucci and Frederik Appel Olsen

Introduction

In the 2020s, discussions about the COVID-19 pandemic and climate change have been prominent in both technical and public spheres: Experts, laypeople, and policymakers have been in conversation more than ever before. The global threats of climate change and COVID-19 have also brought attention to society's reliance on scientific information (Eichengreen et al., 2020; Lavazza & Farina, 2020), as well as the difficulties in mediating scientific advice and the importance of values and culture in policymaking and public-oriented political and science communication (Wolf et al., 2020). Despite the global dimensions of those issues, we have learned that their effects are uneven and felt locally, raising ethical and practical concerns about social justice, management

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and prevention policies, or crafting public communication to advance collective behavioural changes needed to overcome global crises (Jasanoff et al., 2021).

In an extensive comparative report on COVID-19 responses around the globe, for example, Jasanoff et al. (2021) illustrated the difficulties faced by global public-health experts trying to persuade different local publics to accept unpopular restrictive measures, revealing that there is no universal playbook that works across contexts to improve the public-expert-policy debate during a global pandemic. Similarly, in studies about global climate delay discourses—those societal narratives justifying the delay in addressing the climate crisis (Lamb et al., 2020; Painter et al., 2023)—scholars also highlighted the importance of improving the communicative practices among stakeholders to offset their concerning societal consequences (Bloomfield, 2019; Cox & Hansen, 2022).

The link between science communication and public engagement and understanding of science has been routinely identified as central in those contexts, showcasing a pressing need to carefully analyse the rhetoric of scientists and experts and its complex relationship to publics and politics. Among the core questions in this broad conversation, scholars asked: How can science be communicated in a way that builds trust and simultaneously encourages public participation? What can stakeholders on each side of the expert-public-policy debate do to improve their interactions and mutual understanding? How are lay and scientific publics entangled and how does that affect the way they shape and are shaped by political and scientific rhetoric? How do scientists see themselves and their role in relation to lay publics? How do scientific publics engage and participate in public life in ways that exceed technical science communication?

In this chapter, we participate in these ongoing conversations to help answer all the questions above by focusing on a key rhetorical aspect at stake, namely the need of integrating notions of rhetorical and scientific ethos that we unpack through the lenses of *scientist citizenship* and *scientist activism*. Conceptualising a "rhetorical" ethos of science, one that adapts to the pressing demands of the here and now of contemporary and shifting contexts of immanent crises, is significant because it allows us to: (1) deepen our understanding of the link between trust and ethos in science; and (2) explore some possibilities emerging from this conceptualisation that can enhance scientific public agency in a post-pandemic and climate-altered world. In short, by advancing a rhetorical notion of scientific ethos, we contribute to rethinking the role and self-perception of public scientists and experts, as well as the ways they orient themselves towards communication and engagement in the public sphere. As rhetoricians, we adopt the classic division of personal, technical, and public spheres, as advanced by Thomas Goodnight (1982) in his landmark essay on the spheres of argument that differentiate the discursive arenas where specific types of argument and discussions take place.

In the remainder of this chapter, we first conceptualise the notion of integrated rhetorical ethos for public scientists. Secondly, by reviewing the ethos of the "scientist citizen" (Pietrucci & Ceccarelli, 2019), we advance the idea that, in order to face the crises of our time, scientist citizenship should be expanded to openly include different, yet connected, modes of rhetorical engagement in the public sphere. When we talk about "modes" or "modalities" of rhetorical engagement in the public sphere, we draw from Brouwer and Asen's (2010) theory of "public modalities" and on Asen's (2004) "discursive theory of citizenship". In this work, both authors conceptualise "citizenship engagement" beyond its classic venues of civic actions, rethinking citizenship as a process of engagement in public from diverse subjectivities that also entail different modes of contributing to public life. In our view, following Asen and Brouwer and also Kock and Villadsen (2014) and their notion of "rhetorical citizenship", scientists and experts have the opportunity to contribute to public life in ways that are informed by their expertise (technical/scientific ethos), but also equally by their subjectivities as regular citizens that dwell in the public sphere just like everyone else in contemporary society. Understanding scientists as rhetorical agents entangled with current affairs, namely simultaneously as scientists and citizens, we suggest that they would do well to strategise their public engagement according to specific circumstances and audiences in the here and now. Lastly, to exemplify an expanded notion of scientist citizenship, we examine scientist activism, the more radical end of the spectrum of scientific rhetoric engaging the public.

We conclude by reflecting on some significant consequences of this expanded rhetorical ethos of science. We also assess how public trust in science evolves in this frame and, most importantly, we make conceptual space for rethinking and expanding the ways scientists and experts engage in public, participate in democracy, and address crises through drawing not only from their specific, technical expertise, but also from the modalities of public participation of lay citizens, in order to maximise their impact in society.

Scientist Citizens

In recent decades, scholars from various disciplines have discussed strategies aimed at enhancing the expert-public debate. These strategies have often placed the responsibility for improvement on the shoulders of lay citizens, urging them to engage with science and enter the technical realm. Already 30 years ago, sociologists Alan Irwin and Brian Wynne (1996) recognised the critical need to examine the relationship between scientific expertise and the general public. This issue remains a topic of ongoing discussion in fields such as public understanding of science, science communication, and the rhetoric of science (Fahnestock, 2020a, 2020b; Funtowicz & Ravetz, 1993; Jasanoff, 2014; Koizumi & Yamashita, 2021; Lidskog, 2013; Mehlenbacher, 2019, 2022; Nieto-Galan, 2016; Wynne, 1996).

Looking at this theme from a rhetorical perspective, Pietrucci and Ceccarelli (2019) redefined public science and risk communication as a civic duty for scientists by drawing from theories of rhetorical citizenship (Kock & Villadsen, 2014, 2015, 2017) and discursive public engagement (Asen, 2004; Brouwer & Asen, 2010). Pietrucci and Ceccarelli (2019) questioned the separation of scientists from the communities they serve or belong to by suggesting a shift in scientists' roles within society so as to bridge the gap that often artificially isolates them from wider publics of lay citizens.

In their study, they explored the changing landscape of the rhetoric of science and expertise during crises, exemplified by the "L'Aquila

Seven" case, the legal trials of earthquake experts accused of not sufficiently informing the public about their risk assessment before the severe earthquake in L'Aquila, Italy that killed more than 300 people and injured more than 1500 in 2009. They observed how, over time, a trend towards separating technical and public spheres had alienated scientists and experts from their role as rhetorical citizens. Further, building on Kock and Villadsen's (2014, 2015, 2017) theory of rhetorical citizenship, as well as on Asen's (2004) discursive theory of citizenship, they argued that scientists, as part of a larger public collective, have a duty to clearly communicate essential information stemming from their technical/scientific expertise to those who lack the same level of expertise. An illustrative example of the danger of allowing the scientists to remain in the isolation of the technical sphere, rather than engaging as scientists but also simultaneously as citizens in the public sphere, is described in their in-depth study of the L'Aquila Seven case, where scientists failed to fulfil their civic duty, when they did not convey essential scientific information to the local public of L'Aquila and also did not correct pseudoscientific rumours circulating around town before the destructive earthquake struck the central Italian town in 2009. This case sparked international scholarly conversation and analysis on issues related to science, communication, and trust, and it also generated continued public debate during its long trial proceedings. The analysis of the rhetoric in the case of the L'Aquila Seven remains significant here because it hints at the origins of the breakdown of trust (the flawed self-conception of scientists as dwellers of the technical sphere only and separated from their publics), at ways to restore or improve the public trust of science (through developing a rhetorical ethos based on the simultaneous subjectivities of scientists and citizens, dwelling and acting rightfully at the same time in both the technical and public spheres), and at the dangers of not doing so (L'Aquila represents a catastrophic example that showcases the negative consequences of scientists who do not communicate and engage when it is essential for society that they do so, but the pandemic has also showcased more nuanced and complex issues in relation to the public engagement of experts). Because the lessons learned from L'Aquila are not fully known in all disciplinary conversations, we review them throughout this chapter to revisit the notion of scientist citizenship and the related insights from the context of rhetorical studies in order to popularise them outside of their primary disciplinary conversation.

To move beyond the original case study unpacked in Pietrucci and Ceccarelli (2019), we can simply shift our attention to the here and now, as most contemporary rhetorical critics tend to do in their scholarly analytical work. The contexts of COVID-19 and the current climate crisis underscore the urgent need to address persistent challenges in public science communication. Experts, for different reasons, continue to struggle to leave the technical sphere and engage with the public, especially through media platforms that favour sensational communication, soundbites, and fragmented information circulation. This poses structural challenges for the delivery of scientific content to relevant audiences in a timely manner. It also continues to artificially reify the disconnect between science and the general public, and issues pertaining to public trust in science can be exacerbated when science communication occurs in crisis contexts and through media platforms that are ill-suited for technical discourse, as evidenced by the global challenges during the pandemic. One example of this has also been studied by Pietrucci (2023) in her analysis of the Italian science communication at the beginning of the pandemic. The initial confusion and distrust experienced by the public was linked to the emergence of a type of mediated science communication that failed to accurately convey scientific information, due to the exploitation, spectacularisation, and the polarising tendencies of some media platforms that scientists were not fully ready to adapt to.

In discussions conducted within rhetorical studies over the years, new figures have emerged to bring together science and publics, such as *citizen scientists* and *civic scientists*, as John Angus Campbell (2015) defines them. Engaging with these conversations at the intersections of science communication, the rhetoric of science, and civic-political life, we want to make the case that there are various ways of promoting public science in contemporary democracies. We want to shift the focus of some recurring questions about the public-lay divide and offer a different question as well as an inverted perspective: What if the challenge of bridging the gap between scientists/experts and the general public is not primarily due to the public's failure to comprehend or participate in scientific discourses, but instead stems from scientists' inability to fully engage in the public sphere? This question, which has become increasingly significant during the pandemic crisis, aligns with the goal of "democratizing science" (Lidskog, 2013) by not only involving citizens in scientific endeavours but also integrating scientists into the public sphere. This makes experts more connected to their audiences and more aware of the impact of their public communication.

In short, here we want to advance and refine the concept of the "civic scientist" offered by Campbell in 2015, by advocating for experts' self-awareness as *scientist citizens*—experts who view themselves as fully integrated into public and political life—with the goal of continuing to re-imagine public science in the post-pandemic and climate-altered world.

This should not be confused with the *citizen scientist* (Bonney et al., 2009; Irwin, 2001). While the citizen scientist is a layperson who enters the technical sphere to participate in knowledge production processes, the *scientist citizen* is an expert who recognises their responsibility to act in the public interest by transitioning smoothly from the technical to the public sphere and by acknowledging their belonging to both discursive arenas simultaneously, not just the technical one. Scientist citizens acknowledge their intrinsic connection to the public and the wider citizenry, rather than seek to artificially separate themselves by means of the boundaries of the ivory tower. Pietrucci and Ceccarelli (2019) argued for a type of rhetorical citizenship among scientist citizens that includes evaluating and rectifying public rhetoric offered in their name, or who participate as rhetorical citizens with relevant expertise when required for the public good, as exemplified by the L'Aquila's debacle. In that high profile case, risk/science communication became a matter of life and death for local inhabitants, and the scientists lost the trust of the local citizens after the earthquake because they had failed to enact their scientist citizenship, which cast them as experts responsible for accurately informing their fellow citizens in the public sphere.

Pietrucci and Ceccarelli (2019) advocate for an integrated ethos of science on the basis of Aristotle's grounding of a rhetorical ethos in its three components: moral values (*arête*), goodwill (*eunoia*), and practical judgement (*phronesis*)—all of which are necessary components if scientists are to "earn the trust we invest in them" (p. 98). Here is a passage from the original article, closely linking ethos and trust from a rhetorical perspective and clarifying how an integrated ethos of science brings together the classic components of the Aristotelian ethos with technical or scientific expertise. The ethos of a scientist citizen, in short, combines the technical and the public aspects, scientific expertise and citizenship engagement, to build and solidify public trust and thus bridging the lay-expert divide:

> When we release scientists from their duty to communicate the conclusions of their risk analysis to nonexperts under the supposition that their responsibility ends in the technical sphere, we are left with a dangerous gap between science and the public that can have disastrous results. We also agree with Miller that 'an ethos of expertise—that is, an ethos grounded not in moral values or goodwill, or even in practical judgment, but rather in a narrow technical knowledge' tends to accompany the separation of technical sphere risk analysis from public sphere risk communication and does not serve either scientists or the public well. To earn the trust we invest in them, scientists must draw upon a full rhetorical ethos grounded in moral values (*arête*), goodwill (*eunoia*), and practical judgment (*phronesis*). (Pietrucci & Ceccarelli, 2019, p. 98)

To provide a summary of their findings regarding the case of L'Aquila, and to justify further our recurring references to that study, we offer another clarifying passage that elaborates more fully on the integrated rhetorical ethos of the scientist citizen that we advocate for in this chapter, based on the realisation that scientists inescapably belong to and dwell in multiple spheres of argument and discourse simultaneously (Goodnight, 1982), namely the technical and the public one. Because of this simultaneous belonging, the expectation of public engagement by scientists, in public and for the public, is described in Pietrucci and Ceccarelli (2019) as a special responsibility that experts have towards lay citizens, and as a foundation of their rhetorical ethos, which is also the foundation of public trust, from a rhetorical standpoint:

> Considering how the proper role of scientists is configured in the two judicial decisions on the L'Aquila case, we argue that the first decision interpellated the promising figure of the responsible scientist-as-citizen who is expected to enact public engagement by taking up an integrated rhetorical ethos in communicating with a broader public, or at least correcting inaccurate information communicated to that public in his or her name, whereas the second decision assumed a false distinction between public and technical spheres that inappropriately absolves scientists from responsibility to their fellow citizens and reduces their ethos to an expertise divorced from rhetoric. The alienation of scientists from their responsibilities as agents in a broader civic culture comes, as Lynda Walsh puts it, 'at the cost of an integrated ethos' for 'scientist-citizens.' Our study of the civic responsibility of the L'Aquila scientists is important because it helps to establish that cost and thereby promotes the constitution of rhetorically sensitive scientist citizens, who, as philosopher Heather Douglas puts it, 'have the same obligations as the rest of us not to be reckless or negligent'. (Pietrucci & Ceccarelli, 2019, pp. 98–99)

While Pietrucci and Ceccarelli conceptualised the *scientist citizen* as a lesson learned from the L'Aquila case, they also recognised the need for a new relationship between science and the public—an issue that had become a recurring theme in various studies proposing new models of Post-normal Science and Citizen Science. These models aimed, as mentioned above, to foster new connections between experts and laypeople focused on educating the public to bridge the gap between lay citizens and scientists. However, the rhetorical focus of this chapter aligns with the conclusion that part of the solution to overcome the expert-lay divide lies in bringing scientists out of their technical isolation so that they may fulfil their rhetorical duty as citizens and, in certain cases, as activists, too.

In this chapter, we build on the lessons learned from L'Aquila—a case where scientists failed to bridge the gap by not correcting flawed risk communication that was circulated in their name—in order to continue reimagining how scientists can better engage in public life. Examining the contemporary wave of "new science activism" (MacKendrick, 2017), we find further evidence of the need to focus on how scientists and experts can engage in matters of societal urgency based on their scientific expertise and their civic subjectivities. Today's scientist activists, for example, acknowledge that they are already citizens and are thus not fundamentally disconnected from the public. While an ethos grounded in *arête*, *eunoia*, and *phronesis* is theoretically valid for scientist citizens engaged in public discourse, the fact that scientists are increasingly involved in resistive public rhetoric, acts of dissent, and counter-publicity underscores the importance of examining how they do so in the real world, and how such rhetorical expressions diverge from the trust-building approach of scientist citizens. Increasingly, some engaged scientists are now stepping out of the lab and onto the streets to oppose distorted public discourses, fight pseudoscience, or challenge detrimental public policies. This shift in their involvement warrants a closer look, and we will take that look in the final section of this chapter.

Scientist Activists

Scientist citizenship can take many forms, depending on the specific context and the crisis calling for expert response. However, a distinction, although not an entirely rigid one, can be drawn between scientist citizenship and scientist activism. Of these, the latter has to do not so much with actively communicating vital scientific information to the public as with attempting to put pressure on authorities to act on scientific knowledge. Such pressure may be exerted through a variety of public modalities of citizenship engagement (Brouwer & Asen, 2010). Scientist activist rhetoric expands the expert ethos described above without abandoning it: Using the position of a scientific professional or expert to intervene in destructive societal developments, *scientist activists* tap into a historically significant rhetorical mode that straddles epistemic and political spheres of work and action (Frickel, 2004; Kuznick, 2019; Moore, 2008).

Activism, then, should be understood here less as a specific set of actions (demonstrations, civil disobedience, social media campaigns, petitions, etc.) carried out by specific individuals or groups (environmentalists, peace protesters, anti-racist campaigners, etc.) and more as a rhetorical mode of engagement seeking to create changes in society by disrupting dominant structures, as well as the assumptions about political and cultural identities that underpin them. Scientist activist rhetoric attempts to intervene in science-society relations in order to question and destabilise the operationalisation of this relation by those in power. Thus, where the scientist citizen builds trust with publics through displaying goodwill, moral virtue, and practical wisdom, the *scientist activist* will more often seek to address a broken trust between elite decision-makers and the public.

The deepening of the climate and ecological crisis and the generally heightened public awareness of its reality and consequences has spurred activist engagement from individual scientists as well as scientist social movements. For instance, in September–October 2023, more than 100 scientists joined the Scientist Rebellion movement in the broader civil disobedience action blocking a motorway in the Netherlands for more than a month in protest against the Dutch government's continued subsidising of fossil energy (Hoger Onderwijs Persbureau, 2023). Simultaneously, in September 2023, US climate scientist Rose Abramoff was arrested for blocking a pipeline construction site in West Virginia (Pattee, 2023). In December 2022, Abramoff was fired from her laboratory job after interrupting an American Geophysical Union conference meeting with a message to her scientist peers that activism is necessary in the climate and ecological emergency (Abramoff, 2023). These cases are but two examples of a recent surge in scientist activism linked to the climate and ecological crisis. As the Abramoff case shows, such activist rhetoric can address audiences in the scientific community, for instance in scientific journals (Capstick et al., 2022; Gardner & Bullock, 2021; Racimo et al., 2022), and the wider public like in civil disobedience and other protest acts, often linking up with other social movements, as in the motorway blockage at the Hague. As rhetorical performances, these acts differ from scientist citizenship as construed above and, especially, from conventional science communication in that they employ extra-discursive means of persuasion, such as the body rhetoric of blocking a traffic route or pipeline, to create pressure and increased attention devoted to climate political injustices, as well as intervening in the cultural logics of the dominant culture (DeLuca, 1999a, 1999b).

Scientist activism as a rhetorical mode of public engagement puts notions about scientific ethos into new perspectives in light of the societal crises to which such engagement responds (Appel Olsen, 2023). Seeing that social, political, and planetary crises rapidly and unpredictably change the landscapes (political and material) across which scientists move, scientist activism co-constitutes and reconstructs notions of science, society, expert participation, resistance, and institutional power. Viewed in this way, activism is a rhetorical attempt at negotiating scientists' identity and responsibility in times of crisis. In that sense, it goes further than scientist citizenship by having the scientist step into their role as part of the wider public. Thus, the scientist activist is not mainly concerned with ensuring laypeople's adherence to scientific evidence of the climate and ecological emergency. Instead, they use confrontational or disruptive expressions to point to the trust that political elites have broken by not living up to *their* responsibility to act in accordance to the science.

Thus, instead of rejecting activist practices as 'unscientific', we should recognise that they exist and gain their legitimacy exactly from their basis in scientific expertise. The task for rhetoricians of science and other science studies scholars is, then, to understand and evaluate the persuasive processes of scientist activism as these unfold and to examine how they might change science, society, and the relations between the two. Integrating such work with recent studies concerned with social movements and crises (della Porta, 2022) would widen perspectives on both science and activism. Studying scientist activist rhetorical practices as they unfold in specific situations would supplement, aid, and nuance studies of qualitative differences in scientific and activist cultures in terms of crisis communication (Randall & Hoggett, 2019). Such studies should therefore also be aware of the shift in perspective on science and trust that this type of activism brings to the fore: From appealing to public trust in scientific expertise by way of engagement in the public sphere to drawing attention to the lack of trust decision-making elites display in crisis by way of confronting political power.

Conclusion

Our argument for an integrated ethos of science and expertise builds on work conducted in rhetorical studies that are attentive to the conditions for trustworthy, ethical, and effective communication from scientists and experts to a wider public audience (Fahnestock, 2020a, 2020b; Pietrucci & Ceccarelli, 2019). Instead of seeing one mode of engagement as inherently trustworthy and another as inherently untrustworthy, the integrated rhetorical ethos straddling scientist citizenship and activism accounts for the flexibility and diversity of communicative practices needed for scientists if they are to live up to their potential as democratically vital participants. This is a continuous rhetorical negotiation of expertise (Hartelius, 2011) that takes place within the social dramas of our times.

Specifically regarding the question of trust in expert appeals to the public in times of crisis, scientists and experts should consider questions such as: When do citizens need scientists to leave their technical spheres and deal with vital problems with goodwill and moral virtue (Pietrucci & Ceccarelli, 2019)? Do audiences have reason to trust scientists who act compliantly in the face of an impending catastrophe, or is the high level of trust we put in scientists better used exactly for sounding the alarm (Brysse et al., 2013)? Is it possible for scientists in every case to use 'appropriate' means of communication to address societal issues of vital importance, or are 'unruly' modes of argument (Alexander et al., 2018; DeLuca, 1999b) legitimate when protesting the dominant structures underpinning what is deemed appropriate exchanges of opinion?

Lastly, it is important to consider how studying scientist engagement as a socially significant communicative phenomenon requires us to think about how we ourselves participate in such processes, especially in the climate and environmental emergency (Brüggemann et al., 2023). Studying the rhetoric of science is, fundamentally, as implicated in societal problematics as science itself. This article's argument for an integrated scientific ethos thus serves as a bid to reconsider the real-world significance of expertise on a broader scale: As the foundation for all life undergoes biospheric changes, how ought we to act in and outside knowledge institutions?

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3

The Role of Science Communication in Building Trust in Scientific Expertise

Inês Nepomuceno Navalhas

Introduction

Science communication involves the transmission of scientific knowledge in a simple and accessible manner to a wider audience, and this can be quite a complex task. The communication of scientific knowledge can be unidirectional or bidirectional (Lewenstein, 2003) and comprises a relationship of trust involving experts who may be located at different levels and degrees of complexity. For example, with policymakers, the trust they have in an expert allows them to rely on the data provided and to feel supported in decision-making processes, particularly when it comes to public risks (Dierkes & von Grote, 2005; Intemann, 2023), such as the global COVID-19 pandemic. However, not only policymakers establish relationships of trust with experts, but the public also often depend

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on such relationships to help the decision-making process (Intemann, 2023).

Trust, as a broader concept, refers to what brings society together. Since science plays an important role in society and in the public debate (Peters & Dunwoody, 2016), trust in science is also crucial to the functioning of democracy and governance (Gundersen et al., 2022). Relationships of trust involve an exchange between parties, as Gibbons' tacit contract exemplifies (1999), and they are based on a social construction that must be nurtured. These relationships of trust with experts require, therefore, a belief in their competence within a given area of knowledge, their integrity, and honesty (Hendriks et al., 2015; Intemann, 2023; Mayer et al., 1995). These relationships may have a social dimension involving the "reception, transmission, and uptake of scientific knowledge" through social forces whose influence can benefit or harm trust in science (Contessa, 2022). Therefore, the institutions that lead the public to place their trust in an expert are relevant, particularly when facing critical social situations that can jeopardise trust in science and organisations (Steijaert et al., 2021).

The professionalisation of science and resulting scientific specialisation has caused a gap between the language of science and the reality in which the public move (Bensaude-Vincent, 2001), and between the scientific community itself and the audience. That, together with a lack of scientific literacy (Bauer, 2009), may have contributed to the emergence of the fake news and misinformation that have recently become associated with science—a development that has placed a further strain on trust relationships (Mihelj et al., 2022). Nevertheless, when an individual identifies sources of scientific information, such as journalists, teachers, doctors, or scientists, that individual should be able to place their trust in these sources of mediation communication, assured that the information they receive is correct and up to date (Wynne, 1998).

Questionnaires have been used to understand how trust arises when it comes to sources of information regarding science and technology (S&T) topics. In this chapter, the results of such a survey focusing on trustworthy sources of S&T information, involving students and teachers at a Portuguese university, are presented. These data alone may not be representative of the Portuguese population but are relevant when compared with the available results from Eurobarometer surveys (European Commission, 2010, 2013, 2021) of with public perceptions of sources of S&T information. This comparison allows us to understand the Portuguese reality over the last 13 years, but also to comprehend the vision of students and teachers at a science and engineering faculty, and to see if their perceptions differ from the society trends in the most recent Eurobarometer. By understanding the main types of sources on which the respondents rely for S&T, it is possible to clarify which are the most important information sources and thus to locate a starting point for taking a closer look at science communication.

Trust in Science, Risk Society, and Science Communication

A risk society is one where the role of science is focused on its importance for the recognition and legitimisation of risks that society faces (Beck, 1992; Wynne, 1992, p. 300). Modern society's distrust of science is related to the negative impacts of scientific developments, especially during World War I and World War II (Beck, 1992). The way in which a given risk is perceived may differ depending on the role it plays in the process of the production and use of knowledge: For scientists and policymakers, risk often manifests as a set of probabilities; for the public, risk can be a very concrete fear or concern. As science plays a significant role in the assessment and management of risks, the public's attitudes towards science can condition the way in which the public perceive and act towards risks (Delicado & Gonçalves, 2007). The debate surrounding S&T in twentieth-century Europe was transformed considering its social, political, and economic context and went from an optimistic and confident perspective to a more pessimistic and sceptical view (Cheng et al., 2008; Dierkes & von Grote, 2005).

Trust can be a way of delegating responsibility to others (Cologna & Siegrist, 2020), and public trusting in science is the result of a mediated communication (Schäfer, 2016). Since most segments of the public are unlikely to be in regular touch with scientists or go to science fairs or museums, their access to scientific knowledge takes some mediated form or other (e.g., communication through magazines, TV, internet, etc.), which means that public trust in science can be influenced by media representations (Schäfer, 2016). Trust in specialised systems and in science is, thus, a condition of everyday life (Giddens, 1990), considering that we live in a society experiencing risks that are difficult to control and that may have cross-border consequences that can be serious for us as human beings (Beck, 1992; Ojala, 2021). Yet, trusting science and its institutions means trusting that reliable knowledge is being produced, from which it will be possible to improve numerous aspects of life, thus allowing scientific knowledge to be fed into political decision-making and public debates (Schäfer, 2016).

Science communication is among the factors that can influence public trust in science (Miller, 2004). It is a mechanism that seeks to fill the gap between expert and lay ways of understanding science, which is based on the historical idea that the public is a passive consumer (Cooter & Pumfrey, 1994). This gap was created when the scientific community, having established its identity, separated itself from the public (Bensaude-Vincent, 2001), thus creating a breach between science and the public and even between scientific experts from different scientific areas. Characteristic of the twentieth century, and related to the risks and mistrust in science, this gap became noticeable through the gradually increasing need for mediation. Yet, the development of science communication practices underlies the idea that S&T could be complicated for the public to understand. That idea was based, firstly, on scientific communication and, secondly, on the lack of mediation of increasingly complex S&T, as well as on the idea of transforming a more specialised type of knowledge into public knowledge (Bucchi, 2008). This perspective on science communication is described as "diffusionist" (Bucchi, 2008), it consists of scientific knowledge that must move from specialised knowledge to popular knowledge, and it is divided into two aspects. The first is the legitimisation of the role of mediators, such as science communicators and journalists, at both a social and a professional level. The second aspect is the role of scientists in the communication process, who may feel distanced or feel a need to criticise mediators for distorting or sensationalizing the knowledge they convey (Bucchi, 2008). This notion of a division between science and public, when it comes to science communication, has perpetuated the idea of the media as incapable of filtering and reflecting on scientific knowledge, as well as the notion that the public do not have the ability to understand scientific discoveries (Broks, 2006).

Although scientific literacy plays a structuring role in the public knowledge of S&T and in the resulting decision-making within society, it implies that the public has a knowledge deficit (Bauer, 2009). The idea of a knowledge deficit emerged in the 1980s as a result of studying the public understanding of science by social scientists, and it is characterised by the belief that the public's lack of trust in S&T is due to their lack of adequate knowledge combined with their inability to appreciate science (Dickson, 2005; Kim, 2007; Lewenstein, 2003). If the public overcame this knowledge deficit, it would perceive S&T as positive (Dickson, 2005), which would lead to a more positive attitude towards both (Irwin & Michael, 2003).

In the 1980s, this deficit in scientific knowledge was being studied in the context of public attitudes towards science and with a view to the then political need for a more positive attitude in society towards scientific research (a science communication model called public understanding of science) (Royal Society, 1985). Another type of deficit was identified in the 90s, this time associated with the lack of public trust in S&T due to the negative societal consequences of the uses they were being put to and/or the secrecy of the research itself, which is common to Big Science and Big Technology projects (Schiele, 1994). Additionally, the scientific community did nothing to contact the public, nor to understand it or its plurality, which in turn led to an even greater lack of interest in science and consequently to scientific illiteracy (da Costa & Conceição, 2007).

These several studies on the multiple science communication models are not consecutive, nor do they exclude one another (Bauer, 2009; Lewenstein, 2003). However, the public participation model (or public engagement with S&T) emphasises the importance of social trust built through public debates on S&T, aiming to improve public participation and trust in scientific policies. Science shops, public debates, or science fairs aim to remove the exclusivity of scientific knowledge from the experts and share it with the public (Lewenstein, 2003), and such initiatives are also a response to the need for citizens to be involved both in discussions and dialogues between S&T and, subsequently, in decisions that can affect them directly or personally. Following this idea, science communication can, therefore, play an important role in building a relationship of trust between experts and the public and can represent the solution to the society's crisis of confidence in S&T.

With this in mind, the Portuguese public's opinion regarding science, their confidence in, and perceptions of risks involved in S&T are interesting to understand. Delicado and Gonçalves' Portuguese survey in 2007 did not reveal a large difference in favourable and negative opinions regarding science: 55% of the surveyed population considered the benefits of science to be greater than the risks, although some concern among the respondents regarding this topic can be inferred. When it comes to resolving risks, the Portuguese trust that science can indeed help do this, with 80% of respondents saying they have confidence in science. Regarding the importance of science in making decisions that affect public issues, 88% of the respondents considered a scientific input to be relevant, demonstrating confidence in science as a problem-solver (Delicado & Gonçalves, 2007).

Case and Methods

This chapter results from doctoral research carried out between 2018 and 2021. Its main objective was to analyse a S&T collection of scientific popularisation books—Ciência Aberta, from Editora Gradiva in Portugal—exploring all the books published between 1982 and 2018 and considering all their different components, from appearance to writing. Authors and scientists who have published books or book chapters in this collection over the years were interviewed in order to comprehend their relationship both with the tool—science communication and dissemination books—and with the public. Finally, the higher education community was surveyed to find out what influence these books have had. Mixed methods, including methods for collecting and processing quantitative and qualitative data, were the best-suited option for both the quality and type of data in this research (Tashakkori &

Teddlie, 2009). Data collection techniques thus included content analysis, semi-directive interviews, and questionnaire surveys that complied with the General Data Protection Regulation.

An online survey was developed to gather information from students and teachers at NOVA University of Lisbon alongside surveys designed to measure public understanding of science. These surveys focused on levels of interest, information, and, especially, trust in a variety of sources of information regarding in S&T (Centro de Gestão e Estudos Estratégicos, 2017). These two groups were studied since the type of science communication books involved were more specialised than "ordinary popular science", hence the focus on a higher education institution. In connection with measuring trust in sources of information on S&T, students and teachers were asked to choose between several options which ones they considered more and less reliable when it comes to scientific topics. The options were as follows: journalists, doctors, scientists working in private companies, religious institutions, scientists at universities or public research institutes, representatives of environmental organisations, politicians, teachers, the military, writers, and artists.

The two surveys conducted among students and teachers were carried out in different months, which made it possible to change some questions along the way, since there were details in each survey that did not apply to both audiences. The student survey was carried out first (February 2020), using a curricular unit at NOVA University of Lisbon, Faculty of Sciences and Technology, in which students from all the faculty's courses are enrolled. Surveys were sent by email, with a direct link to Google Forms where the survey was done. The teachers' survey was conducted subsequently (June 2020), within the same faculty, also with a direct link to Google Forms sent by email to the faculty teachers' mailing list. As noted, the survey had been slightly modified for this round.

Despite the differences between the two surveys, the trust-related questions analysed in this chapter were conducted in very similar ways for both audiences, thus allowing for an accurate comparison. The statistical data that resulted from the pre-pandemic survey—the students—and from the early pandemic survey—the teachers—were compared with the data resulting from the European S&T-focused" surveys "Eurobarometer,[1] from the years 2010, 2013, and 2021, representing different times and perspectives on the same topics. Below, data from these polls related to attitudes towards S&T are analysed and compared with those from the survey carried out at NOVA.

Considering the survey respondents from the higher education community, it is important to note that the n (total) of students is 394, of which 90% ($N = 358$) are between 19 and 20 years of age, 56% are male ($n = 222$), 43% female ($n = 167$) and 1% identified as "other" ($n = 5$). Of these 394 students, 73% live in the Lisbon Metropolitan Area ($n = 287$). In the case of teachers, the n (total) is 138 and, in terms of age, 66% are between 41 and 60 years of age ($n = 92$). In terms of gender, 49% are female ($n = 67$) and 51% are male ($n = 71$). Of the 138 teachers ($n = 138$), 97% live in the Lisbon Metropolitan Area ($n = 134$).[2]

Analysis

The data from the survey helped to reveal trends regarding the extent to which people trust in various information sources when it comes to S&T, with a special focus on a higher education community linked to science and engineering. It should be noted that, given that each student was able to choose three options in response to this question, it brings the total number of answers to 1182 (three times the number of respondents). Regarding the sources of scientific information to which students attribute the highest degree of trust, 31% consider scientists at universities or public institutes of research ($n = 370$) to be the most reliable source of information when it comes to scientific topics, followed by scientists working for private companies who scored 20% of students'

[1] Eurobarometer surveys are a polling instrument from European institutions, to regularly screen the public opinion in European countries on several questions, including attitudes towards S&T (European Commission, 2010, 2013, 2021). These polls, initiated in 1974, allow for a long-term view.

[2] Surveys were sent to ~1000 students and ~500 teachers. Thus, the response rate was ~40% for students and ~30% for teachers.

responses ($n = 234$). This is followed by doctors, with 17% of students registering this option as the most reliable ($n = 197$), then teachers with 16% ($n = 188$), then journalists with 6% of students regarding them as the most reliable sources on science topics ($n = 72$). Representatives of environmental protection organisations are the choice of 6% of students ($n = 66$), writers are the choice of 2% ($n = 24$), the military register 1% of student responses ($n = 17$), while religious institutions and artists are favoured by 1% of students each ($n = 6$). Politicians are the choice of only 2 students as the most reliable source on science topics.

When asked which sources of information they trust the least for science-related information, the results for the students are practically inverted in relation to the previous question: Religious people are the least trusted source of information, with 26% of students indicating this option ($n = 313$), closely followed by politicians with 25% of responses ($n = 295$), and artists with 18% of responses ($n = 219$). Journalists are the fourth least trustworthy source according to students, with 13% of responses ($n = 160$), followed by the military ($n = 70$), writers ($n = 48$), and representatives of environmental protection organisations ($n = 32$). Scientists working for private companies were the choice of 31 students, followed by doctors with 7 votes, 5 votes for teachers, and 2 for scientists at universities or public research institutes.

Considering the sources of information to which teachers attribute the greatest amount of trust, they referred to scientists at universities or public research institutes. This option recorded around 50% of the responses ($n = 135$), meaning only three teachers have not registered this option as the most reliable one. Next are teachers, with 22% of the answers in this option ($n = 60$), then doctors with 14% ($n = 39$), and scientists who work for private companies which was the response from 10% of the teachers ($n = 28$). Representatives of environmental organisations ($n = 5$), journalists ($n = 4$), writers ($n = 3$), and the military ($n = 2$) are the sources of information least favoured by teachers as the most reliable regarding science topics. Religious people, artists, and politicians did not receive any responses. It should be noted that teachers were able to choose two options in their responses to this question, which brings the total number of answers to 276 (two times 138 teachers).

Regarding sources of information in whom teachers trust the least, the option politicians is the first one, with close to 30% of responses ($n = 82$), followed by religious institutions with around 25% ($n = 68$), and journalists as the third least trusted source in relation to these topics, with 20% of responses ($n = 55$). Artists received close to 10% of teachers' responses as unreliable sources ($n = 29$), followed by the military with 8% of responses ($n = 23$). Representatives of environmental organisations ($n = 10$), scientists working for private companies ($n = 6$), and writers ($n = 3$) are among the options with the fewest votes from teachers, with the options "scientists at universities or public research institutes", "doctors", and "teachers" not receiving any votes (Table 3.1).

It is interesting to note that, when asked about the sources of information they trust the most, teachers point first to scientists at universities or public research institutes, then teachers and doctors, and then scientists working for private companies. On the other hand, when it comes to the least trustworthy sources, teachers consider scientists working for private companies to be less reliable sources than scientist working at universities.

Comparing the two surveys from NOVA, comprising more than 500 individuals including students and teachers, the same option is clearly chosen as the most reliable ones when it comes to scientific topics: scientists at universities or public research institutes. The second most reliable

Table 3.1 Sources of information students and teachers trust most

	Students	Teachers
Scientists at universities or public institutes for research	31%	49%
Scientists working for private companies	20%	10%
Doctors	17%	14%
Teachers	16%	22%
Journalists	6%	1%
Representatives of environmental protection organisations	6%	2%
Writers	2%	1%
Military	1%	1%
Religious institutions	1%	0%
Artists	1%	0%
Politicians	0%	0%

source varies: the students look to scientists working for private companies. For teachers, the second most reliable source is teachers. The third option is the same in both cases: doctors constitute a very reliable option for both students and teachers. It should be noted that, in the eyes of both students and teachers, journalists are far from the most reliable sources in terms of science topics. Comparing students' and teachers' responses regarding the least trustworthy sources, politicians and religious people stand out, being the two least trustworthy options for both groups of respondents. For teachers, the third least reliable source is journalists, while for students it is artists. It should also be noted that scientists who work for private companies, despite accounting for less than 5% of responses in both cases, are regarded as less reliable, ahead of doctors and teachers (Table 3.2).

The Special Eurobarometer 401 (2013)[3] reported on sources considered best qualified to explain the impact of scientific and technological developments. In 2013, 54% of Portuguese respondents viewed scientists at universities and government labs as the best qualified, up 1%

Table 3.2 Comparison of data between Special Eurobarometer 240 (2010) and Special Eurobarometer 401 (2013)

	2010		2013	
	Portugal	EU	Portugal	EU
Scientists working at universities and government laboratories	53%	63%	54%	66%
Scientists working for private companies or laboratories	29%	32%	33%	35%
Television Journalists	24%	20%	24%	20%
Newspapers journalists	17%	16%	12%	15%
Medical doctors	23%	26%	23%	19%
Environmental protection associations	24%	24%	18%	21%
Politicians	6%	6%	5%	4%
Writers and intellectuals	2%	6%	4%	7%
Military	2%	2%	1%	3%
Religious institutions	3%	2%	1%	1%

[3] Although there is no straightforward relation between considered best qualified and most trustworthy sources, since the possibility of answer is the same, I consider it important to refer the 2013 results.

from 2010, but 12% below the EU average (66%). Scientists in private companies were second-best at 33%, up 4% from 2010, but 2% below the EU average (35%).

24% of Portuguese respondents trusted television journalists, compared to the EU average of 20%. Doctors were trusted by 23%, unchanged from 2010, versus 19% in the EU. Environmental protection associations were chosen by 18%, down 6% from 2010, with a 21% EU average. Newspaper journalists were trusted by 12%, down 5% from 2010, compared to 15% in the EU.

Politicians were considered qualified by 5%, down from 6% in 2010, with a 2% EU average. Writers and intellectuals were trusted by 4%, up 2% from 2010, while the EU average was 7%. The military was trusted by 1%, down from 2% in 2010, mirroring the EU average. Representatives of religious institutions were trusted by 1%, down from 3% in 2010, with a 2% EU average (Table 3.3).

According to the 2021 Special Eurobarometer 516, 61% of European citizens consider public sector scientists the most trusted sources on scientific and technological developments. This is followed by private sector scientists (40%), doctors (29%), journalists (19%), and environmental protection associations (16%). Writers and intellectuals (10%), politicians (5%), military (3%), and religious representatives (2%) were less preferred.

Table 3.3 Comparison between the results from 2020 Portuguese Higher Education survey and 2021 Special Eurobarometer 516

	Portugal 2020	Europe 2021
Scientists working at universities and government laboratories	74%	61%
Scientists working for private companies or laboratories	56%	40%
Doctors	24%	29%
Journalists	20%	19%
Environmental protecrion associations	23%	16%
Writers and intellectuals	8%	10%
Politicians	1%	5%
Military	1%	3%
Religious institutions	1%	2%

In Portugal, 74% of respondents consider public sector scientists the best qualified, 13% above the EU average and up 20% from 2013. Private sector scientists are chosen by 56% (16% above EU average, up 23% from 2013), and doctors by 24% (5% below EU average, up 1% from 2013). Journalists are trusted by 20% (1% above EU average), with TV being the primary source. Environmental protection associations are preferred by 23% (7% above EU average, up from 18% in 2013). Politicians are trusted by 1% (4% below EU average, down from 5% in 2013), religious representatives by 1% (1% below EU average, same as 2013), and the military by 1% (2% below EU average, same as 2013). Writers and intellectuals are chosen by 8% (2% below EU average, up from 4% in 2013).

Despite the limitations arising from the research itself (the methodology used was not the same), it is possible to deduce some trends comparing these two surveys. In all cases, when it comes to the most reliable or best qualified sources, students, teachers, and Portuguese citizens alike choose scientists at universities or public research institutes. The second most reliable source is, both for students and for most Portuguese respondents, scientists working for private companies, but in the case of teachers, this is not their second choice. The third most reliable or best qualified source for dealing with scientific development is the same in both surveys: students, teachers, and Portuguese respondents consider doctors the third most reliable source. The trend towards politicians, religious institutions, and the military is also similar in all surveys: These sources are considered the least trustworthy or least qualified sources by most Portuguese respondents, students, and teachers. The trend regarding representatives of environmental organisations and writers is also similar: Students, teachers, and Portuguese citizens at large do not consider them the most reliable or best qualified sources, but nor do they consider them particularly poor sources. A special case is that of journalists: While the Eurobarometer results show that they are considered reliable and qualified sources for dealing with science-related issues by around 20% of respondents, this is not the case in the survey of students and teachers, who consider journalists to be one of the least trustworthy sources on these topics.

Discussion and Conclusion

Analysing the amount of trust lodged in or the likelihood of choosing these sources of information as the better informed when it comes to S&T in four different periods (European Commission, 2010, 2013, 2021; Navalhas, 2023) allows us to see some particularities of Portuguese society. The 2020 survey, despite only being carried out among a specific demographic segment who have a different relationship to S&T from that of the rest of the population, shows the same trend as the 2021 Eurobarometer. The sources of information that students, teachers, and the Portuguese respondents trust most for information about S&T are scientists, whether they work at universities or for private companies. The information sources that score the highest amount of trust, not only among S&T students and teachers, but also, according to the latest Eurobarometer (European Commission, 2021), in the Portuguese population, are scientists working at universities or public institutes and scientists working in the private sector.

As Gibbons' tacit contract states (1999), the social construction that provides them with authority should be nurtured by the scientists, who are the experts and who must try to pass on messages related to their areas of expertise (Royal Society, 1985). This can be an important step in creating the conditions for trust, so that their audiences recognise them as reliable and trust them easily. Therefore, science communication can be extremely important when considering these relationships of trust.

Already playing an important role for the public, by informing about what is currently happening in scientific fields, science communication can also be a strategic tool for experts to build more trusting relationships with their audiences. Intemann (2023) identifies several errors that can undermine the public's trust in scientists, and these include mixed messages that damage trust in scientists, not only regarding the scientific topic at hand, but also other topics. Focusing on scientific results rather than revealing the processes and methods of science is a mistake also pointed out by Intemann (2023), and this concerns the fact that the public, for the most part, do not understand the process a scientific theory goes through until it is regarded as proven. So, problems may arise when it comes to building up the public trust in experts.

The use of technical jargon is another misstep that can undermine public trust, distorting many of the objectives of science communication. When an expert uses technical jargon, the public may doubt whether that expert is really working in the public interest, or it may be perceived as the expert not caring whether the public understand what is being conveyed (Intemann, 2023). Not addressing specific audiences as such but considering the public to be a single entity is another mistake, according to Intemann (2023): ifferent audiences may have different interests and needs that must be understood, and the scientist's speech must thus be tailored to them. Exaggeration in the expert's communication, causing alarm and being too pessimistic, is also an error that the author points to as undermining trusting relationships between experts and public. This may be linked to the fact that the surveyed students and teachers considered journalists as a not reliable source of information regarding science and technology.

The use of science communication to build stronger relationships of trust is possible, but it is necessary to avoid the mistakes mentioned above, as well as seeking to communicate responsibly. Transparency in issues of uncertainty is a good way for experts to present their work, as several studies have shown that this approach not only does not damage public trust in experts, but can even improve it (Jensen, 2008; Retzbach et al., 2016). Explaining clearly how science works, the processes it goes through, and the methods underpinning it (Weingart & Guenther, 2016) are strategies that can help the public to not only better understand the expert, but also to trust that the information and the data are reliable and trustworthy.

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4

Contestation of Science, Post-truth Regimes and Emotions: A Review

Alberta Giorgi and Hande Eslen-Ziya

Introduction

The interplay of emotions in the formation and sustainability of social movements is a pivotal aspect, as Eslen-Ziya (2023, p. 352) notes, highlighting the emotional dimensions that influence individuals' decisions to engage with, remain in, or disengage from these movements. It is through such emotionally charged interactions that "affective publics" emerge (Papacharissi, 2016, p. 311), where sentiments are not only shared but deeply felt. Emotions act as the binding force within these publics, creating a purely spiritual collective as described by Tarde (1969). This collective is unique, characterised by a mental cohesion among individuals who, despite physical separation, are united by a shared idea

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or desire. This unity is significantly bolstered by digital media technologies, which not only enhance feelings of belonging but also foster deeper engagement, thereby knitting these publics closer together. As Papacharissi (2014) points out, digital media offer an infrastructure for networking among physically separated individuals, but it is through sharing emotions that these individuals connect with one another. In this sense, digital media facilitate feelings of belonging and engagement with a broad and physically distant audience. According to the hybrid emotional echo-chamber theory (Eslen-Ziya, 2022), participants' beliefs, motivations, and opinions not only help create affective ties, but also bring forth changes in emotions—from anger to solidarity, or from hope to resentment.

The concept of echo chambers highlights how social media users often selectively connect with those who share similar viewpoints and engage with content that aligns with their own ideologies, leading to a scarcity of exposure to the diverse and conflicting perspectives that define the agonistic public sphere (Terren & Borge, 2021, p. 100). The hybrid echo-chamber theory extends this idea to include interactions that take place both online and offline, thereby considering the communication environment in its entirety. Reviving Gabriel Tarde's seminal insights, this theory emphasises the role of emotions in both digital and non-digital environments, exploring their influence on shaping public behaviour. Moreover, it equips scholars with the analytical tools to examine how emotions play a crucial role in the production and consolidation of power dynamics within social movements and public discourse. Once such intense affective ties are formed, emotions enable solidarity and even collective identity, creating hybrid emotional echo chambers. Hence emotions serve as the fuel in activating or sustaining the ties that may be vital for creating collective imaginations and what Dean (2010, p. 22) refers to as "feelings of community".

In this chapter, we explore the role of emotions in epistemic conflicts that unfold online: As demonstrated by scholarly analyses of the debate over COVID-19 vaccinations, for example, the discourses from both proponents and opponents are deeply infused with emotions (Neresini et al., 2024). Broadly speaking, online epistemic conflicts can assume the form of individual posts imbued with emotions. For instance, in their examination of anti-vaccination discourse on Twitter, Eslen-Ziya and Pehlivanli (2022) delve into how emotions such as fear and pride are expressed and mobilised. Kuhar (2017), for instance, explores how nostalgia for a golden age may activate emotions like longing and hope, that "lead people to react negatively, vehemently, and even violently in such a way as to reduce the impact of scientific research and chill the research itself" (Hsu, 2020, p. 408). Furthermore, epistemic conflicts can contribute to the formation of groups and communities that contest scientific consensus and the authority of scientific experts—in which processes emotions play a vital role. Aupers and de Wildt (2021), for example, investigate the significance of mutual recognition among supporters of "heterodox" science. They highlight how these individuals feel marginalised by mainstream society and how meeting like-minded people turns into a pivotal affective experience that builds strong emotional bonds with virtual strangers. This experience fosters strong emotional bonds within a community that, while virtual, plays a significant and tangible role in their lives.

We argue that, regardless of the specific configuration of online epistemic conflicts, a focus on emotions and their interactional and inter-subjective dimensions is crucial in order to shed light on the implications of these conflicts for the public trust in science. First, we argue that conceptualising contemporary epistemic conflicts as opposing rational and emotional stances leads to a limited understanding of the conflictual dynamics and the issues at stake. Second, we urge researchers to explore the impact of emotions on various parties involved in online epistemic conflicts, and we encourage scholars to examine the specific emotions that are discursively mobilised both in contesting and in supporting expert opinions. Third, we invite scholars to explore how these specific emotions are collectively built and validated in online interactions related to epistemic conflicts, and to analyse the implications of these emotions for collective trust in science.

In the next section, we locate the attacks against science in the context of contemporary epistemic conflicts, underscoring the relevance of the online dimension, and we elaborate on the connection between trust in science and emotions. Then, we discuss the research and analyses that conceptualise the role of emotions in collective behaviour online. In the last sections, we discuss the role of emotions in online epistemic conflicts and draw some conclusions.

Epistemic Conflicts

As Mede and Schäfer (2020) highlight, epistemic conflicts can be analytically dissected into, on one hand, contestations of scientific authorities coupled with the promotion of alternative authorities, and on the other hand, challenges to scientific epistemology alongside the endorsement of alternative epistemologies. This framework is applicable to debates surrounding issues such as climate change, gender studies, and Covid-19, among others (see Eslen-Ziya & Giorgi, 2022). Scientific research is, intrinsically, a site of struggle among scientists proposing competing theories and approaches.

The analysis of trust in science is a classical theme in sociological research, which usually refers to works by Robert K. Merton: scholars are to be trusted because they follow a certain ethos, which includes the principles of universalism, communalism, disinterestedness, and organised scepticism. Following these principles may be more difficult for scholars in contemporary science because of the changed rules of academic research, which promote competition and higher prominence of extra-scientific interests. These changes, combined with the increased availability of scientific knowledge online and the increased complexity and specialisation of scientific fields, contribute to the current decay of trust in science (see, e.g., the discussion in Sztompka, 2007). Scholars have introduced the concept of "epistemic trust" to indicate that the trust in knowledge provided by scientists entails both a *default trust* by laypersons in scientists as knowledge providers, and a *vigilant trust* which includes "cognitive mechanisms that allow people to make rather fine-grained ascriptions of trustworthiness before accepting what others say"—which combine expectations of expertise, integrity, and benevolence (Hendriks et al., 2016, p. 153). In other words, epistemic trust is not mere reliance on scientists' professionalism and expertise; it also presupposes that they have "the right attitude towards what they are doing" (Wilholt, 2013, p. 248).

Belli and Broncano (2017) conceptualise epistemic trust as a "meta-emotion", that is, a broad emotional structure in which diverse constellations of emotions may arise in relation to specific situations, such as epistemic conflicts. Building on these insights, we argue that if we are to understand the role of emotions in epistemic conflicts, it is crucial to consider how emotions work intersubjectively. Hence, we refer to the concept of "feeling rules"—the social conventions that guide the appropriate expression of emotions within a culture. These rules illuminate how emotions, far from being merely personal experiences, are relational and situational, framed by the very social conventions and structures of feeling that govern their expression, intensity, and impact (Ahmed, 2004; Demertzis, 2020; Hochschild, 1983). Moreover, the way emotions are articulated through language plays a pivotal role in shaping identity and influencing decision-making processes. This understanding of emotions as experiences mediated by cultural norms and feeling rules underlines the complexity of emotional dynamics within science-related conflicts and points the attention towards the implications of epistemic conflicts for epistemic trust.

Contemporary epistemic conflicts seem to revive the modern self-understanding of science as the only legitimate way of establishing truths (see Houtman et al., 2021). On the one hand, criticisms against scientific authorities are often based on the idea that the knowledge they produce is not neutral and objective, not "pure" (as, according to the ideals of the Enlightenment, science should be), in that contemporary scientists are politicised or bound by corporations' interests. On the other hand, some scientists react to these criticisms by arguing for the "authority" of science, its political neutrality, and its objectivity, as well as by undermining the legitimacy of the criticisms by deriding the critics' supposed ignorance in science—thus reaffirming a form of "scientism". This type of criticisms, as well as this type of reactions, illustrates a "judicial" understanding of science, similar to the judicial approach to politics described by, among others, Rosanvallon (2008): an approach that rejects the inherent ambiguity of political discourse—or, in this case, scientific discourse—in favour of commitment to a supposed non-political, non-partisan "truth", and includes an imperative of transparency and accountability (see Giorgi, 2022). In this sense, these contestations contribute to the public and political relevance of the narrative and concept of objective truth, and often reframe epistemic conflicts into polarised struggles over truth and falsehood.

At the same time, other contestations challenge scientific epistemology, often by advocating instead for folk wisdom (Wodak, 2015) or for an individual form of inductivism (what has been called "I-pistemology", Van Zoonen, 2012). The latter is based on giving prominence to individual experience as a source of authority for validating scientific assertions, which also means these evaluations are inherently subjective and incontestable, subtracted to the scientific principle of falsifiability (see Harambam & Aupers, 2014). As Griera et al. (2022) point out, this reliance on personal experience, along with concerns over Western medicine (Houtman & Aupers, 2007) and the promotion of alternative medical treatments (such as reiki and homoeopathy) that broaden the understanding of science, is particularly resonant with increasingly popular strands of contemporary spirituality that affirm an experiential approach to truth (Rutjens & van der Lee, 2020).

Hence, the configurations that contemporary epistemic conflicts assume resonate with broader cultural shifts characterising contemporary public and political spheres. Even though epistemic conflicts around science are not a new phenomenon, we argue that contemporary ones are unique in two ways, namely the key roles played by digital platforms and far-right political actors. First, as Aupers and de Wildt (2021), among others, observe, the rise of the internet has enabled the participation of vast audiences in epistemic controversies that used to be reserved for scientific and academic circles, political elites, or social movement activists. Digital platforms have reduced the barriers to participation and enlarged the active audience taking part in epistemic debates. Epistemic debates online are imbued with emotions, as "social networks are a means of communication that privileges the transmission and dissemination of emotional content" (Serrano-Puche, 2021, p. 232). Moreover, digital environments also offer a platform to what has been called the "uncivil society" (for a discussion, see Krzyżanowski & Ledin, 2017): this uncivil society contributes to redefining the borders and norms of civil language, effectively normalising the expression of intense, negative emotions.

The second element that distinguishes contemporary contestations of science is related to the active role that political actors often have in them. Science has a long and steady relationship with politics, for example through the involvement of scientific experts in policymaking (e.g. Antonyuk et al., 2023; Cullen et al., 2019), the mobilisation of alternative scientific authorities, or the production of original research by social movements contesting policy decisions (e.g. Chesta, 2021). Looking from another angle, research in politics and sociology has long explored how politics affect scientific production (e.g. Ahrens et al., 2021; Eslen-Ziya, 2020; Pető, 2017) and has showed that social location influences the perceived credibility of epistemic figures and the legitimacy of science claims (e.g. Ayoub, 2022; Paternotte, 2018). As Pető (2022) has discussed in relation to what she has called the "polypore" state, science politics have become a primary site of action for illiberal governments that establish knowledge institutions alternative to those producing knowledge they disagree with. Research has explored the cases of Hungary, Poland (Grzebalska & Pető, 2018), and Turkey (Çarkoğlu, 2023). Not only governments are taking action: far-right political think-tanks, also, are spreading all over Europe, often openly contesting the knowledge produced within academia on topics such as migration and gender (e.g. Saresma & Palonen, 2022), and political attacks against scholars dealing with topics such as migration, gender studies, and religion have been increasing (Eslen-Ziya et al., 2023). Far-right political actors and illiberal governments combine scientific arguments with emotions in what has been called "the politics of fear" (Rico et al., 2017; Wodak, 2015).

Contemporary epistemic conflicts are thus characterised by the key roles played by digital environments—in which the style of communication privileges the circulation of emotional contents—and political institutional far-right actors largely adopting the language of emotions in their political discourse. Hence, it is important to understand how emotions work in digital environments, particularly those involved in epistemic conflicts.

Online Spaces: Publics, Crowds, Swarms

Scholars analysing digital environments have revived classical sociological notions, such as "public", "panic", and "crowd", to describe online collective behaviour and conceptualise "the simultaneity of the individual and the collective in digital media", as Lee (2017) puts it.

This type of analysis also focuses on emotions. Classical sociologists proposed an opposition between "crowds", conceived of as intrinsically irrational, emotional, and unpredictable, with the "public", framed instead as rational and reflective (Caliandro, 2018). While the public is kept together by "a social imaginary (or a *discourse*) created and re-elaborated by the members themselves that is spread and put into circulation within the same public" (ibid., p. 564), crowd gatherings are characterised by their affective dimension—what in classical sociological analysis was defined as "affective discharge", based on the emotional energy circulating in unmediated bodily encounters. Broadly speaking, the distinction between crowds and public is often based on two elements. The first one is the role of the body: crowds are characterised by the co-presence of the bodies, while publics can exist even without this physical co-presence. If we focus on contemporary digitally mediated interactions, then, the notion of public would fit better. The second element is the relevance of emotions circulation in the crowds. However, as many scholars have pointed out, separating a "rational" and reflective behaviour from the role of emotions is analytically untenable.

Stage (2013) introduced the concept of "online crowds," emphasising how the unique characteristics of online communication—its speed, immediacy, intimacy, and multimodality—centralise bodily connections and reactions in these mediated exchanges. This approach challenges traditional boundaries, blurring the lines between mediated and unmediated crowds, private and public spheres, geographical distance and perceptual proximity, as well as between individual bodies and the collective life of bodies online. Stage observed phenomena such as collective flaming, rage, hyping, bullying, and mourning in virtual environments, highlighting how these behaviours, so prevalent in contemporary online communication, question the once clear distinction between the controlled reflection of an individual engaging with media texts and the uncontrolled actions of crowd participants. In today's digital age, users of online media are not just passive observers but active participants in crowd practices. This perspective aligns with Borch and Schiermer (2021), who further explore how online crowds merge aspects of publics and crowds, showcasing a type of online behaviour where the mediated public engages in shared affective processes and congregates on specific online platforms. The sharing of affective processes occurs via "the expression of bodily reactions within the text of an online content" and "formatting of the online content (e.g. if the discourse is distorted, ruptured, or redundant)" (Caliandro, 2018, p. 562). The concept of online crowds (or digital crowds) would therefore indicate those online gatherings in which communication practices are mostly characterised by emotional activities and "affective discharge" rather than discussion, debate, or deliberation (Borch & Knudsen, 2013).

Similarly, Papacharissi (2016) introduced the concept of "affective publics" to indicate social formations within digital spaces that are bound together through expressions of emotion and feelings of engagement. These affective publics are not merely ephemeral gatherings but are sustained through a relational understanding of affect and emotion, emphasising how these feelings connect individuals within the networked publics, intertwining online and offline experiences into the fabric of everyday political and social activities. In this light, both texts and hashtags become tools that shape our everyday life, not unlike offline interactions, by fostering a sense of belonging and solidarity, albeit in a potentially transient manner. Papacharissi argues that the ambient, self-sustaining reflexivity driven by digital expressions creates a persistent bond among networked publics, a bond that outlives the initial events or discussions that brought these individuals together, through accumulating layers of digital expressions that leave affective traces.

This insight underscores the importance of understanding these casual, often overlooked, online utterances as they offer a window into the dynamics of contemporary social and political engagement. Other concepts, such as "multitudes" and "swarm", have been introduced in social sciences to describe temporary and volatile online collective gatherings that are spontaneous and unorganised and work by means of contagion (Lee, 2017). The common denominator in these notions is the attempt to conceptualise how separate individuals converge and express common behaviour in digital spaces, as well as the role of emotional energy in the creation of the crowds and crowd-based mobilisations in digital environments (e.g. Bennett et al., 2014). The concepts of affective publics and online crowds, and the role of emotions in these digital connections, are particularly relevant to the analysis of epistemic conflicts online, as such conflicts often take the shape of online volatile gatherings full of (and fuelled by) emotions.

(Post)-Truth Regimes and Emotions

As Harsin (2018) pointed out, digital platforms enabled the proliferation of a variety of regimes of truth (or regimes of post-truth, as he suggests calling them—Harsin, 2015). A regime of truth, in Foucault's perspective, indicates the type of discourse that a society accepts as true, and includes "games of truth", that is, the rules and mechanisms separating truth from falsehood, the legitimate ways of producing (or discovering) and telling the truth, and the status of the truthtellers. In contemporary societies, multiple regimes of truth can co-exist in the same field of knowledge and compete for hegemony in multiple arenas, including digital debates—hence, there is also a proliferation of different truth games performed by active audiences in segmented communities (see Giorgi, 2022, p. 234).

In online games of truth related to contemporary epistemic conflicts over science-related questions, the appeal to emotions has a significant role in argument-making, so much so that they have often been framed as struggles between "science" and "anti-science", rational arguments and irrationality (Prasad, 2022). Yet, as many scholars have pointed out, this binary frame has scant heuristic value, as it pathologises the criticisms against scientific claims, traces an untenable separation between science and emotions, conflates the concepts of science and rationality, and conflates criticisms against policy measures and misinformation (Giorgi & Eslen-Ziya, 2022; Harambam, 2020; Ylä-Anttila, 2018). Epistemic conflicts are not (or not always) fuelled by misinformation, nor do they consist of a rational and an emotional side.

This binary understanding of science-related conflicts echoes the distinction between "affect" and "emotions" that is often applied by scholars analysing collective behaviour on digital platforms, but that has recently been criticised by Boler and Davis (2018). Emotions are culturally mediated experiences (Ahmed, 2004; Hochschild, 1983). As Demertzis (2020, p. 5) summarises, any emotion is: (a) elicited and experienced relationally and situationally, (b) expressed according to social conventions (feeling rules) and structures of feeling which make for its valence, arousal, and potency, (c) discursively narrated within and through language games partaking thus in identity and will formation processes.

Contrastingly, affect is conceptualised as an untamed force, an "irrational" energy that eludes the grammars and rules of emotions, and evades the individual's control and comprehension. Challenging this dichotomy, Boler and Davis (2018, p. 81) propose a reconceptualisation of affects as "emotions on the move," which are collectively or intersubjectively manifested, experienced, and mobilised. This reconceptualisation transcends the individual's private sphere, entering shared or public spaces, and potentially catalysing movements. This approach advocates for a synthesis that combines the focus on affect as a mechanism of connection with an analysis of the interactional dynamics through which "feeling rules"—that is, societal norms around emotions—are crafted and solidified.

The application of an approach sensitive to affect and emotions in the analysis of epistemic conflicts unfolding online, we argue, would allow research to better understand the cultures of knowledge spreading (and competing) in the public sphere and their political implications in terms of epistemic trust.

First, emotions are cultural practices (Ahmed, 2004): Culture shapes what we feel, how we should (or should not) express emotions, and what emotions are appropriate or required in different circumstances—Hochschild speaks of "feeling rules" (1983). Studying emotions as cultural practices can help us to unpack which emotions are deemed appropriate in different conflicts related to science. Harsin (2018), for example, proposes the concept of "emo-truth" (or "aggro-truth"—Harsin, 2021) for those truth games—particularly diffused in epistemic conflicts—in which the authenticity of what is conveyed is based on emotional intensity: In these cases, truthtellers are considered as those having the courage to tackle controversial topics in an aggressive style of communication, veined by outrage, disgust, and humiliation (Giorgi, 2022). Focusing on the spread of fake news, Young (2021) analyses the role of "cruel optimism", showing how disinformation campaigns are, in fact, practices of affective warfare based on nostalgia, humour, hate, or hope. To underscore the role of this emotional sharing in spreading misinformation, he speaks of "affective geographies of misinformation".

Second, scholars explore how emotions are corrected, adjusted, and redefined during epistemic conflicts through groups' interactional dynamics (Eslen-Ziya et al., 2019). In this sense, online gatherings are contexts in which feeling rules are constructed and established through the participants' interactions, effectively disciplining what are the appropriate emotions and how they can be expressed. In this direction, a promising approach would be the analysis of how digital platforms enable or hinder certain expressions of emotions, as well as how they shape the interactional dynamics in the case of epistemic conflicts occurring online.

Third, scholars studying emotions point out how the feeling rules are connected to the actors' position in the fabric of society. Lorde (1997), for example, argues that feeling and expressing anger is a profoundly gendered and racialised practice. Along similar lines, Campbell (1994) shows that the anger expressed by minoritised groups is reframed as bitterness, and, as such, delegitimised, by dominant groups, while Scheff (2003) discusses the role of social class, gender, and colour in feeling and expressing shame. In this direction, an approach sensitive to the articulation of affect and emotion, and the online interactional dynamics, would allow the researchers to explore which subjects can express which emotions, on the one side, and how subjectivities are constructed through the expression of certain emotions, on the other. For example, Harsin (2020) argues that "aggro-truth" and "emo-truth" are usually performed by white, toxic masculinities—hence, it is profoundly gendered and racialised. Leidig (2023) shows how female far-right influencers mobilise other types of emotions instead, connected to self-respect, confidence, and positive passions. These studies suggest that feeling rules related to epistemic conflicts are gendered. It would be interesting to further this line of analysis by exploring whether and how they are racialised, for example.

These pioneering studies explore which emotions come into play in epistemic conflicts, such as anger, outrage, disgust, humiliation, nostalgia, hate, hope, passion, self-respect, and cruel optimism, mobilised by diverse gendered and racialised subjects. They show the relevance of unpacking how these emotions are mobilised, which feeling rules apply, how they are enforced and how these rules shape different subjects populating the various communities.

Conclusions

This chapter sheds light on the intricate role of emotions within contemporary epistemic conflicts, particularly in the context of online platforms and the influential presence of far-right actors. Contemporary epistemic conflicts are characterised by the increased accessibility to science-related discussion through the web, and by the active role of politics: We have argued that focusing on how emotions circulate and how the feeling rules towards science are established in online epistemic conflicts would be particularly fruitful in order to analyse the transformations of epistemic trust and its social and political implications.

It is evident that emotions are not mere by-products of ignorance or knowledge, as it is often suggested that they are, but rather significant drivers that shape the dynamics of these conflicts. Additionally, emotions play a central role in shaping collective identities and influencing individual subjectivities. The formation of affective ties and the creation of hybrid emotional echo chambers demonstrate how emotions can lead to the development of shared identities across diverse boundaries.

In revisiting Gabriel Tarde's analysis of collective behaviour and combining it with feminist and sociological approaches to emotions, this chapter has contributed to classical sociological theory by updating and adapting Tarde's framework to the digital age. The hybrid emotional echo-chamber theory proposed by Eslen-Ziya (2022) offers a contemporary lens through which to understand the interplay of emotions, collective behaviour, and power dynamics in epistemic conflicts. The discussion of the role of emotions in epistemic conflicts, misinformation, and truth games shows the importance of paying attention to which emotions are mobilised and how they differently appeal to (and shape) different subjects. Boler and Davis (2018) argue for transcending the simplistic binary between affect and emotions by considering affects as "emotions on the move." This concept is pivotal for us as it underscores how emotions can transform into collective experiences and mobilise public actions, thereby influencing social movements. Acknowledging emotions in this dynamic and shared context allows us to comprehend that distrust in science stems not only from misinformation but is also deeply rooted in the societal fabric, where feeling rules play a crucial role in shaping collective attitudes towards scientific discourse and epistemic trust.

In summary, this chapter has highlighted the centrality of emotions in shaping contemporary epistemic conflicts, emphasising their profound impact on subjectivity and collective identities. By delving into these complexities, researchers gain a deeper understanding of the intricate dynamics at play within post-truth regimes. The exploration of these emotional underpinnings is essential for advancing our comprehension of the socio-political landscape, emphasising the need for ongoing research in this area. Such endeavours will not only enrich sociological theories but also offer practical insights useful for addressing the challenges posed by misinformation and the polarisation of scientific debates in the digital era. The application of an approach sensitive to affect and emotions in analysing epistemic conflicts online can illuminate the cultures of knowledge spreading and their political implications, revealing how digital platforms shape the interactional dynamics and feeling rules in these conflicts. This nuanced understanding of emotions as cultural practices, and their role in constructing subjectivities and collective identities within the public sphere, marks a critical advancement in navigating the complex landscape of knowledge dissemination and reception in the digital age.

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5

Celebrity Scientists as Mediators Between Science and the Public in an Acute Health Crisis

Jessica Gall Myrick and Helena Bilandzic

Introduction

During the emergence of the COVID-19 pandemic, policy-makers and scientists were under extreme time pressure, the stakes were high, and the need for reliable scientific information skyrocketed. Trust in the media, scientific experts, and public officials became a key factor in shaping public opinion and action, especially as the scientific evidence evolved under public scrutiny. In such large-scale emergencies, audiences seek more than just information: They seek trusted individuals, such as public-facing scientists and other prominent public-health experts who have relevant knowledge of fast-moving and highly technical issues (Mihelj et al., 2022).

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In these situations, audiences may turn to so-called celebrity scientists, often including medical doctors. These are mediated personae who not only convey health information but also provide important cues and emotional support to the public. Having an expert explain science makes it more accessible and human. Celebrity scientists also play into the logics of news selection and construction: "Personification," or showing a human rather than an abstract process or statistic, is an important news factor (Grabe et al., 2017). Additionally, celebrity scientists cater to the news factors of "prominence," by showing people who are well-known to the public, and "eliteness," by showing people with elite status, thereby further increasing their newsworthiness (Boukes et al., 2020; Eilders, 2006; Parks, 2019).

Expert scientists are an essential and frequent part of media reports about science issues (Peters, 2021). Despite the very logics of science and media (Kohring, 2005), scientists and journalists invest considerable energy in overcoming discrepancies in expectations, resulting in co-orientation and mutual benefit (Peters, 2007). Expert scientists represent personalised instances of normally abstract science discourses and, thus, are attractive for media reporting. Conversely, scientists readily use media as a forum in which to popularise their projects and present findings from their own (scientific) perspective, which can then indirectly also reach policy-makers (Peters, 2021). Celebrity scientists reinforce the role of public experts as they develop a special connection with audiences, possibly even resulting in parasocial relationships: The expert face in the media becomes the face of a mediated friend, opening up considerable potential as well as risks for science communication.

This chapter proposes that trust in science is, to some extent, fueled by public-facing scientists. We review relevant research on trust in celebrity scientists and audience motivations for seeking out celebrity scientists, from information needs to emotional gratifications to models of parasocial relationships. We have examined research databases (e.g. EBSCO, Web of Science, Google Scholar) for literature on parasocial relationships or parasocial interaction with celebrities and then refined keywords and abstract searches for studies including scientists or doctors and COVID-19. From there, we went on to scrutinise references in relevant articles so as to examine additional research that might inform our summary of the work related to our interest in how celebrity scientists may shape public opinions during a pandemic. We also synthesise empirical studies of the effects of celebrity scientists on audiences. Finally, we conclude by discussing the implications of celebrity scientists for health and science communication more broadly.

Celebrity Scientists as Communicators

Celebrities are individuals who become well-known to the general public through the media (Giles, 2000). A small number of scientists become celebrities via the media, recognisable outside the scope of their narrow scientific fields (Goodell, 1977). Sometimes called "science popularisers" (Scheitle & Ecklund, 2017), celebrity scientists such as Carl Sagan, Richard Dawkins, or Neil deGrasse Tyson gained fame and influenced public attitudes towards science long before COVID-19 (Fahy, 2015).

Celebrity scientists are important for research into the effects of science communication on public trust because they are so visible and have ample opportunities to shift public opinion. As Johnson et al. (2016) argue, "others see them as actual representatives of science as a social institution" (p. 2). Trust in scientists serves as a predictor for trust in science (Wintterlin et al., 2022) or for support for funding of science (Ophir et al., 2023). Fahy (2015) emphasises that celebrity scientists not only communicate scientific facts, but also give the public a glimpse into the inner workings of science, such as a mindset of excellence and competition as well as their struggle with uncertainty and failure. What any individual celebrity scientist says can potentially be viewed by audiences as representing the general state of science and general attitudes of scientists. When celebrity scientists make a public misstep, it could damage not only their reputation, but that of science more broadly.

Celebrity scientists can also be effective communicators in a crisis. During the COVID-19 pandemic, scientists around the world recommended protective behaviours or reported on research recommending such behaviours (Joubert et al., 2023). Algan et al. (2021) provide experimental evidence from across different countries, showing that recommendations by prominent scientists to wear masks were typically more effective than those by governments. Other studies, however, show that the effect of experts depends on the specific COVID-19 containment measure (Yuen, 2023) or citizens' political orientation (Vlasceanu & Coman, 2022).

In addition to recommending protective behaviours, scientists can also serve as models of behaviour (e.g. practising protective behaviours, getting vaccinated). A comparative study across the UK, the US, and Turkey emphasised the validity of this assumption: In all three countries, the most effective incentive to vaccinate was the vaccination of the country's expert scientists (Salali & Uysal, 2023).

Celebrity Scientists as Targets of Anti-intellectualism and Conspiracy

Being in the spotlight of a health crisis has its downsides, however. Scientists around the world defended mandatory interventions and explained their value in public debates through numerous media outlets during the COVID-19 pandemic (Joubert et al., 2023). As interventions often came at a substantial individual cost (not going to work, not seeing loved ones, etc.), these scientists unexpectedly found themselves in the limelight of unfriendly protests and accusations of exaggerating or fabricating the crisis, resulting in public attacks, insults, and threats (Hotez, 2022).

In a survey of 1,281 COVID-19 researchers contacted by *Science*, 38% of the sample reported at least one kind of harassment (e.g. personal insults, attacks on their expertise, excessive contact). The more these scientists were featured in the media, the more harassment they experienced (O'Grady, 2022). In a study of 359 physicians, biomedical scientists, and trainees who used Twitter, 66% reported harassment on social media during the pandemic (Royan et al., 2023).

It is conceivable that the harassment comes from only a few critics who are very active on social media, just as the majority of online disinformation about vaccination comes from a mere handful of active and influential users ("the disinformation dozen", Center for Countering Digital Hate, 2021). A case study of TikTok posts by a Scottish general practitioner, Dr. Michael Mrozinski, who lives in Australia, suggests that conversing with these active misinformation agents can shape public sentiment, too. When medical experts, such as Dr. Mrozinski, are openly hostile towards those who peddle misinformation, that hostility can confirm stereotypes of scientists as elitist and lacking compassion (Thompson, 2022). In short, being too aggressive as a public-facing doctor could potentially foster disliking and further erode trust in medical science.

Mistrust has also been conceptualised as part of a larger phenomenon of anti-intellectualism, or a combination of negative emotions, resentment, hostility, and distrust of scientific experts in public life (Motta, 2017). During the COVID-19 pandemic, a study of anti-intellectual tweets about Dr. Anthony Fauci identified three prominent themes: antagonism between regular people and scientists, delegitimising the motivation of scientists, and delegitimising the knowledge of scientists (Chen et al., 2023). In this study, delegitimising the motivation of scientists was most prevalent in anti-Fauci tweets. The sources of these anti-Fauci tweets were often conservative politicians and conservative news media, as well as some non-institutional actors (e.g. individuals or grassroots organisations).

Bilandzic and Myrick (2023, 2025) investigated public perceptions of leading scientists during the COVID-19 pandemic in Germany and the US. They conducted a cross-sectional survey on a quota sample balanced in gender, age, and education (overall n = 1038 respondents; US: n = 524; Germany n = 514) who were recruited through a commercial online panel providers (for details, see Bilandzic & Myrick, 2023, 2025). The majority of respondents (89% or n = 924) knew of the most prominent COVID-19 scientists—Dr. Anthony Fauci, the director of the National Institute of Allergy and Infectious Diseases (in the US) and Dr. Christian Drosten, a Virologist at the Charité-Universität at Berlin (in Germany). The respondents who knew of the scientists answered an open-ended question: "Describe your perceptions of Dr. Fauci/ Dr. Drosten: What did you think or feel when you saw or heard him in the media?" The open-ended answers were coded by two trained coders with a view to the expressions of positive or negative evaluations, trust, references to their expertise, as well as conflicts and conspiracies involving the scientists, and, finally, whether respondents had uttered any insults about the scientists. The results showed that most respondents (66%) expressed positive attitudes towards the scientists, for instance using such phrases as "competent," "trustworthy," or "I believe him." Only 12% expressed a negative evaluation (e.g. "incompetent," "lying," "I mistrust him," "he annoys me"). Another 3% expressed an ambivalent evaluation (e.g. "ambitious," "seems to have the same opinion as most scientific authorities") and 8% gave a mixed evaluation (positive and negative aspects, e.g. "good scientist, but changes his mind," "great scientist, but his voice should not be the only one heard").

Just over a quarter of the respondents who know of the scientists in question indicated that they trust them (26%; e.g. "has evidence to back his findings" or "delivers good and important research results") and only 4% expressed outright mistrust. The respondents referred to the scientists' expertise in 45% of the cases (e.g. "knows a lot about the virus" or "delivers good and important research results") and the lack of expertise in only 3% (e.g. "no research to substantiate his terrible advice to the President," "not qualified").

Negative aspects were expressed to a lesser extent than the positive aspects. Conflicts were mentioned by 10% of the respondents (e.g. "having to contradict the errors made by the president," or "he may be great in his discipline, but he thinks in a polarising way and does not accept the opinion of other people and scientists"). Conspiracies merited very rare mentions, turning up in only 2% of the cases ("I wondered if he was a puppet for China and the WHO," "he has ties to the Bill & Melinda Gates Foundation. He is in this to make money and kill people through vaccines," "I wonder if he is being completely open with what is going on and if he would cave the demands of those he is working for"). Insults, too, were a rare exception, occurring in only 1% of the sample. This tentatively suggests that harassment may be the result of a "noisy minority" who manages to create the impression of a larger dissatisfied public, when in fact most people support and trust scientists, even in times of a health crisis.

Trust in Celebrity Scientists

What Is Trust?

Experts are distinguished by their training, experience, and authority in a particular field. Through their affiliation with a respected institution (university, research institute, health agency), they have high credentials and are under the supervision of their peers. In many areas of everyday life, regular people often rely on the judgement of experts because their own knowledge is insufficient. If you are not a mechanic, you may need a car expert to explain the rattling in your vehicle and offer suggestions for fixing it. The construct of 'deference to scientific authority' is similar: non-scientists can rely on the judgement of scientists because scientists have understood a problem and found the best solution available (Brossard & Nisbet, 2007). Thus, expert opinion reduces complexity and enables decision-making. Reliance on experts can be a decision-making strategy employed to assess the viability and appropriateness of an option. In this process, trust is key.

Siegrist (2021) outlines three primary types of trust: general trust, social trust, and confidence. General trust can be thought of as a stable trait, such as how some people typically trust or do not trust strangers, while social trust is rooted in shared values. Confidence is a judgement based on past experience or evidence of competence. Hendriks et al. (2015) find that people use three dimensions of expert (including scientist) trustworthiness when assessing information: expertise, integrity, and benevolence. Ophir et al. (2023) find that similar factors influence scientists themselves: They seek to be perceived as credible, prudent, unbiased, and to present science as self-correcting and beneficial.

Trust helps people cope with uncertainty and the distressing emotional states that accompany it (De Vries et al., 2018). In our chapter, we follow Ophir et al.'s definition that trust is based on the perception of shared values between the scientist and the public, and on the perception that the scientist has a general benevolence for the public good.

Trust in Celebrity Scientists During the COVID-19 Pandemic

Compared to other professional groups, scientists in countries such as the US, Germany, and the UK enjoy a high level of public trust. These places display a general faith that scientists will endeavour to inform that public according to the highest scientific standards without a personal agenda (Krause et al., 2019). This trust pays off in times of crisis. For example, Salvador Casara et al. (2022) found that trust in scientists was the best predictor of vaccination intentions at the beginning of the pandemic. Algan et al. (2021) confirmed a positive relationship between trust in scientists and vaccine intention in a study spanning twelve countries. In this study, trust in scientists also predicted support for non-pharmaceutical interventions, such as lockdowns, closing of non-essential businesses, or mandatory use of face masks. Similarly, other cross-national studies found a positive relationship between trust in science (in general) and protective behaviours during the COVID-19 pandemic (Pagliaro et al., 2021). A survey of more than 4,000 Italians, conducted between February and July of 2020, showed that trust in general practitioners and the government or government agencies (e.g. the World Health Organization) increased over time.

There is some indication, however, that being the focus of public attention and being supportive of unpopular truths and interventions may have decreased trust in scientists to a certain degree. Skinner et al. (2020) report that, for the UK, while trust in scientists in general remained stable during the first four months of the COVID-19 pandemic, trust in scientists declined slightly (from 62% trustworthy to 55%). Surveys from the Pew Research Center (2023) also show a slight decline in trust in scientists between April 2020 and December 2021 for American respondents. Possibly, this was fuelled by tensions between former President Donald Trump, a Republican, and medical officials (Dyer, 2020). A national survey of more than 1,500 Americans found that people who identified as Republicans were less trusting of scientists, as were African Americans (Evans & Hargittai, 2020).

Motives for Seeking out Celebrity Scientists

Information Needs

In times of crisis, information is a critical asset. When there is a threat, people need to know how to protect themselves. This uncertainty about which situations and actions are safe creates a need for information, as is suggested by the information utility approach (Atkin, 1973; Knobloch-Westerwick, 2008). According to this approach, information is needed to detect dangers (surveillance), to adapt one's behaviour to current circumstances, and/or to provide guidance and affective reassurance. Within this frame, information is regarded as useful if it provides the recipient with valuable input for coping with daily life and adapting to possible threats.

Celebrity scientists can be a source of such useful information. As a direct mediator between current scientific findings and the public, they can report on hazards and remedies more directly than journalists can. In addition, celebrity scientists often engage in dialogic, discursive formats, such as interviews, press conferences, talk shows, or podcasts, in which they respond to relevant questions directly from the lay public, further tailoring their contributions to people's information needs. For example, during the COVID-19 pandemic, Dr. Christian Drosten, Director of the Institute of Virology at the Charité University Hospital in Berlin, gained rapid and extensive popularity as a public communicator and advisor for the German government (Schmitz, 2020). The German public broadcaster NDR started a daily podcast on COVID-19 developments in February 2020, which quickly acquired a large audience and was downloaded more than 41 million times in less than two months (Hennig, 2020). Each episode of the podcast consisted of an hour-long conversation between Drosten and a journalist, with audience questions, too. These episodes created information utility by providing daily information tailored to the audience's interests.

Within the information utility approach, a purposeful search for information is driven by the need for useful information in a situation of uncertainty. Similarly, information-seeking models assume that people become aware of their information needs in the face of threats. For example, the Risk Information Seeking and Processing Model (RISP;

Griffin et al., 1999) assumes that people compare their current level of knowledge with a desired level of knowledge. The difference between the two is called "information insufficiency." The greater the information insufficiency, the more people seek information and are motivated to process it thoroughly (Dunwoody & Griffin, 2015). Information insufficiency is predicted by several factors: the more serious people perceive the risk to be (perceived hazard characteristics), the more negative the affective reaction (affective response), and the greater the perceived social expectation to be informed about the risk (subjective norm). The greater the information insufficiency that is felt, the more likely that people will engage in information seeking. Two other factors influence how much information people will seek. One has to do with perceived information-seeking ability, or a person's confidence in terms of being able to find adequate and accurate information; if this is high, people are more likely to seek information. The second factor concerns beliefs about the information channel, such as how trustworthy, reliable, and useful it is.

Celebrity scientists shape multiple constructs in the RISP model. Their public appearances can increase awareness of the magnitude of a threat, thus changing the perceived characteristics of the hazard. They can foster a perceived norm that people should be informed about the threat. They can also influence affective responses. On the one hand, celebrity scientists help to define the threat, possibly evoking more negative affective responses. On the other, celebrity scientists can convey hope that the threat is manageable. Given the trust placed in scientists, channel beliefs are likely to be favourable (scientists will be seen as a trustworthy source). Celebrity scientists may also improve the perceived information-gathering capacity, because the potentially extensive search for trustworthy information is reduced to the heuristic of listening to what the scientist says.

Emotional Gratifications

Both theory and data point to the important role of emotions in shaping our behaviour (Lazarus, 1991). Celebrity scientists can alleviate the public's fears and provide reassurance. Of course, scientists who do not have celebrity status appear in the media all the time (Peters, 2021). However, celebrity scientists receive—over time and through processes of parasocial interaction and relationships (see below)—the status of acquaintances or even mediated friends. Rather than having to evaluate credibility cues for each encounter with a scientist, people can build on prior encounters in which they found the scientist's information valuable. Thus, it makes sense to assume that celebrity scientists, more so than less-known scientists, can reassure audiences in times of crisis. This assumption is supported by a cross-national survey in South Korea, Singapore, and the US that examined how trust in the government's ability to address COVID-19 could predict public emotions and information seeking or avoidance (Ahn et al., 2021). The authors found that, across these countries, greater trust predicted lower negative emotions (fear, anger, sadness, anxiety), and predicted greater hope.

Bilandzic and Myrick (2023, 2025) examined the emotional gratifications that people receive from being exposed to Dr. Drosten and Dr. Fauci, who are the two most important celebrity scientists in Germany and the US, respectively. Emotional gratifications included the reassurance that the pandemic is being handled with expertise and professionalism as well as the reduction of uncertainty and fear. To measure this, respondents were asked to think of Dr. Drosten (in Germany) and Dr. Fauci (in the US) and evaluate three statements about the degree to which respondents were reassured by the scientists. Looking at the top boxes of agreement with these statements ("agree somewhat," "agree," "agree strongly"), we find that around two-thirds of the respondents agree with them. Specifically, 64% said they agreed with the statement "I feel less anxious when I learn about new scientific efforts to combat the coronavirus from a real scientist," 72% with the statement "I feel calmer when I know someone smart is involved in efforts to combat the coronavirus," and 67% with the statement "I feel more in control of the situation when I hear from someone who has researched similar situations (other pandemics) before."

Similarly, a survey by Utz et al. (2022) examining reactions to multiple virologists in Germany showed that finding solace was a key effect for listeners of these podcasts. In a qualitative content analysis of the comments on the YouTube video of Drosten's podcast, Gaiser and Utz

(2022) likewise found that listeners mentioned affective benefits of the shows, such as helping to calm them or redirect their fears.

The Knowledge Emotion: Curiosity

Curiosity is an emotion that belongs to the knowledge family of emotions: it is an affective psychological state that motivates people to think and learn more about a topic (Kashdan, 2004). In a January 2018 survey of US adults, 81% cited curiosity as a reason for following science news (Shearer, 2018). Additionally, research suggests that individuals who are generally curious about science are less likely to experience motivated reasoning when processing science-related information (Kahan et al., 2017). Bilandzic and Myrick (2023, 2025) found that general interest in (akin to curiosity about) science positively predicted information seeking and exposure to celebrity scientists.

In a crisis, curiosity may initially be overshadowed by other emotions such as anxiety. However, if we assume that keeping informed is an essential need in a crisis, curiosity can be considered an important driver of information seeking. It is plausible that celebrity scientists generate curiosity about science in audiences who were not previously very interested in a topic. Curiosity is also important for behaviour: For instance, curiosity about the science of mRNA and spike proteins could create a greater openness to getting the COVID-19 vaccine because the technology and science behind it would appear less threatening and more beneficial. Having trusted public figures explain the mechanics of these technologies could reduce the threat of the unknown. In an experiment, Myrick (2023) found that increased transportation into a narrative about a particular scientist led to greater curiosity about the science described in that article.

Parasocial Relationships with Celebrity Scientists

A parasocial relationship emerges when an audience member imagines the media persona to be like a friend or acquaintance (Brown, 2015). Through continued media exposure, audiences start to feel as if they are familiar with a mediated persona and understand how they think and why they act the way that they do. However, parasocial relationships are a notably one-sided phenomenon as the celebrity is likely unaware of the feelings of any given audience member (Brown, 2015; Eyal & Cohen, 2006). Via media, audiences can form psychological attachments to scientists and doctors they see in messages, just like they might with other people featured in media (Rasmussen & Ewoldsen, 2016).

During the COVID-19 pandemic, researchers documented how the public formed parasocial relationships with prominent medical experts. In China, the pulmonologist Nanshan Zhong spearheaded the country's investigation into COVID-19 and regularly appeared in the media (Feng, 2020). A survey of young Chinese adults (aged 18 to 35) revealed that greater exposure to Zhong predicted a stronger parasocial relationship with him, which, in turn, predicted higher levels of general trust in the Chinese government, as well as COVID-19-specific trust in the Chinese government (Liu, 2023).

In the modern digital era, audiences can form parasocial relationships through social media, podcasts, digital newsletters, and more. Through these frequent and regular mediated contacts, scientists often reveal aspects of their personalities and daily lives, which then can make them appear more engaging than is often the case in a typical news report (Van Eperen & Marincola, 2011). In Germany, several virologists began hosting podcasts about the virus and its effects. A two-wave survey found that participants who could identify a favourite virologist were significantly more likely to report higher subjective knowledge of COVID-19, self-efficacy, collective efficacy, preventive behaviour, and even objective knowledge of COVID-19 (as assessed by a quiz) than those who could not (Utz et al., 2022). A structural equation model of the variables assessed during the first wave of data collection showed that frequency of listening to virology podcasts and perceived need for leadership increased the strength of parasocial relationships with the virologist in question, which then predicted greater subjective and objective knowledge levels, as well as comfort (which the authors defined as the ability of the virology podcasters to alleviate some of their listeners' anxiety). However, these direct effects between parasocial relationships and outcomes after the first wave of data collection were no longer significant in a follow-up survey administered two weeks later, which suggests a limit to the power that parasocial bonds have to motivate listeners.

Bilandzic and Myrick (2023, 2025) compared this German context with the American context to explore differences in the process of seeking information from these doctors-turned-celebrities during the pandemic. The study shows that parasocial relationships are more likely to develop when people feel stressed about the pandemic and are generally interested in science topics—in both countries alike. Parasocial relationships were stronger, however, in the US. In addition, political ideology was an important driver—with people on the liberal/left of the political spectrum experiencing more parasocial relationships. However, this was only the case for the US.

Conclusion

Celebrity scientists have the potential to personalise facts and humanise science. It is easier to trust a person than an institution—trust is built more easily and naturally with the human "messenger" of science than with a research facility. Trusting the source makes science and health communication much easier: We can expect more openness to information, especially unpleasant information, more interest and curiosity, and more motivation to process more thoroughly. It is not only the information that matters. Emotional benefits, such as reassurance and guidance from celebrity scientists, are especially important in a crisis and can alleviate fears. It is necessary to take the threat of a health crisis seriously, but excessive fear can incapacitate people, preventing them from taking protective action, making them more vulnerable to motivated reasoning and misinformation. Balancing the fine line between a realistic threat assessment and the hope needed to motivate protective action is a clear case for personal interaction, including parasocial interactions. Trust in celebrity scientists is a gateway to using the expert heuristic, which renders the individual able to avoid being buried by information.

While research has been conducted that explores the functions and effects of celebrity scientists, many empirical questions remain. For example, although we have used the term "celebrity scientist" extensively, it is unclear how much celebrity is needed for a science communicator to be effective. Moreover, another question is how invested the user needs to be for the celebrity effect to occur.

There is also a dark side to relying on celebrity scientists during times of crisis. First, media attention does not simply focus all by itself on the most relevant expert. Availability and willingness to contribute are important factors for featuring a scientist in a media product, but so is a reputation for opinionated statements that generate buzz. For instance, former White House doctor for then-President Trump, Ronny Jackson, is now a member of the US House of Representatives and regularly espouses COVID-19 conspiracies and misinformation (Herb & Liptak, 2021). As with other public figures, such as politicians, there is a potential susceptibility to populism, exacerbated by the difficulty lay people may have in distinguishing between a legitimate expert and an attention-seeking extra with a medical degree.

Second, scientists risk being targeted by hate speech and harassment in response to their public engagement, which can discourage engagement through intimidation and fatigue. Celebrity scientists, as we have argued, can have positive effects on an audience by providing personalised and familiar guidance in difficult times. But the exact same properties make the celebrity scientist a target for hate: Virology as a scholarly field cannot be as easily attacked, as a human personifying this field can.

Despite these risks, the positive potential of celebrity scientists in acute crises is clear. Celebrity scientists can only be useful if the public knows and trusts them. While trust is needed in crises, it needs to be built continuously before, during, and after a crisis. Building trust when you need it—in the crisis—is too late. Advocating, establishing, and building up public trust in scientists is an ongoing—and time-consuming—task.

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6

Communicative Roles of Scientists in Intertwining Online Public Arenas: An Analytical Framework

Kaija Biermann

Introduction

The rise of digital communication environments has radically changed the communicative landscape for science communication, leading to extended opportunities for scientists to communicate publicly (Taddicken & Krämer, 2021; Weingart & Guenther, 2016). Large proportions of the public nowadays mainly inform themselves about science online, including social media (European Commission, 2021; Wissenschaft im Dialog, 2023). These platforms enable scientists to directly engage with the broader public (Della Giusta et al., 2021) and thus operate at "the boundary between science and society" (Roedema et al., 2021, p. 3). Hence, digital communication environments can facilitate scientists' engagement with the public and the public's engagement with science and scientists. This could be particularly relevant in the context of socio-scientific issues (e.g. climate change, Covid-19), which

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are real-world problems of social relevance and controversiality that are informed by science (Sadler et al., 2007; Taddicken & Krämer, 2021). Given these societal challenges that society is currently confronting, there is a growing demand for scientists to actively engage with the public (Calice et al., 2023; Weingart & Guenther, 2016). Therefore, in recent years, the role of scientists as public communicators has come into focus (e.g. Bucchi et al., 2022; Dudo & Besley, 2016). Both the rise of digital communication environments and socio-scientific issues may "shape and challenge professional roles and norms that underlie their [scientists'] communication practices" (Brüggemann et al., 2020, p. 3).

Therefore, it seems imperative to thoroughly examine scientists' communicative roles in digital communication environments. In general, social roles can be understood as expectations, attitudes, and behaviours guiding individuals in certain situations when performing a specific task (Turner, 2001). Scientists' understanding of their roles in digital communication environments can be seen as a constitutive element of their engagement with the public, as it has been shown that various role conceptions lead to different behaviours or role performances (cf. Hanitzsch, 2018). The way in which scientists fulfil their communicative roles may also hold significance for the overall trust in science, because science communication provides an opportunity to form opinions about the trustworthiness of scientists (Fiske & Dupree, 2014). Given that scientists can be a focal point for lay people's contact with science, their epistemic trustworthiness is considered as a predictor of public trust in science (Wintterlin et al., 2022). In circumstances where individuals lack expertise, which is typical for most scientific issues, they have to rely on scientists (Bromme & Goldman, 2014).

The aim of this theoretical contribution is to present an analytical framework to examine the roles of scientists in digital communication environments from multiple perspectives. First, against the background of the concept of online public arenas (Lörcher & Taddicken, 2017; Schmidt, 2013), an insight into the characteristics of digital communication environments is provided in order to better understand the context in which scientists perform their roles on social media. To holistically capture scientists' roles in these environments, the journalistic role concept (Mellado, 2020; Mellado et al., 2016) is introduced, as it combines subjective and more socially structural perspectives on roles into a coherent, integrative framework. Applying the journalistic role concept to scientists in digital communication environments seems appropriate, because parallels between scientists and journalists as public communicating actors can be identified (Brüggemann et al., 2020). Selected results from a case study on the role performance of publicly visible scientists on social media during the Covid-19 pandemic (Biermann & Taddicken, 2024) are presented to exemplify the implementation of the outlined analytical framework.

Scientists' Engagement in Intertwining Online Public Arenas

When considering the roles of scientists in digital communication environments, it first appears necessary to describe the context in which scientists communicate and fulfil their roles there. The concept of online public arenas (Schmidt, 2013) takes the dynamics of digital communication environments into account, seeing online public arenas as a combination of situational practices (e.g. a specific constellation of communicators with different rules of presentation) and overarching structures (e.g. software architecture) (Schmidt, 2013). Through algorithm and affordances (e.g. liking and sharing), the software architecture can influence the communication (about science) in various ways (Taddicken & Krämer, 2021). Online public arenas are not equivalent to online platforms; instead, multiple arenas can be found on a single platform, and they may differ with regard to barriers of communication (e.g. levels of user expertise), inherent norms, intended audiences, or goals of communication (Lörcher & Taddicken, 2017; Schmidt, 2013). Following this, various online public arenas can be differentiated, such as the expert arena, where experts share their research findings with their scientific community, and the discussion arena, where citizens can express their opinions and concerns.

In particular, social media platforms are characterised by a complex network of intertwined arenas (Schrape, 2021). Communication from one online public arena can be transferred to another, where it can be modified by certain rules of presentation and selection and multiple audiences can merge into one, a phenomenon known as "context collapse" (Marwick & boyd, 2010). Scientists can also reach unintended audiences, as different arenas become blurred on these platforms. For instance, platforms' architectures, such as that of Twitter/X, enable scientists to communicate with their peers within the expert arena (Collins et al., 2016; Costas et al., 2020), while also allowing their participation in broader public discussions (Biermann et al., 2023; Jahng & Lee, 2018). In these intertwining online public arenas, scientists have to decide for themselves and, without intermediaries, how they want to perform their roles (Roedema et al., 2021), which requires new skills and a re-evaluation of their roles. Moreover, new public expectations may become associated with scientists' roles in digital communication environments (cf. Loosen et al., 2020). Meanwhile, other actors can present themselves as experts and communicate alleged scientific information on social media (Cook et al., 2017), thereby posing a potential threat to established knowledge and expertise (Neuberger et al., 2023; Schug et al., 2023). Caulfield and Fahy (2016) argue that celebrities, for example, can also use their visibility on social media to introduce scientific concepts into polarising discussions and thus play an influential role in the perception of scientific topics. Hence, while social media platforms enable direct engagement, they can lead to challenges in scientists' communications due to this intertwining of different online public arenas. Because scientists perform various roles simultaneously, role conflicts may arise.

This could be particularly relevant in the context of socio-scientific issues, in which scientists can become publicly visible to the broader public (Joubert et al., 2023; Peters, 2021). Bucchi et al. (2022) have shown that trust in scientists and the perception of scientists' communicative roles during the Covid-19 pandemic played a crucial role in the public's willingness to be vaccinated. As digital communication environments can foster both scientists' engagement with the public and the public's engagement with scientists, scientists' understanding of their roles may influence how they interact with the public, which in turn can be assumed to affect their trustworthiness. Hence, capturing scientists' communicative roles in intertwining online public arenas seems worthy of investigation, especially as digital communication environments may lead to changes in their roles (Taddicken & Krämer, 2021).

Role Concept as Analytical Framework

Roles can serve to analyse social life in terms of norms, ideals, and practices (Mellado, 2020). Role concepts offer a useful structure for capturing scientists' engagement in digital communication environments. These concepts are often applicable within the analysis of public communication (Fähnrich & Lüthje, 2017), making them particularly appropriate for studying scientists who increasingly act as public communicators (Peters, 2021). Roles can generally be described as attitudes, expectations, behaviours, and values guiding individuals in specific situations when performing a particular task (Turner, 2001). Scientists' understanding of their roles—respectively, their underlying values, motives, and perceived expectations—can influence their engagement with the public (cf. Ajzen, 1991; Kim & Hunter, 1993). Thereby, normative expectations can also conflict with the expectations or perceptions of reference groups or personal ideals (Mellado, 2020). Two main strands of role approaches can be distinguished. On the one hand, the functionalist approach conceptualises roles as the expected attitudes and behaviours of individuals who occupy a particular position within society (Goffman, 1959; Lynch, 2007; Merton, 1957). On the other hand, interactionist role concepts define roles as dynamic rather than fixed sets (Ashforth, 2000; Turner, 2001). Roles are adopted and performed by individuals during social processes (van der Horst, 2016). Perspectives that combine interactionist and functionalist approaches view professional roles as situational and always socially constructed, and more specifically as "fluid, non-mutually exclusive, and always negotiable shared understandings in a particular social context" (Mellado, 2020, p. 32).

In the literature, various typologies describe scientists' roles at the interrelations between science and society or politics from a functionalistic perspective (e.g. Peters, 2021; Pielke Jr, 2007). Reference is often made to the roles of scientists in public communication as 'public expert', 'stakeholder', 'research manager', or 'public intellectual' (Brown Jarreau, 2015; Davies & Horst, 2016; Fähnrich & Lüthje, 2017; Peters, 2021). Peters (2021) differentiates three public roles that scientists may take. Besides a 'stakeholder role' in meta-discourses about science and technology, they can act in a 'teacher role' by popularising their research. As 'public experts', scientists are increasingly expected to use their expertise to explain and address socio-scientific issues, thus transcending the boundaries of science (Peters, 2021). Due to the practical implications of their advice, the role of scientists as 'public experts' is frequently interwoven with political interests (Peters, 2021). Peters (2021) notes that the described roles are often not clearly separated in communication settings. At the boundaries of science and politics, Pielke Jr (2007) describes four idealised roles for scientists, which can also be referred to when scientists communicate in public. These roles can be classified as follows: the 'pure scientist' who primarily focuses on scientific research, the 'science arbiter' who impartially provides factual information to decision-makers without expressing personal preferences, the 'issue advocate' who actively promotes a specific policy option, and the 'honest broker' who aims to objectively clarify and expand policy alternatives without advocating for any particular solution (Pielke Jr, 2007). It is important to acknowledge that these roles correspond to ideal types that exist on a continuum and are not mutually exclusive (Pielke Jr, 2007).

As the borders between science and journalism are becoming increasingly blurred, journalistic practices may be adopted by scientists in their social media communication (Brüggemann et al., 2020). Fahy and Nisbet (2011) developed a typology for science journalists online based on interviews with journalists in the UK and the US. They found that there is a greater plurality of roles online than offline. In addition to more traditional roles of 'watchdog' and 'agenda-setter', new roles such as 'public intellectual' or 'civic educator' emerged (Fahy & Nisbet, 2011). Consequently, overlaps with the roles of scientists in public communication appear. In the realm of science blogging, a study reveals that scientists who engage in science blogging perceive their communication role as a way of establishing themselves as 'public intellectuals' regarding certain issues (Brown Jarreau, 2015). In particular, given that communicating scientists can, in the context of socio-scientific issues, act as key figures in public discourses (Safford et al., 2021), the described typologies may serve as a basis for classifying scientists' roles and communication behaviours in digital communication environments.

However, there is a lack of empirical research in the context of scientists' roles in digital communication environments. Studies that have empirically analysed scientists' roles mainly focus on their self-perceived roles (e.g. Getson et al., 2021; Roedema et al., 2021), which may differ not only from the roles actually performed but also from the (perceived) expectations of the public towards scientists' communicative roles in intertwining online public arenas. In the case of journalism studies, where research on roles is a core concept, the framework of Mellado et al. (2016) offers an approach that combines the functionalist view of roles with the interactionist perspective by distinguishing four role dimensions. These operationalisable dimensions appear useful in terms of holistically examining the communicative roles of scientists in digital communication environments.

Role conception can be defined as an individual's own formulation of their most important roles, focussing on the purposes of the profession. *Role perception* deals with the (perceived) role expectations in society and is related to social consensus. Moreover, *role enactment* assesses the implementation of the roles, looking at how individuals evaluate the fulfilment of their ideals (Mellado, 2020; Mellado et al., 2016). Finally, *role performance* concentrates on actual behaviour and outcomes, which may differ from the other three normative dimensions (Mellado et al., 2016). Analogous to the roles of journalists, the roles of scientists can manifest themselves in their actual communication practices, such as in posts on social media (cf. Mellado, 2020). In contrast to journalists, whose *role performance* is usually the collective outcome of concrete newsroom decisions (Mellado et al., 2016), scientists' *role performance* is primarily their own responsibility (Roedema et al., 2021). While the study of *role conception*, *role perception*, and *role enactment* has primarily been conducted using qualitative interviews and surveys, the study of *role performance* can be approached through content analysis or ethnography (Mellado et al., 2016).

The differentiation of various role dimensions proposed in the presented analytical framework enables one to empirically examine scientists' communicative roles in intertwining online public arenas from different perspectives. In this way, possible incongruencies between the role dimensions can be identified, which seems particularly interesting in digital communication environments that may challenge scientists' professional roles and communication practices. The outlined existing role typologies can serve for the classification of these roles. The following section shows selected results from a case study on the *role performance* of visible scientists on Twitter/X[1] during the Covid-19 pandemic (Biermann & Taddicken, 2024) and is presented as an example of applying the framework to communicating scientists.

Application of the Analytical Framework: A Case Study on Visible Scientists' Role Performance on Social Media During the Pandemic

In the context of the Covid-19 pandemic, there was an unprecedented opportunity to analyse how scientists, who suddenly gained high visibility, performed their roles on social media during a global crisis that had an immediate and far-reaching impact on societies worldwide and attracted a great deal of public attention (Joubert et al., 2023; Peters, 2021). Hence, in order to elucidate visible scientists' role performance in digital communication environments in the realm of socio-scientific issues, we analysed the communication behaviour of visible German scientists on Twitter/X during the Covid-19 pandemic. In this context, Goodell's (1977) concept of visibility was applied to scientists who were visible on social media (Olesk, 2021) in the German context.

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[1] The microblogging platform Twitter recently changed its name to 'X', which also comes with changed functions. At the time of the case study, the logic and functions of the original Twitter platform applied.

Operationalisation of Role Performance: Methodical Implementation in the Case Study

A quantitative manual content analysis of tweets (original tweets and quotes) posted by eight visible scientists from the field of virology during the Covid-19 pandemic ($N = 1003$) was conducted to analyse their role performance. These scientists were identified in a multi-stage process that began with a search for scientists on the websites of German virological research institutes and ultimately required that the scientists had a Twitter account with more than 10,000 followers.[2] To capture the communication behaviour over time, six two-week periods over the course of the pandemic (March 2020–January 2022) were selected, focusing on profound political events (e.g. lockdowns) in Germany. The standardised codebook of the study contained formal categories (e.g. period, type of tweet), as well as categories with various subcategories enabling to capture scientists' communication behaviour in detail.

This chapter section focuses on those categories within the codebook that offer deeper insights into the visible scientists' role performance in intertwining online public arenas. Examining the *type of statements*, the *frequency of calls to action*, and *media references* can make scientists' role performance in ways that are empirically measurable, particularly when assuming that parallels between journalists and communicating scientists emerge in digital communication environments (Brüggemann et al., 2020). The categories used in the case study are described in more detail below.

The category *type of statements* aims to capture the nature of the visible scientists' posts. Based on previous research (e.g. Jahng & Lee, 2018; Walter et al., 2017), five distinct statement types are differentiated: Posts coded as *information* convey factual content. *Information seeking* applies when posts aim to seek out information. *Rhetorical appeals* are posts in which visible scientists urge specific behaviour. Posts classified as *expression of opinions* include statements by scientists expressing their own views and feelings. Posts coded as *criticism* contain negative sentiments

[2] For details on the methodological procedure and the overall results, see Biermann and Taddicken (2024).

towards actors, institutions, or systems. Furthermore, the category *calls to action* examines whether the scientists explicitly call others to act. In order to gain an insight into who or which arenas are addressed in such calls to action, the *addressee* of the respective calls to action must be captured. The category *media reference* captures situations where references to traditional media (both online and offline) are predominant. *Media evaluations* can give insights in the assessment of the media in the posts containing media references. To take the *functions of the media references* into account, it may be useful to code these as well (confirmation, appreciation, criticism, announcement).

Categories such as *calls to action*, *rhetorical appeals*, and *expression of opinions* can indicate that scientists are acting as 'issue advocates' (Pielke Jr, 2007) or 'public experts'(Peters, 2021), respectively. Moreover, the categories of media references presented here can provide insights into the roles of scientists that are closely interwoven with journalists, such as 'watchdog' (e.g. Fahy & Nisbet, 2011). Except for *media evaluations* and *addressee of calls to action*, each category and subcategory are coded in binary terms (not prevalent/prevalent). In the case study presented here, Krippendorff's alpha intercoder coefficient varied from 0.67 to 1.00 for all categories. The results of the case study shown and discussed below serve as an example of how the outlined categories can manifest themselves in a specific analysis.

Scientists' Role Performance on Social Media: Selected Findings of the Case Study

The visible scientists in the case study primarily shared *factual information* (53%), but also frequently *expressed opinions* (37.6%) and voiced *criticism* in nearly one-fifth of their tweets (17.5%). *Rhetorical appeals* were used less frequently (11.4%), and *information seeking* was relatively rare (3.1%). Looking at the individual statement types over time, the results indicate that the provision of *information* in visible scientists' tweets increased, while *expressions of opinions* and *criticism* were particularly visible in period two (October/November 2020) and thus at the beginning of the pandemic. No significant changes in the use of *information seeking* and *rhetorical appeals* were found across the observed periods. Taken together, visible scientists provided not only *factual information*, but also extensively *expressed their own views* and even *criticism*. The use of various statement types was dynamic, as some changes were observed over time, with the results indicating a decrease in evaluative statements (e.g. *criticism*). With regard to the role approaches discussed here, this suggests that scientists' roles are indeed fluid and not mutually exclusive (cf. Mellado, 2020).

In the case study, the visible scientists called to action in 25.3% of all tweets, and no significant differences were found over time. Most of the *calls to action* were directed at the public (51.1%) and at political actors (35.6%), to a much lesser extent at science (8%) and the media (2.2%). Hence, advocating for the implementation of certain measures (e.g. containment strategies, strengthening the health authorities) was a practice that was evident throughout the study period in visible scientists' role performance. They also used their social media communication to directly refer to the media by either addressing the media or quoting certain media contributions—in 26.3% of all tweets, *media references* were found. While the results indicate that the use of media references decreased over time, referring to the media was a common practice in visible scientists' *role performance* on Twitter/X. When *media references* were given, they were predominantly neutral (63.7%), followed by positive evaluations (27.3%). In 7.3% of the cases, the visible scientists evaluated the media negatively and in 1.3% both positively and negatively. Negative evaluations were voiced, for example, with regard to perceived exaggerations or misrepresentations by the media from the visible scientists' point of view. Concerning the *functions of the media references*, the visible scientists most frequently referred to the media in order to emphasise and appreciate a certain media contribution (41.9%), and in 31.6% of cases they referred to the media to affirm their own statements (31.6%). In one-fifth of all media references (21.8%), these served to share their own appearances in the media (e.g. talk shows, interviews), and, less frequently, the visible scientists criticised the media (11.5%). Hence, when visible scientists referred to the media, they predominantly highlighted specific media contributions, emphasising either the significance of the topic discussed or the quality of the news article in comparison with others.

Overall, the selected results show that the visible scientists transcended roles of mere knowledge brokering by extensively sharing their personal views and even criticism. The findings also illustrate that their *role performance* was dynamic, as differences over time occurred. The common practice of *calls to action* aimed at the public in the analysed tweets could be due to a strong motivation to address the public directly in the exceptional situation of the pandemic (Joubert et al., 2023). The frequent use of *calls to action* in their tweets suggests that the visible scientists acted as 'issue advocates' (Pielke Jr, 2007) by promoting specific measures beyond official policy recommendations. Additionally, the results of the case study indicate that visible scientists acted as 'watchdogs' of the media by evaluating certain media contributions. They also functioned partly as 'gatekeepers' in digital communication environments by emphasising specific media contributions.

Hence, the presented findings of the case study indicate that the visible scientists performed roles that have in the past mainly been filled by journalists (Taddicken & Krämer, 2021). However, the results of the overall study show that scientists also engaged in communication practices associated with traditional roles, such as the dissemination of scientific information and the use of scientific jargon (see Biermann & Taddicken, 2024, for details). New roles do not appear to be replacing the old ones, but traditional and new roles seem to coexist in digital communication environments. The findings presented here as way of example are constrained by their focus solely on the *role performance* of eight visible scientists in the German context during the exceptional situation of the pandemic. However, this section has aimed to exemplify how role performance as one of the four role dimensions can be empirically measured by means of analysing the outcome of scientists' social media communications. In this respect, even if it should be borne in mind that the specific results are not transferable to all communicating scientists, the categories presented above make it possible to capture role performance in different fields and contexts. Therefore, they can serve as a starting point for further research on the communicative roles of (visible) scientists (in the context of socio-scientific issues) in digital communication environments.

Discussion and Conclusion

This chapter has shed light on scientists' communicative roles in intertwining online public arenas by introducing the journalistic role concept (Mellado, 2020; Mellado et al., 2016) as an analytical framework for holistically examining scientists' (new) roles in digital communication environments. To illustrate the application, the implementation of the approach was presented using selected results from a study on visible scientists' role performance (Biermann & Taddicken, 2024). Socio-scientific issues and the described blurring of boundaries of different online public arenas (Lörcher & Taddicken, 2017; Schmidt, 2013) on social media pose new challenges for scientists' public communication and can lead to role conflicts in digital communication environments.

The outlined framework allows for comparisons of normative dimensions (e.g. *role conception*) and actual behaviour (*role performance*), as attitudes and perceptions are not used as a proxy measure of *role performance*, but *role performance* is directly measured via the outcome of actual behaviour (Mellado, 2020). The four role dimensions enable the study of communicative roles through different methods and approaches. For a comprehensive picture of scientists' roles in digital communication environments, it can also be useful to examine actual *role perceptions* by analysing the public's expectations of scientists' roles in digital communication environments, as these expectations can be important for the public's evaluations (Wicke & Taddicken, 2021; Zhang & Lu, 2022). This can be especially valuable when considering that roles exhibit fluidity and are not mutually exclusive, but represent a shared understanding within a particular social context that is always negotiable (Mellado, 2020). Not least in view of the results of the presented case study, it seems to make sense to link communicative roles of scientists more strongly with journalistic role typologies (e.g. Fahy & Nisbet, 2011). The presented findings support previous research revealing that, in highly politicised fields, scientists tend to express their own views in digital communication environments (e.g. Biermann et al., 2023; Walter et al., 2017). Therefore, it would be fruitful for future research to combine existing role typologies of scientists and role typologies of journalists so as to describe the broader communicative roles that scientists take on in intertwining online public arenas.

Given lay peoples' limited understanding of science (Bromme & Goldman, 2014), they must often rely on scientists as trustworthy sources when engaging with scientific information in digital communication environments (Hendriks et al., 2015). Therefore, there is a need for further in-depth research on scientists' communicative roles from different angles. Public trust in science is "to a considerable extent, the outcome of mediated communication" (Schäfer, 2016, p. 1). Hence, it is influenced by scientists and their communication, as they can shape public perception of science. Consequently, how scientists c*onceptualise*, *perceive* and *perform* their roles in digital environments appears crucial for public trust in scientists and science.

Especially in the context of socio-scientific issues, which not only involve scientific questions but are also characterised by political, normative, and ethical dimensions, scientists may go beyond the boundaries of science (Peters, 2021). At the same time, in digital communication environments, disinformation on socio-scientific issues can develop and spread rapidly (Freiling et al., 2023), and epistemic authorities, including scientists, may thus be called into question (Neuberger et al., 2023). This underlines the importance of scientists reflecting on their own communicative roles (Lewenstein & Baram-Tsabari, 2022), particularly because their communication behaviour can impact public trust in science (Schäfer, 2016; Weingart & Guenther, 2016). Scientists have enormous communication capital, but the challenge lies in utilising it effectively (Nisbet, 2016). Overall, the extent to which scientists actually embody trustworthy scientific knowledge will ultimately depend on their communicative roles. The framework proposed here can serve as a starting point for deeper investigations of scientists' communicative roles in digital communication environments and accompanying questions about the trustworthiness of these roles.

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7

Trusting the Martyr: The Appeal of the "Dissentient Expert" Archetype in Science-Denialist Narratives

Janiv Gabbai-Müller and Alexandra Regina Kratschmer

Introduction

Science-denialist communities usually, and not unexpectedly, regard scientists and professionals as members of a suspicious out-group. However, when such experts express opinions that converge with those of the communities, they are accepted enthusiastically as trustworthy information sources. This is often done using a specific narrative pattern, which presents them as martyr-like heroes, who go against the scientific establishment to uncover inconvenient truths.

Based on narratological (scripts, archetypes) and text-semantic (semantic fields, appeal to emotions) concepts, we link this narrative pattern to previous research on trust and heroism, dive into possible

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reasons for its apparent persuasiveness, and subsequently reflect upon possible implications for science communication.

We begin by looking into the topics of science denialism, trust in science and the notions of heroism, martyrdom, and whistleblowing. We then present our data (concrete instances of the aforementioned script) and analysis methods, perform the text analysis, and, finally, we discuss the results in the context of insights from research on epistemic trust, information virality, and science communication.

Background

Science Denialism

Science denialism is the motivated rejection of well-established scientific facts, or of the scientific method in general (Jylhä et al., 2023; Schmid & Betsch, 2019). The term has also been used to denote the use of unscrupulous rhetoric to promote such rejection (Diethelm & McKee, 2009). While denialism is not a new phenomenon, it has taken on unprecedented dimensions following the advent of online communication, especially social media. The ability to reach vast audiences quickly, combined with information overload, lack of content quality control, and insufficient information literacy, allows misinformation to spread faster than ever (Lev, 2015; Wilson & Keelan, 2013). This problem is exacerbated by the fact that users tend to cluster in so-called "echo chambers", where they reinforce their shared narratives and filter out conflicting information (Schmidt et al., 2018). In the "global village", where users with unconventional views are no longer isolated by geographical distances, the result is often the cementing of denialist beliefs and undermining of science communication efforts. Inevitably, the consequences extend beyond the epistemic realm: The erosion of public trust in science has been named as a factor hindering the adoption, implementation, and acceptance of crucial policies, most notably in the areas of climate change mitigation and public health (e.g. Kumar et al., 2016; Ojala, 2021).

While mediation of reliable information is indispensable, there is a growing understanding that it does not always address the underlying causes of denialism, and that the effectiveness of science communication could therefore be increased by complementing it with additional strategies. Hornsey and Fielding (2017) suggest focusing on the motivational roots of denialism—i.e. what makes people want to reject scientific consensus—and highlighting how accepting this consensus is in harmony with those motives. Other potential strategies include top-down regulation of misinformation (Brown, 2021), exposure of denialist rhetorical techniques (Schmid & Betsch, 2019), and increased use of narrative forms of communication (Kreuter et al., 2010). In this contribution, we involve several of these approaches.

Trust in Science

Trust is a key issue in the perception of scientific subjects in the modern era. Public reception of scientific ideas, which are usually complex and cannot be derived from personal experience, depends less on independent examination and evaluation of these ideas, and more on trust in their sources (Hendriks et al., 2016). However, different sources are not always in agreement: Claims made by scientists are often contested by figures from other fields, such as politics, industry, and religion; and, more importantly, science itself is not a uniform body, but an open arena which accommodates many, often conflicting, opinions. This means that, while laypeople are largely exempt from examining the scientific evidence themselves, this task is merely replaced by the need to decide which pieces of communicated information—if any—to trust.

Besides one's own propensity to trust others, both source-related and message-related factors can affect the level of trust in communicated information (Sperber et al., 2010). Here, we focus on source-related factors. A trustworthy source is, above all, *competent* and *benevolent*: Competence (or *expertise*) generally refers to the degree to which the source is believed to possess skill and knowledge that are relevant to the subject at hand; benevolence (or *motivation*) refers to whether the source is believed to be concerned with the benefit of the trustor, or of society in general, rather than with personal gain or private agendas (ibid.; Hendriks et al., 2016; Rowland et al., 2022). In the model of "epistemic trust" suggested by Hendriks et al. (2016), these dimensions are supplemented with a third dimension, *integrity*—that is, whether the source is believed to have reached their conclusions via a reliable process, following the rules of their profession. By and large, this model is supported by the qualitative study done by Rowland et al. (2022), where respondents were primarily concerned with sources' *expertise*, *motivation*, *independence* (the ability to conduct research, discuss, and debate without being restricted by external pressures), and *commitment* (long-term engagement with the cause). External pressures are a particularly prominent impediment to integrity, and commitment can arguably be a marker of honesty, and, by proxy, benevolence. The notions of *competence/expertise*, *benevolence/motivation*, and *integrity/independence* will guide our analyses below.

Heroes, Martyrs, and Whistleblowers

Narratives play a crucial role in the way we make sense of the world, and everyday storytelling, from political propaganda to popular culture, relies on our inventory of narrative structures. Of all the archetypes reproduced in these stories, arguably the most prevalent is the hero, or the hero's journey (Kelsey, 2021). Hero stories serve the psychological need to find role models to inspire and guide us, be they fictional or real (Goethals & Allison, 2012). Accordingly, they are shaped in a way that both reflects and confirms core ideas and values: The ideal hero is an incarnation of virtue, and the hero story embodies the values one should aspire to imitate (Jolles, 1930, p. 36). This being the case, the concept of heroism is often linked to ideological disputes: The same person can be described as a martyr or a heretic, a freedom fighter or a terrorist, an informer or a snitch, with the nomenclatural contrast normally mirroring an ideological one. Identifying heroes and telling their stories can thus serve as a strong identity marker, defining and reinforcing personal and group identity (Middleton, 2014).

While heroism is construed in the eyes of the beholder, one can point to global attributes that characterise heroes generally. Goethals and

Allison (2012) place particular emphasis on the hero's competence and morality: A hero does the right thing, and does it with a high degree of capability. (The reader will, no doubt, recall that competence and morality are also two of the main components of trustworthiness.) More specifically, they describe the prototypical hero as caring, charismatic, inspiring, reliable, resilient, selfless, smart, and strong. Each of these traits represents a cluster of attributes (e.g. "selfless" also stands for "altruistic", "honest", "humble", and "moral"), and together they provide a more detailed account of competence and morality, as well as support for the hero's position as a role model. In addition to personal characteristics, the archetype is also built on scripts over actions. Some dominant themes in hero stories, which bolster the protagonist's heroic status, include overcoming obstacles and adversities, risking or sacrificing one's own interests for the greater good (and not expecting any subsequent profit), being an underdog and acting despite having no moral or legal obligation to do so, accepting a higher price than what could be expected of one (ibid.; Franco et al., 2011).

Two types of heroes that are particularly relevant to the present study are the martyr and the whistleblower. Franco et al. (2011) define martyrs as "religious or political figures who knowingly put their lives in jeopardy in the service of a cause or to gain attention to injustice". However, categories are rarely rigidly defined by means of necessary and sufficient conditions, and as Middleton (2014) points out, martyrdom is no exception. Specifically, we believe that a protagonist who pays a hefty price in the service of a noble cause would evoke the martyr archetype, even if the price is not the ultimate one. Heroic whistleblowers can be described as "individuals who are aware of illegal or unethical activities in an organisation who report the activity publicly to effect change, without expectation of reward" (Franco et al., 2011). Richardson and McGlynn (2021) likewise stress the importance of altruistic motivation, and add further prototypical features, namely, not being complicit in the wrongdoing, accepting a high risk for exposing it, successfully bringing about a positive change, and being willing to blow the whistle again in the future. This, too, of course, is a description of a prototype, rather than a list of requirements.

Data and Method

In this study, we concentrate on a specific narrative script prevalent in denialist communities. We showcase this script with seven narratives about real-life protagonists, taken from various denialist outlets, in the form of news websites, blogs, and social media.[1] These cases were selected for two reasons: First, they explicitly contain the full script—many cases in our data omit or only imply some of the script's components. And secondly, they concern a variety of scientific fields, demonstrating the usefulness and productiveness of the script. The protagonists and disciplines in these narratives are Judy Mikovits, about carcinogenic vaccines; Patrick Provost, mRNA Covid-19 vaccines; Judith Curry, climate change; Stephanie Seneff, herbicides; Bruce Lipton, epigenetics; Árpád Pusztai, genetically modified crops; and Tyrone Hayes, herbicides.

In our analysis, we first document the intertextual consistency of the script by mapping textual elements from the narratives onto its single components. We then conduct a semantic field analysis in order to isolate potentially important content of the narratives that are not necessarily part of the script. Topics that are crucial for a text (main topic, ancillary topics) are constructed from content vocabulary which consistently belongs to certain conceptual domains, i.e. semantic fields. Isolating vocabulary (e.g. *birth, alive, pulsating*, *dying, kill, grave*), identifying hypernymic (superordinate) conceptual domains, and finding interrelations between these domains (e.g. antonymic patterns: LIFE VS. DEATH) allow one to reliably determine the key topics and content of the text (Kratschmer, 2005). Typically, texts activate semantic fields in opposing pairs, and non-compliance with this pattern can be a factor that invites the first analysis step (e.g. checking for one-sidedness; ibid.). In our analyses of the script, we focus on the conceptual oppositions inherent in (or absent from) it.[2] Based on Kelsey's (2021) underscoring of the crucial

[1] References to each of these narratives can be found in the primary sources section of the reference list.

[2] Other relations between semantic fields are possible. For example, the vocabulary *sick*, *suffer*, *die*, *autopsy* implies causality (DISEASE leading to DEATH). We do not, however, delve into this here.

role of emotions in production and reception of narratives, we conclude our analysis by identifying linguistic material with emotional appeal.

Analysis

The Dissentient Expert Script

In narratives critical of established science, there is a recurrent script: A brilliant, well-respected or promising expert with impressive formal credentials (1) makes a startling discovery about harmful flaws in the existing scientific knowledge or practices (2). They attempt to make their findings known in the academic or professional community—but the establishment, out of financial or power interests, refuses to acknowledge the flaws, and tries to silence the expert (3). With the greater good of the public and/or concern for the truth in mind (4), they turn against their community and make their findings public anyway—at great personal or career-related risk or cost (5). We call this the *dissentient expert* script.[3]

First, we document the existence of the script across disciplines. The different parts of the script can come in different orders in the narratives, but we follow a consistent order here. We document each part of the script (1–5) for each narrative in our corpus (a–g); the narratives are identified by their protagonists.

(1) Usually, the script begins with the mention of a scientist's (impeccable) credentials:

1a a biochemistry and biology scientist and researcher; a senior, brilliant scientist at the National Cancer Research Institute in Maryland [Mikovits]

1b a noted academic; respected climatologist and tenured professor at Georgia Tech University; 186 published journal articles and two books [Curry]

[3] A similar narrative trope was also documented by Hughes et al. (2021), specifically in the context of COVID-19 vaccines.

1c expert in messenger RNA; microbiology and immunology professor at the Université Laval [Provost]
1d senior researcher from the Massachusetts Institute of Technology [Seneff]
1e Ph.D.; job at Stanford University Medical Center [Lipton]
1f published more than 300 articles, contributed to more than 20 books; the world's top expert in his field; worked for the top nutritional research lab [Pusztai]
1g UC Berkeley professor [Hayes]

(2) The scientist discovers a disturbing fact:

2a cancer is caused by a virus that is injected to people in vaccines […] a virus created by man, by crossing mouse cells and human cells [Mikovits]
2b current climate models are inadequate in terms of supporting the claims of the global warming faithful [Curry]
2c the risks of injecting children with an experimental gene-altering mRNA COVID shot outweigh the potential benefits [Provost]
2d the chemical is a slow kill for humans and other lifeforms […] the reason behind the dramatic increase in autism, diabetes, cancer, allergies, as well as many other chronic conditions [Seneff]
2e [what "mainstream medicine teaches you"] is the furthest from the truth [Lipton]
2f the rats [that were] fed GM potatoes developed strange tumours, their brains shrunk, so did their testicles and livers. Their immune systems became damaged [Pusztai]
2g Syngenta's herbicide, atrazine, "chemically castrated" male frogs and turned them into females [Hayes]

(3) The establishment silences the scientist, sometimes combined with retaliatory measures:

3a the establishment hastened to deny the existence of "the cancer virus"; demanded her to retract the findings, to say she made them up [Mikovits]

3b [mainstream climatologists] accept nothing less than complete agreement; they have all the answers, it seems, and no further critical investigation is allowed; I was just beating my head against the wall [Curry]
3c censored; we need to be allowed to question again; because I express opinions against the narrative of the government, I was suspended [Provost]
3d [many scientists] trying to have her peer-reviewed and published works removed through retraction [Seneff]
3e they would not allow him to teach the up to date cellular information he knew to be true [Lipton]
3f he was silenced by the pro-GMO Prime Minister; gag order on his research [Pusztai]
3g first, they tried to buy him off to manipulate the data [Hayes]

(4) The scientist upholds high moral and scientific standards, working for the greater good and protecting the truth:

4a Mikovits, whose passion was to heal and help people [Mikovits]
4b insistence on adhering to sound scientific principles [Curry]
4c doing what I've been trained to do—and hired to do [Provost]
4d I feel like the work I did on glyphosate really helped their cause [Seneff]
4e teach the […] information he knew to be true from the tests he ran [Lipton]
4f being a conscientious scientist, he worried that the GM foods […] might have the similar effects on humans [Pusztai]
4g rejected the agrichemical giant, upholding scientific and academic integrity; ethical and brave whistleblower [Hayes]

(5) The scientist is made to pay a price, which turns them into a martyr:

5a found herself in prison. She was unexpectedly dragged from her home, handcuffed, with no charges, no trial, and no civil rights whatsoever [Mikovits]
5b treated as a pariah within the academic world; vilified by some of my colleagues; I walk around with knives sticking out of my back [Curry]

5c ULaval was suspending him for eight weeks without pay; you are condemned by the media, by the government, and you are chased and put down [Provost]
5d a black mark in a researcher's career; really nasty record [Seneff]
5e actually quit his job [Lipton]
5f he was fired, his research was confiscated and a smear campaign was launched to destroy his career [Pusztai]
5g they spent over a decade trying to destroy his career; stalking and threatening him and his family [Hayes]

The uniformity of the narratives is striking, testifying to the fundamental role of archetypes in narratives (Kelsey, 2021).

Semantic Architecture of the Script

The next stage of our analysis pertains to the narrators' use of semantics in framing the narrative roles of the dissentient expert and of the scientific establishment they oppose. Particular attention is given to the use of pairs of opposing semantic fields, which help to set up the polar opposition between these two entities. In the following, it will suffice to use a few representative examples to support our argumentation.

First, one should note the epistemological framework established by the dissentient expert script. In principle, scientific consensus can be challenged in one of two ways: One option is to attack it with tools taken from the scientific world, e.g. by questioning the methodology of mainstream studies; the other is to suggest an alternative framework for sense-making and truth-seeking, such as feelings or personal experience. Denialist narratives and communities have been shown to use both strategies, often simultaneously (e.g. Carrion, 2018; Provencher, 2011). The dissentient expert script, however, resides firmly within the former category; its acceptance of science as the relevant epistemological framework is evident both from the activation of the semantic field of SCIENCE/ACADEMIA (6), and from the absence of reference to alternative fields:

(6) researcher, prestigious journal [Mikovits]; climatologist, professor [Curry]; laboratory, university [Provost]

The explicit placement of the protagonist within a scientific context is the first step towards framing them as the embodiment of the scientific ideal, and the establishment that rejected them as deviating from it. This is a powerful move of *retorsio argumenti*, or "turning the tables", where the author attempts to show that the opponent's own values and principles should in fact lead them to accept the author's position. The framing is reinforced with a series of opposing semantic fields, where the positive versions, the ones that accord with the scientific ideal, are activated in relation to the protagonist, and the negative versions in relation to the antagonist(s). Corresponding, for the most part, to the components of the epistemic trust model discussed above, these oppositions also help to create the impression that it is the protagonist who is more trustworthy.

One important opposition is between the protagonist's ACADEMIC/SCIENTIFIC INTEGRITY (7) and the MISCONDUCT of the scientific establishment (8):

(7) adhering to sound scientific principles; empirical science [Curry]; doing what I've been trained to do [Provost]; upholding scientific and academic integrity [Hayes]
(8) lied (that such a virus doesn't exist); false propaganda and fake science [Mikovits]; narrow-minded zealots; theoretical biases; bogus science; agenda-driven scientific dogma [Curry]; bunk studies [Hayes]

Playing a crucial part in securing the protagonist's scientific integrity is their INDEPENDENCE (9), as opposed to the DEPENDENCE of mainstream scientists (10), who give in to external pressures:

(9) refused to renounce the findings of my research [Mikovits]; years of battling (with those pushing the climate change agenda); beating my head against the wall [Curry]; express opinions against the narrative of the government [Provost]

(10) mouthpieces [Mikovits]; politicians and other interested parties; scientific research becomes politicized [Curry]; attack on academic freedom; dissuasive effect; self-censorship [Provost]; corruptible scientists [Hayes]

In accordance with the acceptance of science as the relevant epistemological system, the protagonist's integrity guarantees that TRUTH (11) is on their side—and, conversely, the corrupt mainstream position is FALSEHOOD (12):

(11) exposed [secrets]; most reasonable; proved; truth [Mikovits]; true; the data [Provost]; showed; strong evidence; on the right track [Seneff]
(12) debunked; greatly overestimated [Provost]; furthest from the truth [Lipton]

Integrity is also implied in the fact that the protagonist would rather risk downfall than compromise on their values. The downfall is represented by the semantic fields of PUNISHMENT and ABUSE (13), which evoke the martyr archetype. Occasionally, there is direct reference to the PROTECTION (or favourable treatment) given to those less dissentient; usually, however, this side of the opposition is merely implied, often by stating the causal link between the protagonist's dissent and their fate:

(13) prison; handcuffed; behind bars [Mikovits]; treated as a pariah; vilified [Curry]; punished; suspending […] without pay [Provost]; fired; destroy his career [Pusztai]

Another important opposition is between the protagonist's BENEVOLENCE and MORAL COMPASS (14) and the IMMORALITY of their adversaries (15):

(14) innocent; heal and help people; faith in God; [thanks to] my family [Mikovits]; blew the whistle [Seneff]; ethical and brave [Hayes]

(15) humans are the guinea pigs; corruption; personal attacks [Seneff]; misleading; lied about the safety [Pusztai]; criminals and thugs poisoning the planet [Hayes]

The heroic, martyr-like role of the dissentient expert is naturally contrasted with that of the villain, who opposes and impedes the hero. In narratives serving ideological argumentation, the villain represents the very group against which the narrative argues (Middleton, 2014). In our data, there are various ways in which this group is identified (16), but ultimately, the role of the villain is played by the proponents of the scientific consensus:

(16) establishment's mouthpieces; pharmaceutical companies who control the media [Mikovits]; mainstream medicine [Lipton]; corruptible scientists; the GMO/agrochemical giant, Syngenta [Hayes]

Appealing to the Audience's Emotions

Affective-discursive practices play an important role in political discourses; the discourse both affects and is affected by individual and collective feelings, emotions, and ideologies (Kelsey, 2021). We now move on to give an overview of instances of emotional appeal (Aristotle's *pathos*) in our data: content that appeals to the audience's emotions, emotionally loaded vocabulary, or explicit mentioning of emotions.

The two most important emotions appealed to are fear and outrage/indignation—and many textual elements appeal to both at the same time. Appealing to fear is done mostly by describing threats and hazards (17):

(17) horrifying; silent virus; deadly; you may not know that cancer is incubating in your body [Mikovits]; warning; slow kill; dramatic increase in autism, diabetes, cancer (etc.); organ damage; myriad of cancers; reproductive issues; early death; the substance is pervasive,

and despite all her efforts to avoid exposure […] she still tested positive [Seneff]; chemically castrated; eco-terrorist; toxic [Hayes]

Outrage and indignation (18) are most often directed at the establishment's treatment of the dissentient expert and their findings:

(18) unexpectedly dragged from her home, handcuffed, with no charges, no trial, and no civil rights; they have no right to inject unwanted materials into my body [Mikovits]; they have all the answers, it seems, and no further critical investigation is allowed; threatening to destroy one of the foundations modern society was built upon [Curry]; it's hard to believe; a grievance […] had been filed; extremely problematic; condemned by the media, by the government, chased and put down [Provost]

Not unrelated to outrage, the narratives can also appeal to frustration (19) and moral disgust (20):

(19) growing disenchantment; beating my head against a wall [Curry]; being censored for doing what I've been […] hired to do [Provost]
(20) lied; propaganda, deception and brainwashing [Mikovits]; vilified by some of my colleagues; knives sticking out of my back; one unpardonable sin [Curry]

Another negative emotion appealed to in the textual content is physical disgust (21):

(21) crossing mouse cells and human cells; dangerous narcotics; inject unwanted materials into my body [Mikovits]; glyphosate may be incorporated into human proteins; critical changes to biochemical processes in the body [Seneff]

Finally, the narratives also appeal to surprise (22), particularly in relation to the protagonists' discoveries:

(22) astonishing; bombshell [Mikovits]; shocked [Pusztai]

In summary, the narratives contain a significant amount of appeal to emotions (pathos), nearly exclusively negative ones, with fear and outrage/indignation being the foremost examples.

Discussion

When we chose, at the end of a fairly lengthy deliberation, to name the script examined in this work the *dissentient expert* script, we aimed for a designation that would be immaculately impartial. The neutrality was not merely a demand of academic decorum; it reflects the understanding that hero stories are inherently subjective, and that, while at least some of our protagonists can be easily dismissed as "rogue scientists" (the original term we contemplated) from a mainstream perspective, their narrative role is that of heroic whistleblowers. Furthermore, the same script can be used to describe conventional heroes: Consider, for example, the case of the Austro-Hungarian obstetrician Ignaz Semmelweis, who was ridiculed for his advocacy of hand hygiene for medical staff, only to be vindicated decades after his death, following the discovery of bacteria (Kásler, 2018). Rather than categorising the protagonists one way or another, we aim to shed light on the script's role in denialist discourse.

An important characteristic of the *dissentient expert* script is that it addresses all the main components of epistemic trust. The *expertise* of the protagonist is established by referring, often protractedly, to their academic credentials, affiliations, experience, and/or status. Prioritising the search for truth, combined with their unwillingness to alter or hide inconvenient findings, even under pressure, prove their methodological and moral *integrity*, which is contrasted with the lack of integrity on the part of the scientific establishment. Further evidence for the protagonist's integrity is found in their academic background, which lends extra significance to their adoption of ideas from outside the scientific consensus, and especially in the risk they are willing to take—or the price they pay—for revealing their findings. *Benevolence*, or altruistic *motivation*, is usually referred to explicitly, and the protagonist's selflessness is further confirmed by their self-sacrifice. Furthermore, the script evokes the familiar archetype of the martyr, who sacrifices him-or herself for a greater cause, activating such notions as selfless benevolence, strong moral compass, and uncompromising commitment. The presence of trust-building components in the stories is further confirmed by semantic field analysis. These attributes establish the trustworthiness of the dissentient expert and enable them to rise above the denialist audience's inherent distrust of mainstream experts. Additionally, they make their stories more appealing to audiences who sit on the fence.

The communicative function of the script can be understood in the context of (overly) individualistic values. Denialist views often condemn their holders to social rejection, and most denialist communities have to endure life as a small minority. A common strategy used by these communities is to embrace this status, by framing those who accept the scientific consensus as mindless "sheeple", and those who reject it as independent thinkers, who are brave enough to swim against the tide. Indeed, as Hornsey and Fielding (2017) point out, in many cases the function of denialist attitudes is to define and communicate one's individualism, distinctiveness, non-conformism, and resistance to peer pressure—all characteristics that are celebrated in Western societies—and denialists may even perceive their stance as somewhat heroic, "self-styling as moral rebels who face censure for articulating important but unpopular truths" (ibid.). Accordingly, denialist communities across different disciplines often stress values such as independence, self-determination, and epistemic individualism—succinctly captured in the popular call to "do your own research" (cf. Ballantyne et al., 2022; Levy, 2019). The dissentient experts, in their willingness to confront their community and pay a hefty price for their truth-seeking, epitomise these values. Furthermore, as Hughes et al. (2021) note, the script narrativises the idea of brave truth-telling, imbuing it with concrete characters, circumstances, and costs. On top of making the message more compelling (Bloomfield & Manktelow, 2021), the specificity allows the narratives to provide the community with imitable role models, carrying out an important function of hero stories.

The use of narratives, in and of itself, can boost the appeal of messages, and many scholars (e.g. ibid.; Avraamidou & Osborne, 2009; Yang & Hobbs, 2020) have advocated for increasing this practice in science communication, for this very reason. However, the dissentient expert script has further features that amplify this effect. One of these features is its emotional impact. Both of the emotions that are most commonly appealed to in these narratives, fear and anger, have been shown to render information more attention-grabbing and prone to sharing. Descriptions of potential threats enjoy retransmission advantage over other types of information (e.g. Blaine & Boyer, 2018), presumably due to their high information utility (Kim, 2015). Moral emotions that involve the negative judgement of others, and anger in particular, have been shown to contribute to the virality of content online (Brady et al., 2017; Solovev & Pröllochs, 2022). Interestingly, the narratives also feature several elements that have been recommended as attention-grabbing in science communication guides (e.g. Hyldgård, 2014), such as significance, sensation (e.g. in the form of a shocking discovery), conflict, and myth-busting.

What lessons can we learn from the dissentient expert script, and how could we implement these lessons in conventional science communication? First, we concur with the numerous researchers who have already advocated for a greater use of narratives, preferably with real-life characters, concrete settings, and specific goals. More specifically, we suggest harnessing archetypes, and particularly the hero archetype, in our storytelling. Such stories could, for example, portray a hero scientist, or cast the entire scientific community as the hero. The role of the antagonist could be filled by a threat (a virus, climate change, tooth decay, etc.), by less benevolent (e.g. greedy) actors, or simply by the scientific challenge. The stories of scientific discoveries often lend themselves to being framed as a hero's journey, overcoming adversities of various kinds (e.g. Veritasium, 2024, on Shuji Nakamura's pursuit of the elusive blue LED). Other positive archetypes that scientific communication could harness include the explorer, the sage, and the caregiver. Additionally, as suggested by Hornsey and Fielding (2017), scientific communication could benefit from highlighting the inherently sceptical nature of the scientific process, appealing to champions of independent thought. In terms of emotional appeal, we would definitely not want to encourage science communicators to appeal to fear and anger, but one ought not to play down potential threats, either. Indeed, clear accounts of the severity of such threats could contribute to the heroism of a protagonist.

Arguably the most important lesson, though, has to do with trust. The martyr-like story of the dissentient scientist acts as a strong marker of trustworthiness—so strong, in fact, that denialist sources refer to it explicitly. In an opinion column about the COVID-19 pandemic published on the website *All News Pipeline* (Boys, 2021), the author admits that "not being a physician, I can't decide on the scientific merits of the issue", and continues to distinguish between "the CDC officials", who "have turf to defend that includes high salaries, perks, reputations etc." and "may have visions of a trip to Oslo[4]", and "the frontline doctors", who "have risked everything [...] by taking a critical position and opposing the whole medical establishment". "Between the two groups", the author concludes, "I believe the independent physicians who are risking everything, not the political physicians who are desperately fearful of losing what they have". One could, of course, point out that "independent physicians" are not entirely impervious to ulterior motives—hinting at the economic gains potentially obtained from books and public talks could suffice. But, more importantly, what we learn from this quote is that trustworthiness, and particularly perceived benevolence and integrity, is essential to the success of scientific communication—and that stressing the integrity of the scientific community, as well as the goodwill of scientists, is a necessary strategy in the battle against denialism.

Conclusion

In this chapter, we have showcased a recurring narrative script used in various science-denialist contexts. The narrative's protagonist, the "dissentient scientist", is a brilliant expert who discovers an astonishing truth inconvenient to the scientific establishment. Committed to virtuous principles, the protagonist refuses to be silenced and makes the information public, subsequently paying a hefty price. We have discussed how these martyr-like narratives provide denialist communities with concrete role models who reaffirm their core values, and how their correspondence

[4] Presumably, Stockholm is what is meant.

with principles of epistemic trust allows scientists to fill these roles. The insights from this chapter can be harnessed for pro-scientific communication, by making greater use of narratives where protagonist scientists heroically overcome obstacles for the greater good.

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Part II

Trust and the Contexts of Science Communication

8

Messiness, Epistemic Asymmetry, and Reflexivity: Exploring Third-Order Communication in the Wild

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Introduction

Complex, grand challenges and wicked problems, more generally, are unique, interconnected, constantly evolving, and require compromised resolutions (Irwin, 2021; Rittel & Webber, 1973). They are often addressed in public policy or commercial decision-making by highly contested and polarising processes involving an array of different actors with different interests, needs, resources, and ways of expressing and

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affirming their identities, interests, and rights. Building mutual understanding and trust among the parties as part of a search for resolution can fall to science communicators. We increasingly need to employ new ways of thinking about the scope of our activities as well as about the strategies and array of skills, insights, and reflexive capabilities required.

The focus for science communicators has predominantly been on boosting the understanding of science by audiences typically made up of "non-expert" stakeholders, often defined as those who live and work outside paid positions in scientific institutions. These audiences are frequently being asked to place more trust in science in order for challenges to be overcome. That has seen the rise of misinformation, whether disseminated quickly to wide audiences by social media (Weingart & Guenther, 2016) or by word of mouth in relatively isolated rural communities (Espig, 2018). In light of this perceived loss of trust in science (Hotez, 2020; Irwin & Horst, 2016), some people see science communication as a way—or even *the* way—to increase trust. Science

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communicators can become important intermediaries to help build trust as a critical component of meaningful relationships between scientific actors and the multiple audiences they often face. These mediating practices have a complex nature. That complexity is the issue at the core of this chapter—recognising the requirements posed by the many facets of each context in which we and many others are "doing science communication".

Such activities, and the experiences in past years leading up to them, have drawn us together as a group of science communicators, ranging in experience from a few years to over thirty years and spanning both research and practice across diverse settings. We have felt a dissatisfaction with how the work of science communicators seems to be perceived in science and government and how it is sometimes characterised by our own institutions. This dissatisfaction has led to three years of periodic meetings as we consolidated mutual understandings and perceptions in our small community of practice. We have drafted short pieces for social media, made conference presentations, and facilitated workshops to help identify where our discomfort lies. We are identifying others in the profession who share this discomfort and exploring alternative frameworks that might provide a more useful representation of the evolving work of science communicators. We have explored relevant conceptual literature, but our touchstone in discussions, and in this chapter, is our professional experience.

Our re-thinking about science communication practice focuses on working relationships, rather than merely the translation of scientific content for non-scientific audiences. An emphasis on relationships ties into the underlying notion of trust as a core idea in this volume. Trust in science has been portrayed as inherently linked to the *trustworthiness* of science (O'Neill, 2018) and, importantly, trust in scientists and science institutions. Some argue that a deficit of trust is brought about through, at best, the ignorance of non-scientists, and, at worst, active and evangelistic denial of scientific evidence. As an alternative, we argue that the wicked issues and settings in which science is often employed, and in which science communicators interact in actual practice, make it difficult for the various actors, organisations, and communities involved to assess the trustworthiness of scientists and of claims about scientific insight. In other words, some models of science communication are not well suited to help address deficits in perceived trustworthiness. This lack of trust can, in turn, lead to relevant scientific insights not being acted upon by key audiences. Put simply, the old models of the work of science communicators are not helping us to do our jobs effectively.

In this chapter, we present a set of related insights as a work in progress. We briefly discuss how science communication as a field of inquiry and practice has shifted away from one-way communication models "from science to society" to consider more inclusive practices of knowledge exchange, such as two-way dialogue and participatory science. Irwin's (2021) framework of "third-order thinking" about science communication is then described as an appealing model because it considers dimensions of socio-technical and political cultures. We present an example that many readers will be familiar with, namely COVID-19 responses, followed by examples from our collective experiences to illustrate three key elements that emerge when taking a third-order view of complex challenges. First, there is an inherent messiness in these settings, which cannot be reduced to binary models of "science and the public". Second, the concept of epistemic asymmetry addresses the question of whose knowledge counts most in societal or professional debates and in local discussions among concerned stakeholders and scientific experts. Third, we discuss how reflexivity is vital for working meaningfully and effectively as science communicators, and we offer some strategies for becoming more reflexive.

Background on First-, Second-, and Third-Order

Perhaps surprisingly, early models of science communication did not focus attention on trust—neither at the level of science being a trusted institution nor at the level of individual scientific or technical experts being trusted by their immediate audiences. Instead, the focus was primarily on transferring knowledge from scientists to audiences, who were perceived by scientists to lack this knowledge, in order to help them to make better decisions (Grant, 2023). It was simply hoped that this one-way approach to communication would resolve any deficits in knowledge, and therefore people would become more "rational", in the eyes of scientists (Simis et al., 2016).

This approach, now referred to as the information-deficit model, has been repeatedly critiqued for having significant limitations (Ahteensuu, 2012; Bucchi & Trench, 2017; Wynne, 1992, 1993). It does not take into account the many personal factors that influence human decision-making, such as attitudes, trust, values, and worldviews (Longnecker, 2016; Bray & Ankeny, 2017; Manyweathers et al., 2017; National Academies of Sciences, 2017; Seethaler et al., 2019; Sturgis & Allum, 2004). These limitations led to the recognition of a need for "second-order" thinking about science communication (Irwin & Wynne, 1996), that is, to foster two-way communication aiming to establish mutual trust and understanding among stakeholders. This framing acknowledges that attitudes, trust, values, and worldviews are fundamental to interpretations of risks and issues involving scientific matters (for a fuller discussion of each of these orders, see Irwin, 2021).

While second-order thinking—and communication models built around it—represented a significant step forward, it in turn risks being overly prescriptive and inflexible. Stocklmayer (2013) argues that, "[The] ideal mode has now shifted, however, from one-way transmission to some form of two-way, participatory practice" (p. 19). Indeed, scholars of public relations have argued that such ideals could be used as a panacea, where two-way communication is employed in all situations for all purposes (Kent & Lane, 2021). Kent and Theunissen (2016) warn, however, that dialogue approaches are frequently implemented superficially, as "dialogue in name only" (p. 4044), which Mercer-Mapstone et al. (2019) state merely "ticks the box" as a form of community engagement.

Usefully, Irwin (2021) proposes a third-order way of thinking about science communication. This approach steps away from the starting assumption that a particular method of communication can be applied universally. Irwin (2021, p. 156) argues that, "Deciding what is appropriate to any particular situation must be a matter for contextual judgement but also recognition of the limitations and strengths of all approaches".

Irwin (2021) urges science communicators not to focus upon one-way or two-way communication but to acknowledge that each situation is unique and requires an individually tailored approach across the many internal and external facets of a given communication challenge. In this way, third-order thinking seeks a “horses for courses” approach, which appears well suited to addressing wicked problems.

One way to illustrate this more holistic framing is the Koru Model of Science Communication (Longnecker, 2016, 2023) (Fig. 8.1). It presents a visual metaphor of individuals and groups in a complex, messy, lifelong-learning ecosystem with many sources of information. The “koru”—growing, unfurling fern fronds—represents individuals within a community, who are recipients of new information. The model identifies many internal and external factors that impact engagement with and use of that information. Internal factors are shown in Fig. 8.1 as “Identity” and include values, beliefs, attitudes, awareness, interest, understanding, skills, and behaviour. External factors that impact engagement with information—and engagement with those who have that information—include culture, communication channels, social norms, control, and support. The model forefronts the complex nature of communication on scientific issues by highlighting the context rather than focusing on one-way or two-way arrows of information flow.

The Koru Model embodies the three themes identified in this chapter, which we will now deal with in sequence—messiness, the sources of potentially dangerous epistemic asymmetries, and the need to be reflexive.

Messiness

The messiness of science communication here refers to attributes of our science communication work that are typically cited as arising in relation to wicked problems. This messiness emerges from factors, such as engagement with a diverse array of stakeholders who can disagree with one another about what the problem is and what might count as a good or

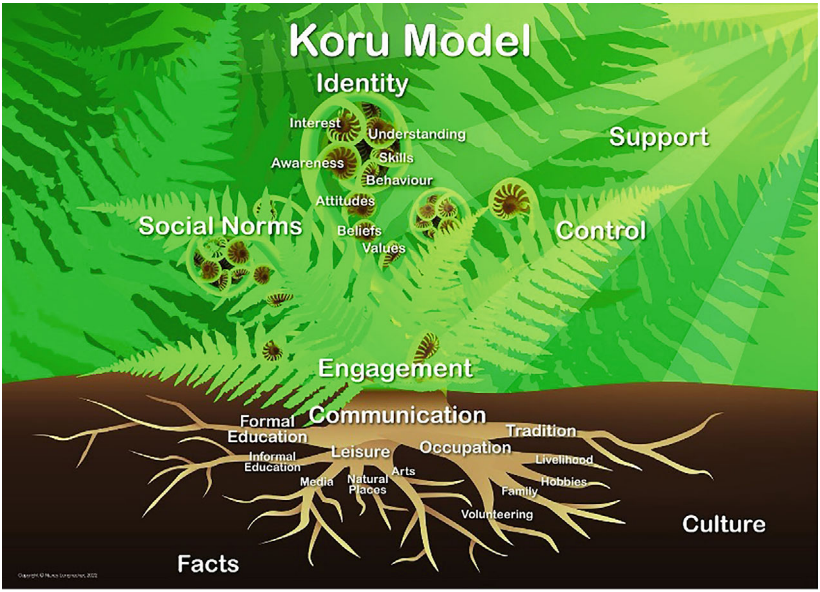

Fig. 8.1 The "Koru" model of science communication, see Longnecker (2016, 2023) (Reprinted with permission from N. Longnecker)

bad solution. With wicked problems, options are bounded by each stakeholder group's worldview, and every problem can be seen as a symptom of another problem (Rittel & Webber, 1973).

As a result, success or failure of a science communicator's efforts—however success is defined—can rely on a huge number of factors, many of which are outside the science communicator's control, as seen in the Koru Model of Science Communication (Longnecker, 2016, 2023). The messiness applies to relationships, understandings, and beliefs of members of the potential audiences, clients, or professional counterparts of science communicators. Also messy are the array of often overlapping and sometimes conflicting bodies of knowledge, sets of tasks, and working relationships addressed by the science communicators.

Individuals and groups that are relationally multi-faceted and impacted by history, culture, and the politics of power make things messy. In analytical terms, this view sees third-order thinking as being about extending the system boundary beyond a vaguely defined recipient audience (e.g., “the public”) to involve a varied array of specific audiences. These audiences have agency, and each one is interacting with others in a multi-faceted context, including ongoing interaction with the science communicator. Consider, for example, our author in the biosecurity area who is liaising among livestock producers, private and government veterinarians, local government representatives, rural bankers, abattoir workers, sheep shearers, and others.

This extended domain of responsibility can be seen to reflect a maturing of the field of science communication (Adorno & Becker, 1999). Responsibility suggests a need to respond (implying a need to interact with more stakeholders), while also necessitating a willingness to be held accountable. Such issues of accountability across complex relationships have been depicted as an inherent part of addressing wicked problems (Rittel & Weber, 1973).

The COVID-19 pandemic provides a useful, well-documented example to highlight how first-order and second-order thinking proved inadequate due to the messiness of the situation. Deeply conflicting interests played out over a prolonged period, driving public debates that were as much about values as about science (Hooker & Leask, 2020). While some people welcomed disease-mitigating measures, other people’s values were challenged by the idea that the government—or, indeed, scientists—were telling them what they could and could not do (Kleitman et al., 2021).

In many parts of the world, this debate fed polarisation along political lines, despite the best efforts of the scientific community to focus on the science involved (Flores et al., 2022). For example, in the US, political parties of the ideological right and their supporters quickly grew wary of social distancing measures, while political parties of the ideological left and their supporters were sometimes dismissive of valid concerns. Science communicators who urged compliance with measures were rapidly drawn into an increasingly ideological, rather than scientific, battle (Callahan, 2021).

This example highlights that managing health communication during the COVID-19 pandemic as a first-order activity—with the sole purpose of putting out information—will not suffice on its own (Irwin, 2021).

One can only really make sense of the COVID-19 communication challenges by drawing the system boundary so that it encompasses a wide array of actors. That then requires using a third-order lens that considers media avenues and technologies, political polarities, and conversations and relationships among many different types of actors.

A firm focus on two-way communication channels advocated by second-order thinking is better replaced by a broader, more situation-dependent and constantly evolving form of thinking about communication. For example, the rise of a polarised communication landscape, where alliances of stakeholders are forming, may require the development of strategic objectives designed to build and maintain relationships with and among different groups in order to keep communication channels open (Manyweathers et al., 2022). Two-way communication may not be needed when simply providing updates on COVID-19 case numbers or alerting segments of the population who are very keen to be vaccinated that those vaccinations are available. However, there is a place for a third-order approach if stigma, polarisation, misunderstanding, misinformation, and related factors emerge.

In sum, the COVID-19 pandemic can be seen as an apocryphal illustration of the type of messiness that challenges many science communicators on a day-to-day basis in less prominent settings. Fact sheets and roundtable discussions were certainly part of the suite of strategies required, but they fell far short of the relationship- and trust-building needed and the maintenance required to keep those channels open—something that may help to affirm the voice and agency of those who might be marginalised in the stormy weather of a wicked communication challenge.

Epistemic Asymmetry

Epistemic asymmetry arises in situations where knowledge is withheld by powerful actors and groups in relation to issues that can have widespread human and political dimensions (see, e.g., Holst & Molander, 2018). Unequal power relationships linked to different types of knowledge can be observed when decisions concerning scientific information are contested among different stakeholders. That occurred in the COVID-19 example above and arises in debates in more localised projects and commercial initiatives affecting, for example, small business operators and local residents.

The authors have, in our professional experience, encountered many examples of epistemic asymmetry and witnessed the adverse outcomes that it can lead to. Our experiences include working on an education programme with a Māori collaborator (cross-cultural distrust), documenting and addressing fear and resistance to “fracking” in an agricultural area (distrust of big industry), and responding to concerns about animal health (distrust of scientific experts and government).

One of our authors found that they lacked sufficient awareness and understanding of both the history of oppression and the current lived experience of First Nations partners in a project. That deficit could be traced, in part, to school curricula that provided a storyline of “taming” a wild country and its people but failed to address dispossession of land, breaches of treaties, genocide, removal of children from households, poor healthcare, and high levels of unemployment and economic marginalisation. The author sensed that a greater awareness of the impacts of their own privileged access to higher education, such as having the financial means while not having burdensome family obligations, could have opened them more readily to options for their engagement and education initiative with Māori partners. That awareness could lead to more constructive, respectful, cross-cultural communication and collaboration (Cisternas et al., 2019; Longnecker & Pōtiki Bryant, 2023; Longnecker & Scott, 2018; Mercier & Jackson, 2023; Mills & Regenbrecht, 2023; Wehi & Lord, 2017).

Two of our authors were engaged with stakeholders disputing the risks of developing natural gas resources on agricultural land, a process that could involve controversial extraction technologies in the form of hydraulic fracturing or “fracking”. Industry proponents of these developments (the oil and gas industry in this case) could strategically use scientific knowledge claims to delegitimise the concerns of members of the local community about uncertain environmental risks or associated health impacts (Einfeld et al., 2021; Espig, 2018; Espig & de Rijke, 2016, 2018). Conversely, opponents could cite scientific research that conflicts with the claims of the industry proponents, highlighting key technical questions that had not yet been sufficiently studied, such as how much groundwater would ultimately be extracted in harvesting the natural gas resources. Alternatively, residents could argue that impacts were already recognised through local forms of knowledge, such as the smell or taste of water coming from the kitchen tap or methane gas observed to be bubbling to the surface in a local river.

When people are at risk of contracting a disease from their own animals, two of our authors found, the discussion around risk and decision-making can become contested (Manyweathers et al., 2017). The tension between local knowledge and scientific knowledge means that questions of recognition and acceptance of expertise become elevated (Manyweathers et al., 2020). Over 60% of human infectious diseases and three out of four emerging infectious diseases come from animals (Centre for Disease Control & Protection, 2021). That makes it important to resolve any tension about what each given knowledge base offers. That tension will not be dispelled without respect for the dangers of epistemic asymmetry and the marginalisation that it can engender. Such marginalisation can create a chasm between the research-based development of appropriate, evidenced-based, protective behaviours, and the adoption of these behaviours by animal owners. In other words, creation by scientists of a protective vaccine or the designation of desired public health behaviours by health experts, such as the use of masks or greater hygiene, is not the same as adoption of these measures. "Non-compliant" behaviours should be expected and planned for (Davis et al., 2015; Kahan, 2010; Vaughan, 2011), as they may reflect local understandings (Manyweathers et al., 2020), rather than simply being expressions of passive non-compliance (Davies et al., 2013).

These professional examples illustrate how we authors have encountered epistemic asymmetry that has added dimensions of power and distrust in relation to entities such as a dominant culture, big industry, government, and scientific experts. One coping strategy in such cases is effective engagement, which can often involve co-design. However, implementation of that sort of engagement requires reflexivity so that we can avoid inadvertently doing more harm than good.

Reflexivity as a Tool

What Is Needed?

The challenges exemplified in epistemic asymmetry seem hard-wired into our ways of interacting, asking, studying, and expressing ourselves as science communicators. This situation points to a need for reflexivity—both individually and in groups—so as to monitor and reconsider our actions and decisions in relation to those who are marginalised and those with influence.

One mechanism meant to host such reflexive activity in communication processes is the use of dialogue, in the classic sense of conversations that constitute joint inquiry (Krishnamurti and Bohm, 1999). The approach here actually differs from the dialogue model proposed as part of second-order thinking about science communication, which often refers to the use of two-way consultation processes (Irwin, 2021; Metcalfe, 2019).

The essence of dialogue, as described by Bohm and Weinberg (2004), is to make statements in a group and leave them to be interrogated by others, not attaching one's identity to claims of truth. Analysis of dialogue in processes of organisational learning (Schön & Argyris, 1996; Senge, 2006; Skordoulis & Dawson, 2007) suggests that reflexivity and associated learning are emergent in transient moments when hierarchy in the relationships among the people involved is suspended for a few minutes or an hour or longer (Rifkin & Fulop, 1997). Command of the conversation can be seen to be distributed more evenly in these moments. That redistribution of authority within a conversation can be recognised as a shift in "participation status" (Goffman, 1979), the ability in an event to speak and be heard, to set the topic, to ask questions that are responded to, or to be silent in a way that is understood as intended (Jaworski, 2011).

Emergent moments in such dialogue can lead to reduced feelings of vulnerability by those who are more powerful and those who are less powerful, which can in turn enable individual reflexivity and social learning. In other words, you can ask yourself whether you are wrong or misguided, or whether you could view a situation in a new way, without a sense of shame (Schneider, 1977). This sort of dialogue can support social learning in relation to complex socio-environmental challenges, conclude Collins and Ison (2009).

Ironically, this perspective can be seen to turn risk communication inside out. It is not the technological, environmentalor health risk that is being communicated about. Rather, it is the risk in the communication process itself—about power, influence, and marginalisation—that is being addressed. This form of dialogue reduces the perceived danger of being excluded by not being seen to have "expert status" (Rifkin, 1990, 1994). The accompanying shift toward greater safety means that an inquiry-focused dialogue process can enable the surfacing and examining of assumptions held by the various partners involved, which is core to reflexivity.

Reflexivity can foster acknowledgement that none of us is neutral, free of value judgement, and unrestrained by our birthplace, upbringing, education, and affiliations. This critical self-reflection has been described as a necessary component of socially responsible science communication, in terms of both research and practice (Jensen, 2022). However, while inquiry-based dialogue is one tool that is sometimes feasible to employ, there are few empirical studies or published tools aimed directly at science communicators to provide further assistance in this process (Roedema et al., 2022).

A Simple Reflexive Tool: Who Do We Work with?

Science communication practitioners and scholars should be engaging in self-reflection on the knowledge, expertise (real and assumed), and relative power of individuals and groups with whom they work.

In order to prompt this process, at the 2023 *Australian Science Communicators Conference* (Canberra, Australia) and the 2023 *Public Communication of Science and Technology Conference* (Rotterdam, Netherlands), two of the authors ran a reflexive activity as part of a workshop exploring third-order thinking about science communication. We asked the prompting question, "Who do you work with?" This prompt was deliberately open-ended to encompass a wide range of people and groups that science communicators would encounter in their work. After brainstorming onto post-it notes for fifteen minutes, participants were then asked to place their contribution onto an axis plotting knowledge and power (Fig. 8.2).

Terms prevalent on the post-its and in the discussion included "researchers", "community", "government", "traditional owners", "scientists", "policy makers", "students", and "partners".

The exercise allowed participants to reflect on their practice in several ways. Discussion during the session addressed the terms that we are using for the people and groups we interact with and the assumptions that are built into these terms. We discussed whether terms, like "stakeholder", come with their own baggage (Reed, 2022). Participants shared observations on the types of knowledge and expertise that the people we work with bring to the issue at hand and how this knowledge is recognised or valued by other participants in the system. Discussion also covered how (if at all) these parties are able to exercise power over what happens in relation to the issues being addressed in the given context.

The prompt, the knowledge-power chart, and the discussion accompanying the process appeared to enable self-reflection on the gap that often occurs between the aspiration that the science communicators who

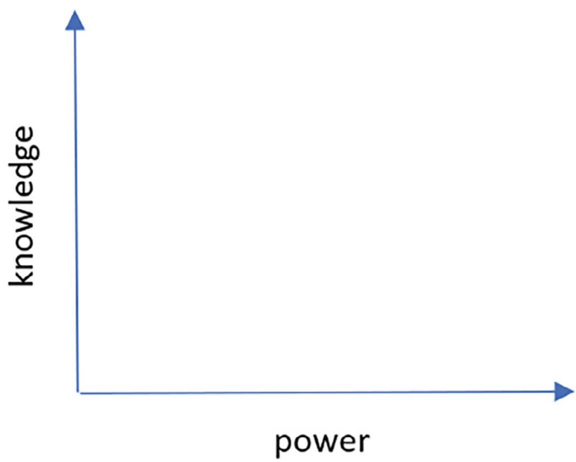

Fig. 8.2 Knowledge power axes used for participant post-it plot exercise

participated wanted to achieve—such as recognising expertise outside the realm of scientific research or the value of co-design and participatory processes—and what was *actually* happening in the types of work that they were doing. So, even this simple approach seems able to foster reflexivity, which we hope can lead to review and suitable modification of science communication practices.

The exercise can be seen to represent a form of emergent learning dialogue. That was possible to achieve in this context due to the relationships of the presenters with their audience of professional colleagues in a setting where our authors were seen as trustworthy. Now, how do we translate that capability to other settings for use by other science communicators?

Conclusions

Our experiences as science communicators have highlighted the highly complex nature of the challenges that the profession faces in the commercial and the public spheres. After years of intense discussion within the group, we have concluded that this complexity argues in favour of third-order thinking about science communication. This frame of reference has moreover allowed us to identify three key elements: messiness; epistemic asymmetries; and reflexivity.

Dialogue processes, though offered only in crude form by the existing second-order paradigm, do constitute an improvement upon the first-order provision of information. However, a heavy focus on establishing two-way communication has not, in our experiences, proven entirely effective. Building trust with our audiences seems to require something more. Third-order thinking about science communication can be seen to have identified and explored these weaknesses, but it has fallen short when it comes to informing practise.

Addressing epistemic asymmetry means resisting the false-binary thinking that lazily puts knowledge into baskets of "scientific" and "other". Learning from those with other forms of knowledge and those with different and even challenging perspectives involves reflexivity. It means being prepared to update or even discard our assumptions, our methods, and our objectives based on the context in order to address the needs of stakeholders with different views. Learning dialogue, which can involve co-designing communication protocols and methods, can deliver beneficial outcomes for the communities we work with, including scientific communities.

Our professional experiences suggest that communication approaches must be adaptive and situational in nature. This flexibility enables meeting an array of potentially diverse goals and objectives of different parties, a diversity that is inherent to wicked problems. This "horses for courses" approach avoids the tactical focus of both of the previous paradigms, such as filling deficits (first order) or focusing heavily on tightly structured modes of two-way communication (second order). It can also be seen to reflect a maturing of the field of science communication, a willingness to accept social responsibility in the sense of being responsive in the moment to varied parties.

Our conclusions are based on a conceptual exploration that is ongoing, which in turn draws on experience covering an array of wicked problems. We are mindful that science communicators and science communication scholars will have useful critiques to our contribution here. We acknowledge that science communication is a rich and diverse field of practice and research and that others may disagree with our observations. We welcome engagement on these questions because the third-order thinking itself is still developing. It needs a community of practice where assumptions, priorities, and different perspectives are considered, tested, and developed. It is only through this process that we will have new models for the work of science communicators that are well suited to navigating the wicked problems of today and tomorrow.

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9

The Devil in the Disciplines: Towards a Science Communication Culture Informed by Field-Specific Self-Reflection

Tobias Kreutzer

Introduction: Layers of Reflexivity in Science Communication

On April 22, 2017 (St. Fleur, 2017), science stood up against President Donald Trump's disregard for widely accepted scientific facts and budget cuts affecting the work of researchers all over the country. The signs held up by protesters in Washington D.C. went around the globe, cementing once again the well-established public image of research: atoms, test tubes, and DNA strings. Thus, climate change (denial), a complex and unbounded Herculean challenge that affects technological, social, economic, and political levels equally was once more reduced to the practices and symbols dominant only in certain research communities. The unintentional but sticky message reads: The best knowledge available to mankind comes from laboratories and can be quantified and turned into graphs. This poses a specific challenge for securing trust in

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those research practices that deviate from this image, which are common in the social sciences and humanities.

Observing and criticising the "deficit model" as the long-time leading paradigm in science communication (research) has long become a discipline classic itself (Bauer et al., 2007; Simis et al., 2016). At the same time, voices from the social sciences and humanities have repeatedly pointed out the need for a strict distinction between truth and power as different ordering principles in science and politics (e.g., Bogner, 2021; Sarewitz, 2011). Even more constructive perspectives, such as the call for "technologies of humility" (Jasanoff, 2007, p. 33) coming from the realm of STS, offer only starting points for what arguably needs to be developed into a whole new paradigm for science communication research and practice. Picking up Sheila Jasanoff's plea to communicate scientific "partiality" and "uncertainty" (ibid.), I want to suggest a further layer of reflexivity in science communication, namely one that will enable lay audiences to appreciate the diversity of research practices and to develop more differentiated trust patterns. This chapter therefore outlines some early conceptual thoughts on a new communication culture informed by discipline-specific self-reflection and considers the implications this may have for public trust in (life) sciences, social sciences, humanities, and applied (engineering) sciences. To do justice to the broad spectrum of institutional, communicative, and epistemic cultures in between STEM and SSH disciplines, the term "science" as used in the following is to be understood in the sense of the German *Wissenschaft*—as an umbrella term generally referring to the entire spectrum of scientific research.

Before exploring selected cases of disciplinary specifics and their significance for science communication, the chapter will first introduce, combine, and operationalise two concepts of scientific disciplinarity and trust in science. The text concludes by providing general principles for a new, discipline-specific science communication culture, as well as some perspectives for further research on the potentially integrative role of social sciences in self-reflexive communication.

Talking About Disciplines

While the era during which scientific disciplines were seen as the structuring principle of scientific knowledge production has long since been declared over (Gibbons et al., 1994), and interdisciplinary transfer, if not co-production, has become a requirement of many funding lines, disciplines for now remain at the core of the institutional, epistemic, and communicative organisation of science (Lenoir, 1997; Stichweh, 1992). "Although there are certainly successful examples of interdisciplinarity, established academic disciplines remain dynamic centres of knowledge production that are open to external developments even while insisting on internal standards" (Jacobs & Frickel, 2009, p. 60). Global crises such as the COVID-19 pandemic and the climate crisis have been publicly negotiated along disciplinary domains—with several observers remarking on a public imbalance between the social and the natural sciences (Holmes et al., 2020; Lohse & Canali, 2021). The infamous incompatibility of a world with problems and a university with departments does not seem to be easily resolved through journalistic and public intermediaries. On the contrary, medialisation (Weingart, 1998) has affected different scientific disciplines and cultures variously, from their institutional public orientation (Serong et al., 2017) to their research topics and publication practices (Franzen & Rödder, 2013).

I argue that, from a science communication perspective on the question of public trust in science, the reality of the disciplinary paradigm of science has not been given enough attention hitherto. Disciplinary specifics of knowledge production, publication and communication cultures, and the ways in which they are communicated and received shape how trust in science develops—leading to a certain disregard of practices and disciplines outside of what is perceived as the 'scientifically orthodox'. Consequently, the effects that, for example, the strict isolation measures that were brought in by various countries during COVID-19 had on the education, mental, and social life of children as well as adults were taken into account relatively late in the public discussion (see Lohse & Canali, 2021). The discipline-sensitive approach presented here carries implications for the public understanding of science as well as new requirements of reflexivity for the scientific community and communication intermediaries, so that future crises might be negotiated from various disciplinary angles and with diverse forms of knowledge all along.

In order to reconceptualise trust in science as an affair of scientific disciplinarity, this chapter theoretically combines two pertinent concepts of trust and disciplinarity and develops specific case examples in which these concepts would be expected to mutually affect each other. My first conceptual point of access is situated within information science and bibliometrics. In their exhaustive review of scientific literature on the most common conceptualisations of disciplinarity, Sugimoto and Weingart (2015) identify three main aspects of disciplinarity. These aspects were deemed especially suitable for the concept presented here, since they mirror what scientific communities themselves believe to be the crucial elements of disciplinarity. Accordingly, scientific disciplines will subsequently be understood along three "frequently used axes" (Rauchfleisch & Schäfer, 2018, p. 32): communication, "aboutness", and aspects of social organisation (Sugimoto & Weingart, 2015, p. 788). According to this understanding, scientific disciplines form, by means of communication networks, as can be made visible through citation analyses, a shared epistemic approach to an object of scientific interest. This results in the establishment of field-specific institutions, such as thematic conferences, journals, and university chairs. Naturally, these disciplinary "axes" serve as mere approximations to a term, a category, which has for decades been debated in the history, sociology, and philosophy of science.

Trust in a Fragmented Environment of Knowledge-Production Sites

The second theoretical pillar of the concept presented here builds upon psychology and marketing research. These fields have developed a widely accepted concept of trust, which allows for a realignment of the concept of trust in science along academic disciplinary axes. For this, I suggest following Hendriks et al. (2015) and their influential operationalisation of the concept of "epistemic trust" (p. 1), drawing on the works of Mayer et al. (1995) as well as O'Neill (2002). These authors were able to theoretically conceptualise and empirically show that laypeople evaluated scientific expertise based on the three dimensions of "*expertise*", "*integrity*", and "*benevolence*". From this angle, trust in science takes the form of epistemic trust: "It's about the trust, that science and scientists provide 'truthful' (meaning also: *relevant* to the question) answers" (Bromme, 2020, p. 11 [translation by the author of the chapter; italics as in original]).

The idea of epistemic trust seems especially relevant and fruitful in the context of unbounded and multi-dimensional problems, such as the COVID-19 pandemic and the climate crisis, which are publicly negotiated and politically framed by mobilising scientific expertise from various fields (e.g., Bogner, 2021; Brint, 2020; Fage-Butler, 2024). Such problems are discussed along a highly specialised and internationalised research landscape in which epistemic trust becomes a necessity, since everyone is a layperson in one field or another. The underlying premise for the conceptual thoughts presented here is twofold: On the one hand, the age of "massification" has led to an increasing number of people who are "familiar with the methods of research" (Gibbons et al., 1994, p. 11). On the other one, modernisation and structural differentiation have cemented the default state of all of us being laypeople.

Hendriks et al. (2016) have elaborated on the three dimensions of epistemic trust in more detail. According to them, the key characteristics of *expertise*, *integrity*, and *benevolence* can be described as follows:

> First, a layperson should trust someone who is an expert because she is knowledgeable […]; she possesses *expertise* [italics as in original]. Expertise refers to someone's amount of knowledge and skill, but […] the dimension of expertise also encompasses the aspect of pertinence […]. Second, an expert should be trusted when a layperson believes her to have a reliable belief-forming process […] and to follow the rules of her profession […]. These factors make up her perceived *integrity*. Third, an expert is considered trustworthy if she offers advice or positive applications for the trustor or (more generally) for the good of society […]; that is, she must act with *benevolence*. (p. 153)

The emphasis on the perceived pertinence of *expertise* in addition to the amount of knowledge implied by it reflects the general mode of differentiation of knowledge production in modern societies described above. The universal scholar is a concept of the past. Trust in expertise is allocated on the basis of topics, problems, and disciplines—posing further challenges for laypeople to identify fitting trust cues. *Integrity*, according to Hendriks et al. (2016), very much depends on what are considered the rules of a certain profession: Research cultures and scientific disciplines form their very own professional rules that run along communicative, social, and institutional disciplinary axes (e.g., Engelen et al., 2010). Finally, *benevolence* as a dimension of trust seems closely connected to the positive potential for application that a (scientific) expert is offering. Again, this structural component of trust can exist to varying degrees among the different scientific cultures. Applied disciplines might be assessed differently than theoretical ones when it comes to their perceived *benevolence*.

Bromme et al. (2008) have themselves partly addressed the "complicated relationship" between knowledge and epistemological beliefs: "We claim that epistemological judgments onto a specific topic rely on different sources, like (discipline specific [sic!]) epistemological beliefs, ontological knowledge, and topic-related knowledge" (ibid., p. 437). This chapter, however, treats epistemological beliefs as only one aspect of the disciplinary kaleidoscope among others and tries to arrive at novel implications for a discipline-sensitive concept of public trust in science.

Disciplinary Dimensions of Epistemic Trust—An Overview

The following table exploratively assigns concrete examples of different dimensions of epistemic trust to the dominant axes of disciplinarity described above. The goal is to indicate the complexity and multi-layered structure these dimensions of trust necessarily develop when applied to specific scientific research cultures and disciplines. The concretisations in the table are by no means exhaustive. They are formulated as questions intended to go beyond theoretical framework building and further stimulate reflexivity in science communication practices. Science communicators, science journalists, and other intermediaries, as well as scientific laypeople, could systematically think through answers to these questions when confronted with knowledge claims from a certain scientific field and reflect on how these answers might affect the perceived *expertise*, *integrity*, and *benevolence* of the discipline. A postcolonial studies researcher might come to the conclusion that her field is: (1) highly visible, it is confronted with professional stereotypes, and it faces controversial interpretations of its agenda; (2) communicatively blurring the boundaries between scientific, political, and private roles and outlets; and (3) is undecided about its methodologies and inherently critical about scientific boundary work.

Some especially crucial aspects of each disciplinary axis in relation to the three dimensions of epistemic trust will be further discussed in Table 9.1.

Public trust in science is necessarily shaped by social and institutional dynamics arising from the medialisation of science (e.g., Weingart, 1998, 2022). Influenced by Luhmann's (1984) theory of social systems, Weingart's (2022) initial concept was able to reveal a "spread of mutual observation and attention seeking [between science and the media] as defining societies after WWII" (p. 288)—a tendency accelerated and complicated further through the rise of social media and the need for research institutions to adapt communication efforts to new attention economies. The discipline-specific dimensions of epistemic trust described in exemplary form below are to be understood against this backdrop, including subsequent research on the discipline-specific forms of medialisation (Franzen & Rödder, 2013).

Institutionalisation: Fragmentation, Quantifiability, and Internationalisation

Modern academia has developed various heuristics and shortcuts to cope with the exploding field of academic publishing (e.g., Gu & Blackmore, 2016) in an increasingly internationalised research environment (e.g., Rostan et al., 2013). These symptoms of modernisation and social differentiation in academia are, however, articulated differently depending on the respective discipline. In his influential call "For Public Sociology",

Table 9.1 Disciplinary dimensions of epistemic trust

Dimension of epistemic trust ▶ Disciplinary axis ▼	Expertise	Integrity	Benevolence
Institutionalisation of the discipline	How visible is a certain branch of research? Which disciplines dominate public conceptions of competence?	How settled are the professional rules of a certain discipline? What is publicly known about them?	Where is the discipline situated institutionally (public university, university of applied sciences, private research institute), how is it funded and what do laypeople associate with it? How visible are the related institutions?

Dimension of epistemic trust ▶ Disciplinary axis ▼	Expertise	Integrity	Benevolence
Communication of the discipline	How does the disciplinary publication culture fit into public attention economy?	Is there an internal discourse on self-reflection? Does the disciplinary research process match public symbols of scientific endeavour (test tube, book, etc.)?	Does the discipline have its own "public intellectuals"? Do they strive for role clarity?
Epistemology of the discipline	To what degree is the discipline publicly perceived as "scientific"? Can disciplinary methodologies (especially qualitative/ hermeneutical approaches) be demarcated from "everyday epistemologies"?	Is the disciplinary method publicly known? Is this method (and sticking to it) considered scientific?	Are the disciplinary methodologies in danger of being seen as politicised instead of benevolent?

Burawoy (2005) highlights the individual historical circumstances under which “national sociologies” with different degrees of public orientation have formed around the world (p. 21). Sociology’s (normative) embeddedness and its highly context-specific objects of research make institutional standardisation more complicated. As will be described in more detail in the following section, sociology, among other social sciences and humanities, also partly withstands the quantitative and cumulative forms of evaluation regarding its publication culture. The lower publication frequencies of monographs and anthologies in combination with an internationally more segregated research community lead to fewer citations. Non-scientific qualities, as attributed to the “public sociologist”, further complicate the judgement of *expertise* on an institutional level.

Institutionalisation as a key axis of disciplinarity takes elusive public forms. A discipline might have established relevant journals *as well as* pertinent book series and semi-public conferences—and thereby complicated the process of evaluating *expertise* based on publishing institutions.[1] The evaluation of the *integrity* and *benevolence* of scientific experts equally depends on the degree of institutional uniformity and comparability within a certain discipline. Intra-disciplinary competing orthodoxies, for example, can be observed in the case of analytical versus continental schools of philosophy (e.g., Levy, 2003). In a similar vein, Lewis et al. (2023), drawing on Collins and Evans (2007), have pointed at a greater tolerance for dissent and mavericks within the social sciences and at extended “loci of legitimate interpretation” (p. 659) in a field concerned with something as general as the social.

It should be noted that the axes of disciplinarity, which serve as a frame for applying the three dimensions of epistemic trust, partly overlap. Communication around a scientific discipline, which constitutes the main aspect in the following section, can hardly be separated from the institutional means of communication discussed above.

[1] The complex and discipline-specific transitions and interplays between scientific journals, handbooks, and textbooks have been prominently described by Fleck (1980).

Communication: Discipline-Specific Publication Cultures, Public Attention, and Expectations

Publishing and sharing scientific results among the community are pillars of the collective endeavour of modern science (Merton, 1973). However, the fixation and transfer of scientific ideas and findings can take very different forms. The *German Research Foundation* recently remarked that, in Germany, the humanities rely heavily on monographs as a way of publishing their scientific advances, while in the natural and life sciences, journals, and preprint servers are the dominant publication platforms (German Research Foundation, 2022). More extensive publication formats naturally take more time to compile. Accordingly, faculties of arts, humanities, and social sciences publish less frequently than their colleagues from engineering, natural sciences, and medical and health sciences (e.g., Shin & Cummings, 2010, p. 589).

Granted that each publication, whether big or small, may potentially serve as a communication event, these disciplines can communicate results and findings of their fields at a higher frequency than certain "book sciences" within the humanities and social sciences can. Indeed, Serong et al. (2017) found that disciplines such as medicine, information technology, and biology quantitatively dominated the overall science communication output of scientific institutions in Germany. This frequency then provides a journalistic pattern wherein most forms of result-oriented science coverage take place in the classic science departments of daily media outlets (Summ & Volpers, 2016): Fresh studies and journal articles are picked up through press releases which then trigger news coverage. This is probably one reason behind the observation that "science news journalism" (e.g., Wormer & Karberg, 2019) is focused on the natural and life sciences.

Authors such as Cassidy (2014) have taken a meta-perspective on the specific challenge of communicating results from within the social sciences. In her meta-analysis, she was able to ascertain what Summ and Volpers (2016) were to observe for the German media landscape later: Mass media treat the social sciences and humanities very differently from the natural and life sciences. The social sciences and humanities are more likely to be consulted on social issues of general interest, often outside of science departments. Recent research results from their disciplines play only a minor role, and it is more likely for experts from such disciplines to be consulted about a topic on the periphery of their original research interest (Cassidy, 2014).

There is a direct link between the often historically evolved ways and formats through which scientific knowledge is shared within different disciplinary contexts and the public image of certain fields of research. It can be argued that all dimensions of epistemic trust outlined above, are affected: The more experts are questioned about topics outside of their formal realm of expertise, while their intra-discipline knowledge transfer is ignored, the harder it gets for lay audiences to identify relevant and pertinent *expertise*. The trust dimension of *integrity* likewise depends on the degree to which the rules of a certain [scientific] profession are publicly discussed—in other words: the scientific sincerity with which it is met. A complex scientific monograph might be overlooked by fast-paced news media. Methodology and the process of reasoning will likely have to stand back behind the catchy but simplified analysis of contemporary society, which has been identified as a popular genre of public sociology (Osrecki, 2012). Accordingly, the trust aspect of *benevolence* and how it is perceived will depend on the application potential that a discipline introduces in its publications or through its public experts.

Epistemology: Public Methodological Biases and the Allocation of Trust

According to Schäfer and Rauchfleisch, the epistemic axis of disciplinarity is formed around a "shared research object", "a characteristic common body of knowledge", and shared methods and methodologies (Rauchfleisch & Schäfer, 2018, p. 32). Engelen et al. (2010) have impressively illustrated the variety of epistemic cultures in modern science by summoning scholars from various disciplines to receive detailed epistemic self-assessments from renowned active researchers. However, several contributors of their volume pointed at different degrees of epistemic pluralism even within single disciplines. Moreover, relatively new research areas such as the digital humanities prove that the accepted methods within a given discipline or a research field are subject to constant change.

The concurring research logics structuring the natural sciences on the one hand and the humanities (or "cultural studies") on the other are at the core of a classic science studies debate. Its roots in German academic discourse lead back to Windelband (1904) and his distinction between "ideographic" cultural studies and "nomothetic" natural sciences. Heavyweights of sociology such as Max Weber (1904) and Jürgen Habermas (1982) have later described the special epistemic premises of the social sciences. It seems quite obvious that these epistemic differentiations influence the way trust in different scientific disciplines is built.

Again, the media play an important part in this process while by no means being immune to bias themselves. For example, in an early analysis of leading US media outlets, Evans (1995) observed that social science was "portrayed in the media as a less distinctive and valid way of knowing" (p. 168). The data available for Germany shows that most German science journalists have an academic background in the natural sciences—a possible source of a negative bias towards the social sciences and humanities (Blöbaum, 2008). Another source could be the perceived news value of numbers and quantitative disciplines alongside the unequal editorial treatment of different disciplines resulting from this perception (Luhmann, 1995). Regular population polls on scientific trust indicate that the social sciences and humanities are perceived as less scientific than the natural and life sciences also among broader lay publics (Wissenschaft im Dialog, 2017).

Different disciplines are perceived and evaluated very differently by both professional science communicators and laypeople of different degrees. *Expertise*, *integrity*, and *benevolence* are much more likely to be allocated to those disciplines that match the public image of scientific reasoning. The disciplinary axis of epistemology therefore affects all dimensions of epistemic trust—just as has been anecdotally deduced for the two other axes.

Conclusion: Towards a Science Communication Culture Informed by Field-Specific Self-Reflection

The previous sections have themselves opened up a kaleidoscope of discipline-specific dimensions of epistemic trust. In this concluding section, I want to explore some concrete suggestions that may further illustrate the concept of a science communication culture informed by field-specific self-reflection. These suggestions are addressed to researchers from all disciplines, as well as professional science communicators and science journalists interacting with experts from diverse fields regularly. Naturally, they also apply to science communication research itself.

Bromme (2020) names goals, actions, and risks as the three centrepieces in acts of trust (p. 11). Different lay audiences usually consult science in order to be told the "truth" about a certain matter (ibid.). Bromme et al. (2008) have pointed out the inherent paradox of this relation: "[…] there is some evidence that the amount of knowledge with regard to different topics and the quality of epistemological beliefs is [sic!] correlated negatively. Furthermore, gaining factual knowledge sometimes results in less sophisticated epistemological beliefs" (p. 423). Science does not provide absolute truth but only the best knowledge available at a certain point in time (Kuhn, 1962).

This realisation offers the opportunity to rethink science communication and the premises of trust in science altogether. Such an approach would have to include disciplinary self-reflection, expectation management, and humility in trust communication, as well as the willingness to initiate a structural process decoupled from short-term performance figures. If we can redefine the goal of trust allocation away from "the truth" and towards an "approximation of truth" through different "disciplinary lenses" (Sarewitz, 2004, p. 386), this could also reduce the "risk" of being led astray. The practical implications could take very different forms: From professional science communicators developing a visual vocabulary mirroring the diversity of disciplinary research practices over (science) journalists giving qualitative research results a chance in their coverage to the implementation of introductory courses in epistemology and philosophy of science at an undergraduate level. Such a process would require radical honesty regarding all dimensions of trust, *expertise, integrity*, and *benevolence* and could very well lead through a period of disillusionment. In the long run, however, it could build a sustainable bulwark against science populism, false expectations, and anti-scientific backlashes.

The Integrative Role of the Social Sciences

The social sciences have already been discussed as an object of science communication and trust in science throughout the previous paragraphs. This concluding section goes beyond that and argues that the inevitably self-reflexive approach of a research field concerned with "the social" can act as an integrative force in the proposed new paradigm of science communication.

Subjects such as science studies, science communication, history and philosophy of science add an inward perspective on the social, institutional, and epistemic foundations of science and its disciplines (Bloor, 2005; Kuhn, 1962; Latour, 1987). They ask fundamental questions worth considering within the separate contexts of each discipline. Scholars would be empowered to take a meta-perspective and reflect on how their discipline is organised *communicatively, institutionally*, and *epistemically* and how these specific constellations might shape public interaction with it. Simis et al. (2016) have already offered a perspective on how the social sciences might help overcome the "deficit model" still prevalent in many research areas. However, their suggested applications did not go beyond practical training for scientists and science communicators as well as different outreach initiatives (ibid., p. 410). The meta-perspective suggested here would generally include the interplay between disciplinary characteristics and dimensions of epistemic trust within specific fields of research and focus less on desirable communication practice but more on broadening the general scope of scientific ethics (e.g., Medvecky & Leach, 2019).

This integrative function of the social sciences would not have to be limited to intra-scientific research and communication processes. Intermediaries of science communication such as science journalists could profit from a more reflective perspective on both science and the journalistic profession by embracing meta-principles from science studies. Ultimately, they are themselves engaged in a form of knowledge production that makes use of scientific methods (Meyer, 1973; Sponholz, 2009). Equipped with a certain degree of awareness regarding the historical, institutional, social, and epistemic peculiarities of science and its disciplines, journalists could function as "second-order observers" (Luhmann, 1984, 1992) across the different departments—critically reflecting scientific knowledge production as well as journalistic world-making (Luhmann, 1995, p. 9). A professional journalistic ethos of constant reflection could also help overcome what Kohring has called "the paradigm of science popularisation" (Kohring, 1997) and strengthen the science journalists' self-perception as critical observers of their subject—as is the current situation in other journalistic departments. Overall, *reflexive linking* could become part of the mosaic currently forming around the discourse on the "public understanding of social science" (Lewis et al., 2023)—pervading all manifestations of internal (among scientific colleagues), external (between scientific disciplines as well as between experts and laypeople), and mediated (institutional, journalistic) science communication.

More than 30 years ago, Shapin called for finding "ways of introducing the citizens of democratic societies to the work-world of science-making" (Shapin, 1992, p. 28) because they needed to be "trust[ed] with the truth" rather than being presented with an "idealised" version of science (Shapin, 1992, p. 29). In the present contribution, I have argued that not only should science communication (especially from the STEM disciplines) refrain from idealising science, its institutions, and processes but it should also stop standardising its complicated and rich research cultures. A new public position of the social sciences at the crossroads between various institutions of science communication could be a pathway to more reflection and mutual trust.

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10

Risk Communication and Stories

Brandi Shaw Morris

Introduction

When it comes to engaging the public with forecasts about potential hazards, scientists rely heavily on the presentation of empirical data but rarely heed empirical data about how this information is decoded. Evidence from modern neuroscience suggests that the brain's primary function is allostasis, the optimal allocation of scarce bodily resources. Experiential processing is more metabolically efficient than cognitive elaboration, and affect is data. It plays a crucial role in focusing attention on information that warrants the allocation of scarce bodily resources and action-taking. Informational frames do not easily spark either. The author's work suggests stories are more effective than fact-based frames at triggering affective engagement and action-taking in the face of threats such as climate change (Morris et al., 2019, 2020). With biology as our point of departure, the following chapter will discuss how stories exert

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their influence on emotion and behaviour in the context of risk communication, a specific type of science communication involving not only the presentation of empirical data, but also forecasts, projections, and regulatory consequences.

The Problem

When presenting the public with empirical evidence and predictions about pressing societal threats, risk communicators usually aim not only to inform or educate, but also to influence attitudes, beliefs, and behaviour in specific directions. However, as the recent COVID-19 pandemic and over 120 years of communication regarding the threat of anthropogenic climate change have clearly shown, when trust is lacking, information alone will not be sufficient for overcoming the biased assimilation of information; not even when that information represents scientific consensus (Greitemeyer, 2023; Kahan et al., 2012).

Building on interdisciplinary research from the fields of psychology, neuroscience, narratology, communication, and education, the following chapter will make the case that stories have greater potential for overcoming the various forces that undermine trust, than do the analytical frames typically used by risk communicators. To this end, I will present evidence for several biological realities with important implications for risk communicators, elucidating several mechanisms underlying how stories are thought to exert their influence, and highlighting directions for future research.

A brief acknowledgement and disclaimer: The topics addressed in this chapter are so substantive and complex that an in-depth exploration of each could easily fill many volumes. Nevertheless (and perhaps foolishly), I will attempt to distil the complexity of these topics into one overarching argument: because the brain is dedicated, first and foremost, to the optimal allocation of scarce bodily resources, frames that foster experiential processing and affective engagement are likely to be preferred to those that rely on the energetically costly process of cognitive elaboration. Moreover, affective engagement with stories occurs largely through empathic connection with identifiable characters who are seen to share important goals and values.

Biological Reality #1: The Brain's Main Purpose Is Not Thinking

Darwin theorised that natural selection pressures organisms to economise their use of metabolic resources (Darwin, 1964). Modern neuroscience offers evidence that the brain's main goal is allostasis—the optimal allocation of energetic and metabolic resources in order to keep the body upright, alive, and thriving (Schulkin & Sterling, 2019). Allostasis can also be understood as the process of budgeting scarce metabolic resources to meet the needs of the body (Barrett & Quigley, 2021). To this end, most of the brain's activity is dedicated to monitoring the environment, running and selecting among competing models and predictions, using three primary forms of data: past experience, exteroception (i.e., the five senses: sight, sound, taste, touch, and smell), and the lesser-known interoception (Barrett, 2016), to be explained in greater detail below. The brain uses this data to run predictive models about threats in the environment and to choose an appropriate plan of action (Barrett, 2016). But how does the brain decide what is important and when action is required?

Biological Reality #2: Emotion Is Data

In seminal work on the psychology of risk, consequentialist perspectives of 'risk as analysis', e.g., Theory of Reasoned Action (Ajzen & Fishbein, 1980); Health Belief Model (Maiman & Becker, 1974) have traditionally viewed emotion as epiphenomenal to decision-making, relegating its role primarily to anticipation of future outcomes. 'Risk as feelings' perspectives (e.g., Loewenstein et al., 2001; Slovic et al., 2004), on the other hand, acknowledge emotion as both an input into decision-making (in tandem with cognition) and a potential outcome.

Interoceptive sensations happen mostly outside of our awareness and function as a form of neurobiological data used by the brain to regulate the various systems of the body, e.g., metabolism, immune system, endocrine system, autonomic nervous system, and skeletal muscle system (Barrett, 2016). The steady stream of data produced by interoceptive predictions is called affect, a neurophysiologic state described as simple feelings or "a faint whisper of emotion" (Slovic et al., 2004, p. 2). Affect fosters experiential processing, which is more energetically efficient than the process of cognitive elaboration (Barrett, 2017), and serves as an important cue for judgements about probability (Slovic et al., 2004). Affect is thought to be a form of heuristic (Finucane et al., 2000) and an evolutionary orienting mechanism that directs attention (Armony et al., 1995), helping us to navigate complexity and take action in dangerous environments (Zajonc, 1980). In contrast to cognitively-controlled processes, these simple emotions are automatic and can best be understood as a form of action-readiness in the face of threats (Kiverstein & Miller, 2015).

Affect is usually characterised along two primary dimensions: valence (the inherently positive or negative, pleasant, or unpleasant charge of an emotion), and arousal (high vs. low) (Barrett, 2006). Each affective dimension represents a different type of information considered crucial for judgement and decision-making (Storbeck & Clore, 2008). From a neural perspective, valence is thought to be a form of valuation about the expected consequence (Barrett, 2006), desirability, or importance of a specific piece of information (Damasio, 2011), while arousal is thought to determine which threats we attend to and care about at any given moment in time (Barrett, 2017).

To optimise the allocation of scarce bodily resources, the brain uses these interoceptive predictions to make an educated guess about the state of the body's budget and to assess whether action is required in the face of threats (Barrett & Quigley, 2021). When this need is perceived, the brain constructs an instance of emotion which manifests itself as arousal (i.e., involuntary changes in the autonomic nervous system) (Barrett,

2017) measurable through, among other things, electrodermal or cardiac activity.

Curious to understand how valence influences risk perception and outcome efficacy in ideologically diverse audiences, my collaborators, and I conducted a series of survey experiments testing three different affective endings (optimistic vs. pessimistic vs. fatalistic) (Morris et al., 2020). We found that negatively-valenced endings not only increase risk perception, but also outcome efficacy (i.e., the sense that one's own actions matter to an outcome), and that this is the result of heightened emotional arousal. Moreover, we discovered evidence that, while the mediating effect of emotional arousal was significant for all groups, it was most pronounced in the very groups that not only typically exhibit low levels of risk perception and outcome efficacy on this issue, but also decry 'the sky is falling' messaging most loudly (see also Chapter 4).

These findings are in line with work suggesting that negative affect increases estimations of risk probability while positive affect reduces it (Finucane et al., 2000; Ganzach, 2000). The findings make sense given the informational value that positive valence provides to the brain, suggesting that all is well, and no action is needed (Barrett, 2006). How could participants be so optimistic even in the fatalistic condition? Humans tend to overestimate the likelihood of positive events and underestimate the likelihood of negative events (Sharot, 2011), a propensity that deludes us into believing that things will be fine, even when the empirical evidence suggests otherwise. Not only can unfounded optimism lead us to inaccurate conclusions, less guilt, and less perceived responsibility, but also to devastating outcomes when we exhibit lower behavioural intentions (Pahl et al., 2014; Sharot, 2011).

Our research findings suggest that the most ideologically conservative audiences might be more threat-reactive when emotionally aroused compared with liberals, possibly because of differences in brain anatomy and function (Morris et al., 2020). Although the formation and processing of emotion involves complex neural connectivity, conservativism has been associated with increased volume in the right hemisphere of the amygdala (Amodio et al., 2007; Kanai et al., 2011), an area with greater influence than the left hemisphere when it comes to emotional expression and the processing of primary emotions such as fear.

An in-depth discussion of the neurological propensities of different political and ideological groups is beyond the scope of this chapter, but it does bring us to our next point. From an evolutionary perspective, our biological and social lives are inextricably linked. Science communication has historically embodied the 'deficit approach' (Brown, 2009; Fischhoff & Davis, 2014), the notion that if we just give people more information or increase their statistical literacy, they will behave more 'rationally.' Not only does this view of 'rationality' ignore neurobiological evidence indicating that, when areas of the brain associated with emotion are impeded, people make less—not more rational decisions (Bechara & Damasio, 2005), but research also suggests that science literacy and comprehension do not predict 'belief' when it comes to issues that represent potential threats to identity and social affiliation (Kahan, 2012, 2017). Whether the brain constructs an instance of emotion to signal that action is required depends on which threats we perceive as most dangerous and probable, which brings us to our third biological reality, the intertwining of our biological and social lives.

Biological Reality #3: The Intertwining of Our Social and Biological Lives

Danger is real but risk is socially constructed and context-dependent, so a 'rational' individual's perception of risk is highly influenced by who is assessing and communicating the risk (Slovic, 1999). Individuals are more likely to trust and be persuaded by messengers communicating risk if they are perceived to share closely held values (Twyman et al., 2008). Here we define trust as "a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another" (Rousseau et al., 1998, p. 395). Perceived value similarity is a critical component of credibility and trust (Earle & Siegrist, 2008), and information that threatens values and ideological commitments is less likely to be trusted (Campbell & Kay, 2014; Kahan et al., 2011). Values are strongly tied to identity and, as Social Identity Theory outlines, people derive "a sense of social and personal worth from the identities that they hold (Cohen et al., 2007)."

Social belonging and coalitional thinking have been crucial to our survival as a species. As such, when processing new information, 'rational' individuals might be (subconsciously) willing to sacrifice factual accuracy if updating their beliefs might result in the severing of valued social ties or represent a serious threat to their identity. In their biologically founded mathematical model of social pressure based on the metabolic costs of information, neuroscientists Theriault et al. (2021) demonstrate the benefits of social conformity, positing that humans attempt to make their social environments predictable by inferring the expectations of others and conforming to them as a form of energetic 'coasting.' "By conforming, an individual can regulate others' behaviour, the rate of her own learning, and the metabolic costs imposed by her social environment" (Theriault et al., 2021, p. 5).

Indeed, science communication research by Drummond and Fischhoff (2017) found that individuals with high scientific literacy have more polarised beliefs on controversial scientific topics, while Kahan (2017) found that they decode the same empirical information in ways that support divergent conclusions in an attempt to cohere with current social affiliations and identities. Confirmation bias is a form of 'motivated reasoning' where individuals process information in biased ways that confirm rather than disprove their existing beliefs. Identity-protective cognition is another unconscious mechanism that protects individuals or groups from potential threats to their values or identity. Cultural cognition theory posits that cultural worldviews (individualistic vs. communitarian, hierarchical vs. egalitarian) expressing core values more accurately predict an individual's belief regarding issues such as climate change than any other variable, including political affiliation (Kahan, 2012).

Since around 2000, for example, an American's stance on climate change has provided a reliable indicator of their political affiliation and ideological identity, with those expressing concern likely to hold an ideologically left-leaning, liberal worldview and those expressing scepticism or a lack of concern more likely to be on the ideological and political right. Similarly, during the recent COVID-19 pandemic, behaviours such as mask-wearing, vaccination, or the taking of Hydroxychloroquine were reliable markers of trust/distrust in governmental institutions and its representatives. This is unsurprising since people tend to defend systems they support, believe in, and benefit from (Jost, 2005), and people with conservative worldviews are typically opposed to governmental regulation, which they view as interference with free market dynamics.

Against this backdrop, it is critical to note that 'regulatory science' involves not only the presentation of empirical data, but also forecasts, predictions, proposed regulations, and cut-offs, which mirror specific values and worldviews. Put another way, 'regulatory science' is not 'just the data' but also a 'therefore what' with distributive consequences, winners, and losers (Eyal, 2019). It represents a form of power to which citizens who do not share these values may experience psychological reactance (Brehm, 1966).

As such, when evaluating communication about threats such as climate change or a pandemic, individuals appraise not only the objective danger itself but also *who* is communicating the threat. The degree to which the public perceives alignment/misalignment between a messenger's values, worldview (Kahan, 2015), and incentives (Mercier, 2020) and their own, becomes a heuristic about the potential social cost of trusting. When it comes to regulatory science, the messenger becomes the message. Indeed, prior work provides evidence that scientists enjoy the public's respect but not necessarily their trust (Fiske & Dupree, 2014). A series of survey experiments we conducted (Morris, 2024b) suggests that conservative audiences are more likely to counterargue and less likely to identify with scientists on issues related to regulatory science. In a recent mixed-methods study using qualitative interviews and psychophysiology, we found that Danish farmers perceive policymakers as having unaligned agendas which motivate them to cherry-pick data that suits the emotional temperature of public opinion in order to achieve their own personal ambitions, political goals, and agendas (Morris, 2024a). (See also Chapters 2 and 3.)

Up to this point, I have argued that because the brain's main purpose is to optimally allocate scarce bodily resources, interoceptive predictions (affect) are used to assess the state of the body's 'budget' and whether action is required. I have presented evidence that experiential processing facilitated through affective engagement is more energetically efficient than cognitive elaboration, the valence of elicited emotion matters, and emotion is data that manifests itself as arousal. Finally, I have claimed that, as part of our evolutionary legacy, values, identity, and our drive for social-ingroup belonging continue to play an important biological role in how we decode information about risk and whether we are likely to be persuaded by a particular messenger. That brings us to the final biological reality to be discussed in this chapter: Our brains decode the world in story structure.

Biological Reality #4: Wired for Story

Stories have dominated human interaction for over 100,000 years, and this may have rewired the brain to decode the world in story structure (Damasio, 2012; Nelson, 2003; Pinker, 2003). As the famous Heider and Simmel animation (1944) illustrates, humans have a propensity to project meaning and story structure onto something as simple as geometric shapes moving across a screen. In short, we are storytelling animals (Gottschall, 2012).

We define story as, "a detailed, character-based narration of a character's struggles to overcome obstacles and reach an important goal" (Haven, 2007, p. 79). While the terms are often used interchangeably, in this work stories are considered a specific subset of narratives; all stories are narratives, but not all narratives are considered stories (Dalkir & Wiseman, 2004). Stories have specific features, characteristics, and a structure that differentiates them from narratives in general. While stories are often associated with fiction, they are actually "a way of structuring information, the scaffolding upon which the information is hung, not the content itself" (Haven, 2007, p. 79). Stories may be fiction, non-fiction, or any mix of the two.

Stories are an effective way of communicating factual as well as tacit information and knowledge (Dalkir & Wiseman, 2004) and are the framework most conducive to long-term recall (Mandler, 2014), comprehension (Armbruster et al., 1987), retention, application, and learner enthusiasm (Coles, 1989). Story structure has been shown to facilitate all six levels of Bloom's taxonomy (knowledge, comprehension, application, analysis, synthesis, and evaluation) by providing context and relevance as well as information (Clandinin & Connelly, 2000).

One of the main ways that stories are thought to exert their influence is through a phenomenon known as narrative transportation. As previously mentioned, stories are a subset of narratives, but the term narrative transportation is commonly used to describe being 'lost in story' (Nell, 1988); a state where story receivers lose track of time and space, suspending existing beliefs (vanLaer et al., 2014). Through narrative transportation, stories foster experiential rather than analytical processing (Kahneman, 2003; Petty & Cacioppo, 1986), reducing critical thoughts and counterargument, increasing the likelihood of narrative persuasion (Green, 1996; Green & Brock, 2000; Green & Clark, 2013) by conveying a desired way of thinking, feeling, or acting (Gerrig, 1993).

Narrative transportation is a convergent process (Green & Brock, 2000) involving experiential processing through immersion into a story. This is distinctly different from the divergent process of cognitive elaboration (Petty & Cacioppo, 1986), which entails analytical attention and scrutiny to major points of an argument. Under conditions of high cognitive elaboration, a person can still access pre-existing schemas, prior knowledge, experience, and opinions. Experiential processing increases the likelihood of affective engagement in a way that analytical processing does not. Indeed, prior work suggests that stories with high emotional valence better capture attention (Bagozzi & Moore, 1994; Fisher et al., 2008; Hoeken et al., 2016; Lin et al., 2013; Loewenstein, 2010) and are better able to inspire pro-social behaviour (Barraza et al., 2015; Lin et al., 2013; Morris et al., 2019; Small & Loewenstein, 2003) compared with informational narratives (Morris et al., 2019; Small & Loewenstein, 2003).

To investigate whether real-world climate appeals structured as stories more effectively trigger emotion and action-taking on climate change vis-à-vis analytical narratives, my colleagues and I (Morris et al., 2019) conducted a series of studies triangulating self-report and pro-environmental behaviour together with neurophysiological measures shown in prior work to be indicative of emotional arousal. Using a curated set of more than one hundred naturalistic climate (video) appeals, rated and scored by independent coders on essential story features, stimuli were categorised as 'low' or 'high' based on their narrative structure (the degree to which a narrative tells a story and contains essential features, including an identifiable character, plot [temporal dimension, goal], and setting. The higher the narrative structure score, the more story-like the narrative).

Our findings indicate that the more story-like the climate narrative, the greater the emotional arousal and the more likely a participant was to engage in pro-environmental behaviour. Moreover, we found that the effects lasted six weeks post-study with no additional treatment or remuneration (Morris et al., 2019). Given that most science communication uses informational frames, it is particularly troubling that participants in the randomly assigned group who received this type of treatment, performed fewer pro-environmental behaviours than those in our control group who received no information about climate change at all. We are constantly bombarded by external stimuli competing for our attention. As discussed, information that lacks affective relevance is more likely to be treated by the brain as noise and less likely to make it into the 'affective niche' (what we pay attention to and care about at a given moment in time).

This brings us to the final—and perhaps most important—takeaway of this chapter. Research across disciplines strongly suggests that one of the most predictable ways in which stories trigger affective engagement, narrative transportation, and post-narrative influence on attitudes, beliefs, and behaviour is through empathic connection with identifiable story characters seen to share important values (Bagozzi & Moore, 1994; Fisher et al., 2008; Lin et al., 2013; vanLaer et al., 2014). From a neural perspective, release of the neuropeptide oxytocin has been strongly associated with the subjective experience of empathy with another person (Barraza et al., 2011; Hurlemann et al., 2010) and identified as a biological basis for pro-social behaviour in humans (Heinrichs et al., 2005). When humans experience empathic connection and synthesise oxytocin, they are more likely to trust and become invested in helping to realise the goals of the person with whom they are connecting (Barraza et al., 2011; Heinrichs et al., 2005).

Character identification is defined as a process of self-other merging, where the story receiver shares (1) the perspective of, rather than judgements about, and (2) feelings with, rather than feelings about, the character in a story (Cohen, 2001). A story receiver is more likely to self-report identification and to be influenced by a character (Jones, 2014), less likely to have critical thoughts (Fiske, 1989) or counterargue with them (Green, 2004; Moyer-Gusé & Nabi, 2010), when they perceive the character's values and goals to match their own.

So, does the public identify with scientists? Believe them to hold shared similar goals, values, and worldviews?

According to 2022 polling data, 77% of Americans had at least a fair amount of confidence in scientists to act in the public's best interest, but a strong partisan divide exists (Kennedy, Tyson & Funk, 2022). Just 13% of Republicans express 'a great deal of confidence' in scientists while the share saying that they have 'not too much or no confidence at all in scientists' doubled as of early 2022. Notice that these polls ask about confidence, not trust. This is an important distinction because trust is based on perceived similarities in intentions and values (e.g., Earle & Siegrist, 2008; Nakayachi & Cvetkovich, 2010) while confidence is based on perceived competence (e.g., Bauer et al., 2007; Terwel et al., 2009). When asking about a notoriously polarising issue, Funk (2017) found that just 39% of Americans expressed strong trust in information from climate scientists and only 28% expressed strong trust in scientists' understanding of the causes of climate change.

So, does the public identify with scientists, believe them to share their closely held values, goals, and worldview? Our currently unpublished work suggests they do not. Here are a few potential reasons.

Worlds Apart

For starters, as of 2021, six out of ten Americans over the age of 25 had not earned Bachelor college degrees (Schaeffer, 2022)—a significant dissimilarity from scientists with PhDs and elite academic titles. Moreover, although many scientists view themselves as 'neutral' sources of empirical data, this does not match public perception. Only 16% of

Americans say that environmental research scientists, for example, admit and take responsibility for their mistakes all or most of the time, and just 17% believe that these scientists are transparent about potential conflicts of interest (Funk et al., 2019). More broadly, scientists are highly associated with liberal values, a secular worldview (Funk et al., 2015), and atheism (Simpson & Rios, 2019). Whereas roughly 83% of Americans surveyed believe in God, this number was just 33% among scientists; this is noteworthy since religious believers harbour an implicit bias towards atheists, associating them with immorality (Franks & Scherr, 2014; Gervais et al., 2017). For more on the topic of trust in scientists, see Chapters 6–7.

Conclusion

Because the brain is miserly, people are more likely to attend to and affectively engage with information embedded in story structure. Furthermore, in our efforts to build public trust in the face of societal threats, science and risk communicators would do well to consider the critical importance of identification with messengers charged with presenting empirical information. Like it or not, science communicators are identifiable characters in vivid sagas playing out in the public mind. Far from being neutral 'conduits,' these communicators are seen as having agendas and goals which may or may not be perceived as aligned with the best interest of the public. Since empathic connection is central to narrative persuasion, affective engagement, and action-taking, we must ask ourselves whether the public identifies with—and therefore trusts—the people assessing and communicating risk in the context of science. One thing is certain, when it comes to regulatory science in particular, perceptions of competence are not enough. As we have seen with climate change and the recent pandemic, lofty academic credentials are not necessarily sufficient to engender trust. The public must know and believe that the people assessing and communicating risk share their closely held values and have their best interest at heart, rather than hidden agendas. Does the public view scientists as characters in an unfolding story? Do they identify with scientists? Empathically connect with them? See them as sharing similar values? Future research should investigate these questions and seek to better understand how trust (epistemic trust in particular) in science and risk communicators might be strengthened using the power of essential story elements. That the empirical work discussed in this chapter relies heavily on controlled experiments and self-reported measures of trust is not unproblematic (see also Chapter 16). Future work should strengthen ecological validity by employing field studies and construct validity using behavioural measures of trust to ensure that what we are measuring is, in fact, trust, rather than (for example) political signalling—or virtue signalling.

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11

Science Communication and Radical Trust

Adalberto Fernandes

Introduction

This chapter will defend the following claim: Science communication may produce radical trust, characterised by a lack of scientific knowledge. The aim is to better understand what radical trust consists of and what its relationship to knowledge in science communication is. The second claim that will be argued is that this kind of radical trust may (1) result from a rational choice to voluntarily abstain from trying to understand complex science and simply accept what experts have to say; or (2) it can be the result of socioeconomic disadvantage that force people to trust science radically. This means that there are two kinds of radical trust in science, and science communication should be critically aware of what types of radical trust it is contributing to.

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This chapter tries to understand the conditions under which radical trust in science communication could be a good thing and to explore the dangers associated with practices of forced or obscure "trustification". Trust can be "extracted" from people in a process of "trustification – [it] works in a similar way to how consent is extracted from individuals when they click 'accept' on a cookie popup notification" (Benjamin, 2023, p. 1), usually without users knowing what they are putting their trust in. This trust is obligatory if we want to benefit from the results of science and to refuse to trust in this way would amount to cutting ourselves off from a world where being scientifically and technologically savvy is a necessity. Trustification erodes the complexity of placing trust in daunting scientific and technological details by "collapsing complex social relations into a single metric of trust/no trust, risk/benefit" (Benjamin, 2023, p. 143). This obfuscates that trust includes larger political and economic conditions: "We often cannot even tell who, what or where we are expected to place our trust in the power structures and sociotechnical assemblages that surround technology" (Benjamin, 2023, p. 10).

Radical Trust

In one specific radical sense, trust is inherently antithetical to knowledge. This relationship of opposition stems from the circular situation in which trust sometimes seems to be trapped. Radical trust happens when subjects *do not know*, presenting them with the risk of being misled, fooled, injured, and betrayed, *and do not also know* that these nefarious possibilities are on the table. The radical case of trust explored in this chapter is the one in which knowledge plays no part. It is the case of individuals' lack of knowledge about the fact they are trusting the moment they are trusting. This radical version of trust has been proposed by Derrida (1998, pp. 47–48), who considers that, in a world without radical trust, everything would be "programme or proof, predictability or providence, pure knowledge and pure know-how, which is to say annulment of the future". If everything could be known beforehand, without the need to trust in the future that may come with its unexpectedness, the proper possibility of the future would disappear. Only when the future is uncertain can the future be called the future; otherwise, it would be an eternal present or a repetition of the past. To leave open the "futurity" of the future, it is necessary to trust that something unpredictable, not calculable, or known, can happen. Trust is, thus, one important condition for science. Any scientist who does not trust that an experiment can succeed in the future probably will not even try to do it or, indeed, dedicate their entire life to science. On the other hand, scientists who do not believe that an experiment can fail in the future, or that it can disprove a hypothesis, cannot trust that experiment to refute scientific claims. This trust is radical because it cannot be eliminated by any amount of knowledge. If it could, it would signify the end of the future, of novelty, and science.

Besides the place that radical trust has concerning the novelty and futurity of everything, including science, radical trust also has an ethical aspect in Derrida's eyes:

> No discourse or address of the other without the possibility of an elementary promise. Perjury and broken promises require the same possibility. No promise, therefore, without the promise of a confirmation of the yes. This yes will have implied and will always imply the trustworthiness and fidelity of a faith. (…) A chance that entails the greatest risk, even the menace of radical evil. (Derrida, 1998, pp. 47–48)

Radical trust is not reducible to knowledge, including that knowledge of not knowing, because trust is a radical and gratuitous "yes" to what may come in the future (the other, a new meaning, a scientific discovery, etc.). But this yes is not simply an "intentional" decision of affirming trust. Merely to exist, to be a witness of what happens, to listen to someone and to talk to others, is to "unconsciously" trust that those things are possible. We do not simply talk to achieve trust, trust is already working before we engage in communication as its precondition, otherwise, there would be no motive to listen and to talk. We trust that we will be understood by others and will understand them, even before understanding occurs. Without this basic radical trust, scepticism would take over everything. But even to be a sceptic is to believe that scepticism itself is possible. It is to trust that nothing can be trusted, given that a sceptic cannot *know* anything for sure. For Derrida, this radical trust of the "yes" is prior to the possibility of being betrayed or misled. To be misled is a secondary moment that can only stem from the first affirmation of surrendering oneself to that risk. It is not because individuals are intrinsically vulnerable that they need trust to survive, nor do they trust because they know for sure that they will be betrayed (that kind of suspicious *knowledge* would not amount to trust). They trust because their vulnerability cannot be fully known at the moment when they trust, given that knowing that one is at risk is already knowledge that reduces the amount of trust needed to live. That is why we are not immune to failure. It is because it is not possible to know fully that we are trusting the moment we are actually trusting that we are vulnerable to accidents, betrayals, or errors.

The ethical reading of this gratuitous "yes", an affirmative trust that is unrecognisable to itself, points to an openness to the other, even if that also exposes individuals to the dangers that may come by being open. Without this openness, nothing would be possible. Life would be filled by continuous hate, suspicion, and crippling anti-sociability. Anti-sociability would not be even possible without the minimal and imperceptible trust that would expose a person to the risks of sociability. An anti-social subject was social at some point before tasting the shortcomings of sociability. It also means that if trust is not breached, it may not even be possible to know that trust was, in fact, at work. Trust is, thus, closely linked to failure, to treason, but that does not mean that evil and error are looming everywhere. It just means that, for error and evil to happen, trust must first be placed in something or someone. To say that, without evilness and errors, trust would not be known is not the same as claiming that trust does not exist beforehand. To know and to exist are two different things, so trust reigns every time things run smoothly and subjects do not know that to be the case.

What can be summarised from this description of radical trust is that trust has a paradoxical relation to knowledge. Once people know how to trust, once they know that they are trusting, or know that they must trust because they do not know something, they are not trusting radically.

They are, at best, "semi-trusting". Full trust is, according to Derrida, unknowable and cannot be instrumentalised or requested on demand, which calls into question any research and practice of science communication that has as its goal *knowing* how to attain radical trust in science. Such a project would negate itself. If trusting were absolutely within the realm of knowledge, there would be no need for trust. Trusting is a fragile thing when it encounters knowledge, and it seems to be a condition for passing from ignorance to a state of knowledge and back again: Individuals cease to trust once they know, until their knowledge proves to require revision—which in turn reveals that they were trusting all along, given that they did not have knowledge in the first place, only trust. This radical version of trust suggests that we do not know when we are trusting because knowledge is antithetical to trust. To know how to acquire trust is a self-contradictory exercise because it entails knowing something that requires trust in the first place. If there is no trust in the possibility of people obtaining knowledge about trust, trust is not possible. If individuals know that they are trusting, they are no longer *fully* trusting. They are knowing, instead of trusting *completely* or radically. That just means that trust cannot be fully known, and to know how to trust completely is, paradoxically, to not know how to trust radically, because the strongest form of trust appears when there is no full knowledge, a situation which forces one to trust. This is more obvious when people do not even know that they are trusting, something that can only occur a posteriori but not at the moment when trust is being performed. And maybe it could never be known if trust were never breached.

This definition of trust is a challenge for science communication. It is not the version of trust that is at play in the discussions of trust and mistrust in science, given that trust is always associated with some sort of knowledge (e.g., about oneself or scientific institutions), so science communication works with impure or non-radical forms of trust. If science communication is in the business of *knowing* various strategies for obtaining trust and giving people *knowledge* that may make them trust science, it always results in an act of partial trust, not in its fullest and radical version. However, this chapter will try to argue that even this radical definition of trust can be deemed useful to understanding contemporary science communication because it shows the tension between knowledge and trust in a more intense mode. It shows the fragility of trust and how, in this very fragility, trust reveals its utmost strength because it is auto-performative or tautological. *For trust to exist, we have to simply trust*: "if we are very conscious of the fact that we trust one another, or keep talking about it, one will have some reason to wonder if there is really trust between us at all" (Lagerspetz, 1998, p. 29). As expressed by Baier (1986, p. 260), "Trust is akin to a delicate plant […] that might not withstand scrutiny of its foundations, even if those foundations were entirely robust before the scrutiny".

Does Science Communication Promote Radical Trust?

Science communication has become a necessary feature of a healthy democracy, given the role that science has in the life of the citizens, and the amount of political decisions that are based on scientific expertise. Thus, to communicate science is to communicate something necessary to govern oneself and others. This means that a radical trust should have no place in science communication, given that such communication is to ensure that individuals *know* something about science and can make informed decisions in a democracy dependent on scientific knowledge. However, perhaps radical trust may be inevitable in a world that depends on increasingly complex science that cannot be understood by all individuals. Concretely, by making people depend on experts, by appealing to trust in something that most people cannot, completely or even partially, know, science communicators ask people to suspend their self-rationality when evaluating their trust in science. For a democracy to benefit from science, which entails having extended public support for complex science that cannot be fully understood by laypeople, science communicators cannot help people to think for themselves if it is to obtain trust in science. This seems to be thus a case of radical trust, that is, of trust without scientific knowledge. Notice that this kind of radical trust occurs when science is highly complex, the kind of complexity that not even one scientist alone can master and fully comprehend, given its interdisciplinary nature.

This claim seems to contradict the proper reason behind the existence of science communication as a social function that responds to an increasingly complex science-society relationship, which is to make less prominent the knowledge and power gaps that stem from the lack of public engagement and dialogue with an omnipresent science in the way in which democracy is governed. Radical trust is not the main objective of science communication, and certainly not one with which most science communicators and researchers would identify. The reason is that one aim of science communication that makes it politically relevant is its contribution to achieving a certain degree of epistemic balance or knowledge distribution between experts and laypeople, allowing decisions to be as informed as possible and not just based on gratuitous trust. It is, thus, *not* claimed that science communicators *should* actively promote radical trust. Simply trusting without knowledge makes people more vulnerable to epistemic harm. What is claimed here is that, in some situations, science communication is *forced* to produce radical trust, even if it is not a desirable outcome.

Science communication "suspends" the appeals to the rationality of individuals by showing that it is better, in some complex matters, to not think for themselves but let the scientific experts do the thinking for them instead:

> the rational layman will recognize that, in matters about which there is good reason to believe that there is expert opinion, he ought (methodologically) not to make up his own mind. His stance on these matters will – if he is rational – usually be rational deference to the epistemic authority of the expert. (Hardwig, 1985, p. 343)

In this quote, a paradoxical trust is produced by reasoning about suspending reasoning, when the "rational" subject has "good reasons" "not to make up his mind", to be reasonable by not using reason, or to limit the uses of reason to achieve a "rational deference", that is, a reason to obey what cannot be fully understandable.

Given the impossibility of being an expert in more than two or three disciplines, something that occurs only in highly rare cases and is certainly much rarer for most people across the world, given unequal access to education, "we can use a number of fallible proxies for expertise, like social accreditation, or cognitive capacities, but we cannot detect expertise directly" (Martini, 2020, p. 121). This means that expert testimony must be trusted because in some cases it is not possible to understand the expert's reasons and thus to how they were obtained. It is this difference in knowledge access that makes someone an expert. What justifies trusting in an expert? It seems that people justify their trust in experts through non-scientific factors. Goldman (1999, p. 372) suggests that novices may trust indirect evaluations of expertise: (1) the evaluation of the quality of the argumentation presented; (2) the evaluation of the credentials of other experts with established expertise in related scientific fields who can be called upon to assess the authoritativeness of the original expert. While the second option only increases the burden of trusting another supposedly credited expert to scrutinise the good credentials of the first expert, the first option of analysing the argumentative quality of the expert's argumentation, albeit through a layperson's rational judgement, is still not the same as directly knowing what the expert knows. What Goldman (2002, p. 147) means when he refers to the argumentative quality as an indirect marker of expertise can be understood by his division between "esoteric" and "exoteric" statements. Esoteric statements pertain to the realm of expertise and are typically inaccessible to novices, while exoteric statements pertain to what lies outside the domain of expertise and may thus be accessible to novices. For instance, an appeal to common sense or using shared metaphors can be understood as exoteric ways to approximate to esoteric statements. Usually, the layperson is only able to evaluate the exoteric sentences provided by the expert, and it is based on these that the expert constructs a form of argumentative justification which is "indirect" as opposed to "direct" (Goldman, 2002, pp. 147–148). The layperson's ability to acquire direct justification from expert arguments is limited in situations where various matters are esoteric (e.g., some argumentative premises are based on technical skills in using and interpreting scientific instruments). Also, to rationally adhere to well-argued exoteric arguments is not always a warranty for trusting experts: "Skilled debaters and well-coached witnesses can appear better-informed because of their stylistic polish, which is not a true indicator of superior expertise. This makes the proper use of indirect argumentative justification a very delicate matter", and that is why it is a "non-conclusive" signal of expertise for the layperson (Goldman, 2002, p. 148). In summary, the layperson places trust in exoteric statements and indirect argumentative skills concerning an esoteric topic that remains inaccessible to them as a non-expert.

This epistemic dependency of trusting in the esoteric aspects of science, especially when laypeople cannot understand all its inner workings, is not necessarily irrational but may imply a strange rationality to not try to use reason autonomously. Were they to do so, individuals may become engaged in futile and dangerous acts of "epistemic superheroism" (Buzzell & Rini, 2023, p. 912). People who consider themselves epistemic superheroes

> feel a need to draw on their inner power and solve the epistemic problem through sheer force of cognitive will. They hunt for data in obscure journals (despite having no background in medicine) and recalculate the statistics offered by public authorities (despite not understanding sampling correction techniques). (Buzzell & Rini, 2023, p. 910)

In this sense, attempts to persuade people to question science, as those made by science denialists or by corporate or political interests, do not make people dogmatic, but they follow the best Enlightenment tradition of urging people to think for themselves (Buzzell & Rini, 2023, p. 907). They appeal to an important "epistemic virtue: You should be fair, consider the evidence, think for yourself" (Bishop & Trout, 2021, p. 1). It is this boosting of self-trust to think for oneself that correlates with mistrust in science when science is not intelligible to the non-expert. To accuse science of being non-understandable, complex, and esoteric constitutes, for epistemic superheroes, an increase in their critical thinking and trust in their reasoning powers. To remedy this confusion between linking mistrust of science that is too complex to be understood with critical thinking or cognitive autonomy from the experts, "the first rule of avoiding the con is to admit you're vulnerable: Know you can be conned" (Bishop & Trout, 2021, p. 2). People who commit acts of epistemic superheroism believe that they are epistemically infallible, that they can understand all the important scientific facts on their own, and that they do not need to trust experts when matters are too complex to be understood by laypeople. Assuming that we can be wrong in our reasoning, that it has limitations, and that there are experts who know better, is the outcome of having to trust when we realise that it is not possible for us as individuals to know everything. If an individual cannot trust oneself to understand everything and need to trust others in things we cannot comprehend, radical trust seems to lurk in science communication: "admit that you can be conned because you have to trust people. […] The general lesson is that people who fall for cons are just like you" (Bishop & Trout, 2021, p. 2). If an individual believes it is always the others who are wrong, because the others cannot think for themselves and trust experts on scientific issues they cannot verify as laypeople, that individual probably attributes too much self-trust in his abilities to self-reason about complex issues that are only understandable to an expert. The solution for this self-deceiving attitude is, paradoxically, to fight the mind's desire to achieve epistemic autonomy and defer to science, because, in certain complex matters, there is no other choice. For instance, if "the evidence for global warming were easy to sift, we wouldn't need a deference rule. We could figure out the right answers on our own" (Bishop & Trout, 2021, p. 10).

This deference to experts, this abandonment of laypeople's power of reason to understand the scientific evidence, methods, and instruments and place trust in someone who seems to have better exoteric arguments, but whose esoteric arguments non-experts do not have the means to evaluate, seems to violate individuals' epistemic autonomy that should in principle be needed when it comes to evaluating rationally whether to trust an expert or not. However, as Medvecky (2020, p. 88) argues, such deference is both unavoidable and desirable, given that people do not have unlimited epistemic resources; in fact, being epistemically independent could lead to significant epistemic deficiencies. Trusting science does not always stem from knowing more science; instead, it is to trust that individuals' reasoning alone is not trustworthy, that they should trust science even if it is not possible for them to find esoteric reasons to trust it. Trust in science seems to be close to the radical definition of trust because science communication asks people to strip away some of their fundamental resources for thinking for themselves. It asks people to trust that their rationality is limited, which is, paradoxically, necessary if they are to trust others. Therefore, science communication is not simply in the business of making people think for themselves, because this is not always possible in a world where some fields of science have become extremely complex and where information is too abundant to be manageable and understood by individuals alone. That means radical trust sneaks back in when it must be conceded that science communication cannot work

> just by downloading responsibility to the individual agent. Notices and warnings are ineffective if we can't heed them all, and education and encouragement to act with epistemic virtue demand time and attention we can't always offer. We can do little to reduce the extent to which we rely on others for our knowledge. (Buzzell & Rini, 2023, p. 924)

Not all science communication leads to situations of radical trust. What these arguments show is that, sometimes, when science is too complex to be properly understood by non-experts, there is no other option for laypeople but to simply trust. In some cases of highly complex science, there are severely limited options for translating expert knowledge into common knowledge. Were this not the case, the role of the expert in society would cease to make any sense. It is because there is an expert that translation is necessary for non-experts, and it is because it is hard to become an expert that getting a direct translation is not always possible. The inevitability of trust without knowledge, a radical trust, appears when the layperson does not have the means to use reason to evaluate expertise because it is too complex to be understood by a single agent. In those complex cases, science communication may be described as an endeavour that *indicates* to the laypeople who are the trustworthy scientists and scientific institutions that can deal with a certain matter. Accepting this indication is based on trust, given that people cannot do a full background check on experts and institutions and assess whether they are suitable for the complex matter at hand. Obviously, this sort of naked trust can lead people to accept rationally that they must trust in science through the exoteric communicational means available to them.

However, where even exoteric means are not enough—because they are still very hard to understand, or are too far from translating the complex esoteric scientific knowledge—people end up trusting science without knowing that they are radically trusting in it. That is, people trust that they know science, but they are only trusting in the indirect exoteric clues of expertise that may be far removed from the direct esoteric knowledge. They do not only trust that they are in the presence of a scientist capable of dealing with complex matters, but they also trust that the translation from esoteric to exoteric knowledge is faithful, although the criteria for that faithfulness cannot be accessed by them because this would require them to be experts in the first place. With highly complex science, the proper esoteric scientific knowledge is at no point apprehended by laypeople. Thus, if laypeople are made to believe that they trust science because they know it, they are radically trusting in something that can only be fully known by an expert. Again, this argument applies to complex science, one that even an expert cannot understand without the help of scientists from other fields.

It can be claimed that science communication, in cases of complex science, is no different from other non-scientific matters where it is not possible either to obtain direct knowledge, a situation which forces individuals to trust radically. However, the fact that this is no different should be a concern for the field of science communication because this is characterised by dealing with *scientific knowledge*, it is not just a question of indicating which authoritative experts or institutions should be trusted. Science communication should be critical of claims that suggest that science communication *always* makes people trust in science by making them more knowledgeable, since trust cannot be produced simply by more scientific knowledge per se but only through an admission of the limits of reasoning that makes one trust what cannot be understood. A critique is more necessary when those kinds of claims may promote acts of epistemic superheroism (e.g.: "always think for yourself") that can lead to science denial when individuals try to strip away any need to trust in science that cannot be understood. In sum, science communication also promotes radical trust, but that is not necessarily bad. It merely shows how trust in science cannot always be promoted through a greater input of scientific knowledge, and that the need to trust in the unknown is an inevitable part of a healthy expert-layperson relationship.

Political Economy of Trust of Science Communication

Arboledas-Lérida (2023) argues that science communication does not solve a problem by mediating trust in science, but is, in fact, the very symptom of inequalities in the access to scientific knowledge that it contributes to by not questioning why this knowledge imbalance exists in the first place:

> communicating science beyond the narrow circle of scientists is unavoidable for capitalistic societies. Even more so, they need to allot more social total labour time to SC [Science Communication], since the polarisation of the intelligence of production proves to be increasingly dysfunctional in the face of the on-going scientification of social production [...]. Therefore, there is no virtue in the fact that more science is transmitted to the 'public'. (Arboledas-Lérida, 2023, p. 700)

People need science communication because they have been deprived of the means to understand science by themselves; that understanding is accessible mainly to people with resources, for instance, to pursue careers in science. The fact some people do not understand science works in favour of capitalism, which needs an inexpensive workforce to build the world and not just scientists to think about it. Manual labour does not require the same monetary and educational investment in the workforce by businesses as skilled workers do. However, according to Arboledas-Lérida (2023), given the increasing role that science has in innovating capitalist lucrative production, workers too need to know more about science. Considering that they were stripped of the means to understand science autonomously, workers are now the main audiences of science communication. Simplified versions of science are necessary for them to adapt to the evolving technoscientific work environment. They are not receiving scientific knowledge to be emancipated from their precarious work conditions, but merely to make them work better, faster, and cheaper by being attuned to the complexities of technoscientific capitalism. In sum, science communication is justified because there is an unequal distribution of capital that forces some disadvantaged people to be the receivers of mediated forms of science only, rather than being able to understand science itself, and for them to adapt to the fact that science is increasingly present in work life. This situation renders science communication a partner of capitalism by maintaining epistemic inequalities that stem from economic injustices. In Arboledas-Lérida's words, science communication

> would be superfluous were people carrying productive attributes that allowed them to assimilate scientific knowledge in an unmediated form [...]. But the restricted capabilities that capital equips workers with render impossible and even meaningless to them any non-mediated appropriation of objective knowledge. (Arboledas-Lérida, 2023, p. 705)

It means that, according to Arboledas-Lérida (2023), laypeople trust the expert not because the science itself is too complex for them to understand, but because there are economic powers that create the gap between experts and scientists, and so an asymmetrical dependency is promoted by science communication. Science communication should, if Arboledas-Lérida's (2023) argument is taken into its extreme consequences, be terminated because it is simply a way of maintaining unequal epistemic relationships, where some experts know the science and others receive simplified versions—a distinction that stems from unequal economic conditions. Following the consequences of Arboledas-Lérida's (2023) argument, if science communication does not take the steps to make itself unnecessary by making people independent of experts and mediated knowledge, science communication is maintaining unequal power relationships, instead of working towards the autonomy and emancipation of people.

However, there are two important objections to Arboledas-Lérida's (2023) argument. (1) If radical trust is a pervasive force, if it is not possible to achieve a state where trust has no role because people could know science without the need to trust the mediation of science communication, it is hard to see a moment where science communication, even in an egalitarian society, would not be needed. We must remain open to trusting in what comes, in the future, in what cannot be fully known, including new scientific developments. (2) To know science, as opposed to receiving mediated forms of it, should not be something that every person has to strive for. Different trajectories in life, such as being an athlete, an artist, or a philosopher, should not be replaced by a complete dedication to knowing science just because receiving mediated forms makes people dependent on experts. *The fact that some people need to trust in the incomprehensible knowledge of others is also what gives them the possibility of knowing something that others do not know*. Even so, Arboledas-Lérida (2023) points to a crucial need to question the reasons for the existence of science communication and, especially, its economic reasons (Gregory, 2016), which systematically make some people the producers of science and science communication and others, who are usually economically more vulnerable, its receivers. It can be said that science communication may produce *a bad kind* of radical trust when people are forced to trust because of unequal power relations, and not just because their capacity to think autonomously can lead to acts of denial in the form of epistemic superheroism.

Laypeople are "likely to think of experts not simply as people with more academic qualifications, but people in a significantly different class, and potentially with significantly different interests", especially when "access to upper-tier income brackets, as well as the communities that house higher earners and the schools that educate their children, is determined by access to elite-college education" (Bennett, 2022, p. 559) and vice-versa. In the same vein, because

> the biophysical sciences are primarily populated by the socially dominant groups, and science communication promotes science as the good knowledge, this reinforces the view that the dominant social group is also the epistemically dominant group; those in the socially dominant group know better while those in other groups become epistemically inferior (Medvecky & Leach, 2019, p. 109)

To trust science that is too complex to be understood would thus be to accept uncritically all the reasons why some people have to trust scientists without understanding the science, while others have access to and may know the science. In this vein, and adapting an argument from Fuller and Collier (2003, p. 312), any science communication that does not make explicit the economic and political dimensions of science and its diffusion across the social fabric will not contribute to the "emancipation" of laypeople. Science communicators should thus inquire into who bears the cost of knowledge production and mediation, who benefits more from them, and what the economic imbalances between experts, laypeople, industry, and the state are. Making salient the economic dimension of the production and communication of science allows such matters to be open to negotiation between experts and laypeople in a field of dispute that is not just—using Goldman's (2002, p. 147) distinction—esoteric, but one that is exoteric, in the sense that people have a relevant knowledge about their economic difficulties. The science communicator can play a role in articulating how those difficulties correlate positively and negatively with the pursuit of science, and how investments in science and its communication either contribute to and/or fight against economic vulnerability. Scientists and science communicators may have better socioeconomic conditions than those who do not know science and therefore need to trust experts. This should be critically approached in order to understand and oppose the unjust effects of epistemic dependency. Trustworthy science communication will need an *open discussion of the political economy of science and science communication*, where the political and economic powers that make science and science communication possible are openly discussed with laypeople.

Conclusion

The radical form of trust, a trust without knowledge, seems to surface in contemporary science communication, especially in two situations. The first one is the deference to experts, which suggests that we should be wary of our self-reasoning capacities and embrace epistemic humility when faced with complex scientific issues. This is especially important in the case when the open and inquisitive mind may, paradoxically, be counter-productive because placing too much trust in one's reasoning skills can increase the possibility of being wrong, which goes hand in hand with an inability to accept that some things are just too complex to be properly understood. In this case, people live in a world permeated by so much scientific and technological opacity (e.g., the inner workings of a laptop or the engineering of a car) that they do not even see that they are, in fact, trusting science, let alone know in what or whom their trust is being placed. This is a case of radical trust that no science communication could make fully explicit without casting doubt on everything that cannot be known by everyone in a highly esoteric technoscientific society.

The second situation is the deleterious political effects of deferring to experts, highlighted by the fact that the epistemic humility that makes people radically trust in experts of scientific matters too esoteric to be understood has as its basis power imbalances. The fact that capitalism needs a cognitive division of labour, where some less-skilled workers receive only mediated scientific knowledge to keep up with the upgrades of highly technoscientific work environments, while others produce and disseminate science that contributes to those upgrades, should make science communication critically ask what the objectives are of obtaining trust from laypeople. People may be forced to trust radically, i.e., to trust what they cannot know, simply because the resources to question that need to trust were not provided to them. Laypeople may trust because they do not know that their need to trust potentially contributes to the maintenance of unequal power relationships.

The problem is that the virtues of epistemic humility and the inequalities that make some people humbler than others may go hand-in-hand. To distinguish good radical trust from bad radical trust is a hard task. There may be cases in which it would be difficult to know whether laypeople are deferring to an expert because the matter at hand is too complex, or because the important, *and also complex*, issues about the power imbalances between experts, industry, government, the military, and laypeople have not been made explicit, voluntarily or involuntarily, or cannot themselves be easily understood. That scientists and science communicators may have better socioeconomic conditions than those who do not know science and need to trust experts is, nevertheless, something that should be handled critically. Trustworthy science communication will need a *science communication that focuses on the political economy of science and science communication*.

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Science Communication, Languages, and Trust in Small Linguistic Areas: Examples from Finland and Estonia

Sanna Kivimäki and Arko Olesk

Introduction

Collections of national science communication narratives (Gascoigne et al., 2020; Schiele et al., 2012) demonstrate that cultural contexts impact understandings of science and its values, thus shaping the development of science communication and its practices. Science, academic cultures, and their histories form part of a modern social imaginary, a way of imagining collective social life (Taylor et al., 2004). Especially in the case of smaller countries and their historical nation-building narratives, the founding of national universities that function in national language(s) has often reflected a remarkably inclusive turn in their respective histories.

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In contemporary late-modern knowledge societies, science and science communication are central aspects that affect democracy, culture, and identities. To a very high degree, these shape our thinking about almost everything, not least about science and technology (Davies & Horst, 2016). Thus, living in contemporary societies requires experts to explain how members of the public are to cope in a society that is built with and on expert knowledge. The availability of such expertise to the public and trusting in it—understood as readiness to integrate that expertise into discussions and decisions at individual, group, and societal levels—plays a strong role in shaping the democracy and (science) culture of that society.

Languages play a crucial role in all these activities—not only the choice between scientific and lay vocabulary but also the choice of language as such. Regarding the definition of science communication as communicating and *translating* scientific knowledge for society (e.g., Davies & Horst, 2016), surprisingly little attention has been paid to the actual languages used in these practices. Challenges arise in multilingual societies where people work across disciplinary and linguistic barriers and where various languages influence the dynamics of societal communication, raising questions related to identity and trust (Blumczynski & Wilson, 2023).

In this chapter, we ask how considerations and policies related to languages shape science and science communication in two countries with small populations, Estonia and Finland, both of which have a well-established science communication ecosystem and high levels of trust in science. With this theory-focused chapter, we aim to demonstrate how languages, trust, and diversity are intertwined in science communication practices in these areas that constitute small linguistic entities.

Our theoretical background lies in cultural studies, whose theoretical approach to science communication emphasises cultural aspects, such as identities, citizenship, and relations between dominant and subaltern groups (Grossberg et al., 1992). According to this understanding, science communication is about meaning making, understood as creating, translating, and exchanging meanings in societies, where meanings are not necessarily shared and common (Davies & Horst, 2016). In the translation process, whether from scientific discourse to public discourse, from one academic discourse to another, or from one language to another, the interaction of these cultures and norms will shape the linguistic outcome and the construction of societal trust. The cultural studies approach also emphasises interdisciplinarity; in our discussion, we moreover refer to some sociological conceptualisations of trust and to contributions from translation studies.

First, the chapter will introduce language-related aspects of science, science communication, and trust. Second, it will reflect the approaches of two small linguistic areas, Estonia and Finland, to these questions. Third, it will analyse the position of linguistic minorities within their science communication framework and discuss the implications that linguistic choices have on trust.

Language and Trust in Science Communication

Despite the fact that numerous studies have been devoted to it, trust is a slippery concept that tends to remain vague. Research has established a wide range of aspects that influence perceived trustworthiness and different forms of trust, which are constructed in varying ways in different contexts and languages (e.g., Bachmann & Zaheer, 2006; Blöbaum, 2016). The indexicality of languages means that it is difficult to study the meaning of phenomena independently of their context of use (Clifton, 2012). In general, trust and trustworthiness are relational, not all-or-nothing issues, and they may best be conceptualised as a continuum (Jucks et al., 2016).

In this chapter, we rely on understanding trust not as something that we "have" but as something that is made (Clifton, 2012). Thus, trust is more like a verb than a noun, a discursive practice continually constructed, negotiated, accomplished—or not—among different communication partners with different interests and in different settings (Candlin & Crichton, 2013).

Generally, trust is studied on three levels: societal, organisational, and individual (Bachmann & Zaheer, 2006; Blöbaum, 2016). Linguistic questions are pertinent on all these levels. Languages are never "just" languages, but carriers of cultural knowledge, presuppositions about the world, and cultural models, which are taken for granted and are mainly shared by the members of a given society but are also dependent on the language used (Holland & Quinn, 2000 [1987]).

From a sociological point of view, trust is a social mechanism that reduces complexity on the macro level. This may result in democracy and transparent decision making, citizen engagement, and digital solutions. Regarding science communication, for instance, (free) education, trustworthy translations of scholarly books, open science activities, and open memory organisations, such as museums, libraries, and archives, are tools for building a shared foundation of knowledge and social trust.

From an organisational point of view, trust can be divided into two categories: (1) trust within professional communities and (2) outsiders' trust on these professional communities (Yearley, 2000). The second is related to research organisations' external communication and linguistic practices. The first one includes several aspects pertaining to multinational, multicultural, multilingual, and/or multidisciplinary academic teams, where questions concerning the common and shared language may be multifaceted (e.g., Kivimäki, 2020). The number of institutions where professional activities are performed mostly in and through second-language conversations is increasing rapidly (Kurhila, 2006). Several scholars from international business and management studies have noted that language-related issues can significantly impact trust formation in professional teams, damage relationships, give rise to insecurity and distrust, and lead non-native speakers to distrust native speakers because of their superior language skills (e.g., Hwang, 2013; Tenzer et al., 2014). Within conversational organisations, the unequal linguistic positions of the participants, including the public, may shape their respective contributions (Kurhila, 2006).

In individual situations, the grounds for trustworthiness are constructed at the micro-level, depending on domains, sites, and interactions in multilingual societies (Candlin & Crichton, 2013). Scientific arguments and findings need to be translated in a process that involves contextualisation, consideration of purpose, negotiation, probably facing resistance, reacting to feedback, and so on (Blumczynski, 2016). Trust is something that can be constructed by first choosing the right language, then the right words, thus creating—in modern societies—the illusion of intersubjectivity with strangers (Linell & Markova, 2014).

Estonia and Finland: Relevant Background

Estonia and Finland are small countries (1.3 million and 5.5 million people, respectively) situated in the northeast corner of Europe, bordering Russia and separated by the Gulf of Finland. Their languages belong to the Finno-Ugric language group, which is quite distinct from Indo-European languages. The national language is used in all spheres of life, including science, and at all levels of education, but it is rarely spoken outside these countries.

Historically, both languages have suffered from old social-Darwinist ideas and ethnocentric biases that have seen them as lower races and languages. They have struggled to obtain and maintain a public position next to the historically dominant languages (Swedish, German, and Russian). Therefore, raising the profile of the "language of peasants" and proving that it could be used in literature, higher education, and science became a major part of the national awakening movement in the nineteenth century. Both in Estonia and in Finland, language played a big role in the construction of the country as a historic, linguistic, and scientific unit, a separate entity with its own culture (Huumo, 2005). In both countries, a leading role was played by learned societies. Despite intermediate russification campaigns, the nation-building process culminated in national independence, which Finland achieved in 1917 and Estonia in 1918.

Language has remained a strong part of national identity in both countries, shaping both policies and public discourses around science and science communication. During, for example, the struggle to sustain Estonian as the language of science throughout the period of Soviet occupation (1940–1991), frequent Estonian-language communication to the public was a deliberate choice made by many scholars to counter the russification tendencies within society. This kind of linguistic purism has dominated the discourse on language planning also in Finland since the late nineteenth century. This ideology has manifested in the avoidance of foreign words, favouring domestic expressions, and the ideal of using one language at a time (Kalliokoski & Mäntynen, 2022).

Currently, however, both countries find themselves in different situations regarding minority groups. The largest minority groups in Finland and Estonia are Swedes and Russians, respectively (both with approximately 300,000 native speakers). Swedes, historically speaking the cultural elite, have a strong legal position in Finland. For example, Swedish is the second national language, an obligatory subject for all at school, and it is used on all levels of society, including university education at two Swedish-speaking and three bilingual universities.

Estonian historic minorities, German, Swedish, and Jewish, were almost fully exiled or eradicated during World War II. Instead, the Soviet Union facilitated a large Russian-language migrant influx, which made Russian the dominant language in some areas in northern and north-eastern Estonia. The integration of the Russian-language population has been a major issue over the past 30 years, as national policy aims to provide them with sufficient knowledge of the Estonian language. Despite these efforts, communities remain largely segregated. Russian is used in the public sphere, there are Russian-language media (including public TV and radio broadcasting channels), and Russian has remained the primary education language in 14% of the schools in Estonia (with a complete transition to Estonian-language education planned by 2030). However, the Russian language does not have legal status in Estonia.

Trust in Science (Communication)

Recent national Science Barometer surveys have shown a high level of general trust towards science in both countries, i.e., above 85% (Ainsaar et al., 2020; Varpula, 2022). Similar questions from a Eurobarometer survey (European Commission, 2021) have also yielded responses that reveal trusting attitudes towards science and scientists. For statements such as “Science and technology make our lives easier, healthier and more comfortable”, “There should be no limit to what science is allowed to investigate”, or “Decisions about science and technology should be based mainly on the advice of experts", Estonia and Finland rank among the most supportive nations in Europe (European Commission, 2021).

Despite their relative smallness, both countries have highly developed science and education systems, as is evident from a global comparison. Estonia and Finland rank at the top in PISA results (Schleicher, 2019), scientific impact (Allik et al., 2020), innovation (WIPO, 2023), and start-up funding (Bulgakova, 2023). They host a rich science communication ecosystem, including dedicated media outlets, an annual conference for the professional community, science centres and festivals, and academic research (Olesk, 2020). In Estonia and Finland, the designation "science communicators" is understood in a broad sense that includes both university communicators and journalists, as well as museum educators and exhibition designers.

English as a Lingua Franca

The main point of discussion in both countries concerns the relationship between the national language and English. While emphasising the need to support high-level research on national language, science and higher education policies in both Finland and Estonia have also set international collaboration and academic mobility as important performance indicators for higher education and research institutions, thus reinforcing the position of English.

The current overwhelming dominance of English as a lingua franca in the academic domain has an insidious effect on other languages and their use as academic languages. First, market forces ensure that texts written by foreign academics need to be thoroughly domesticated in order to ensure acceptance, which sometimes means the destruction of the entire epistemological infrastructure. Second, English rhetorical patterns are often calqued onto the target language (Bennett, 2013).

One crucial example of this dominance of English is the understanding of "science". In English, "science" usually refers to a much narrower research area than equivalent words do in many other languages, namely to STEM areas (science, technology, engineering, mathematics) and medicine. Estonian and Finnish are among the languages (with, e.g., Swedish and German), where the general concept of academic research also includes AHSS areas (arts, humanities, and social sciences). Thus, "research communication" could be a better English expression to capture the same breadth in what is understood as "science communication" in countries with a wider definition of what the concept of science includes (Davies & Horst, 2016).

Recently, both Finland and Estonia have experienced in-depth public discussions about the dominant status of academic English, initiated by the perception that universities teach too much in English. The arguments for the widespread use of English in science and higher education point to the need to participate in international collaborations (also supported by European-level cooperation schemes and programmes such as ERA, Erasmus, and EHEA) and to attract high-quality students and researchers who can increase the quality of science and teaching (e.g., Rungi, 2022). In Estonia, English-language programmes are also considered partly inevitable, since the resultant smaller numbers of students would not make it economically viable to teach certain subjects in the local language only (e.g., Land, 2022).

The arguments for reducing the dominance of English have included that students have a right to get a university education in their national language (e.g., Svan, 2023), the need to preserve the national language as the language of science (e.g., Seeder, 2020; Valtanen, 2023), and the fact that the contribution of foreign students and researchers to local society tends to be low (Niemi, 2023; Valge, 2022).

Initiatives to support national languages and multilingualism include, for example, the Annual Award (established in 2010) to promote academic writing in the humanities, social sciences, and environmental sciences in Finnish. The Helsinki initiative, adopted in 2019, celebrates multilingualism and science campaigns in all languages. Estonia has a state-funded programme for commissioning Estonian-language university textbooks. In Estonia, foreign students are now being taught mandatory classes on Estonian culture and language, and half of PhD graduates are expected to speak Estonian at an advanced level to increase their chances of staying in Estonia and contributing to society (Haridus- ja teadusministeerium, 2022).

The Small Countries' Dilemma

All of this has been achieved in the context of the small countries' dilemma as described by Ukrainski et al. (2014): If small countries focus on high-level research (involving higher degrees of international cooperation and publishing in English), they may risk having limited local relevance. However, local relevance is expected, according to the third mission of the universities, which requires universities to interact with society and face the social-economic needs of it. Conversely, if they focus too much on local issues, in terms of both their publishing and impact work, they risk international isolation (Ukrainski et al., 2014). Additionally, a small country is rarely able to advance all academic fields equally and is likely to choose its focus areas based on historical legacy, expected international recognition, or national priorities. Such prioritising may run the risk of losing some minor but important research fields.

On the other hand, some aspects of smallness may be favourable for intra-national collaboration. Due to the often more flexible institutional research systems, and often more personal relationships, multidisciplinary working cultures may be easier to construct. It has also been argued that, in smaller countries, the influence of researchers on scientific policy is greater, as policy and communication networks are smaller in scale and characterised by informality (Ukrainski et al., 2014).

In science communication, the small countries' dilemma presents itself in an additional version: For communicating scientists, trust in society is achieved both by displaying competence (Fiske & Dupree, 2014) and by building a relationship with the audience (Borchelt, 2014). The first presumes scientific excellence and therefore fluency in the English-dominated academic world. The second cannot be achieved without knowledge of the local language and the local context.

Public communication is part of the third mission of universities, which, in Finland, is described in the University Act (2009) as one of the main duties of universities, and it holds a central place in the strategic documents of Estonian universities as well (Oone, 2020). As argued, the role of scientists in small countries involves translating scientific knowledge for society and participating in public discussions personally when needed (Ukrainski et al., 2014).

In small countries, science-related media and communication tend to prefer a local framing and thus serve an identity-building role. In an analysis of science-related social media content produced by journalists, organisations, and other science stakeholders, it was found that, in Estonia, the country's name was the most frequently used word in social media posts, whereas in countries such as Italy or the UK, science-related keywords dominated (Davies et al., 2019, p. 94).

One side effect of local framing is that small countries are probably more ready to spawn domestic celebrity scientists (i.e., general commentators), who are willing to comment on a wide variety of issues, regardless of their academic background. This may be due to the media's working routines (Peters, 2014), but the effects are amplified in a small country by the limited number of experts and the close, informal networks.

Some efforts have been made to counter this "general commentator" trend. In Finland, a science communication company arranged a campaign called Alternative to Esko (*Vaihtoehto Eskolle*) in order to get more researchers and specialists—of all genders—involved in the mediated public discussion. "Esko" refers to Professor Emeritus of astronomy Esko Valtaoja, who is a popular speaker and commentator of many other topics in addition to astronomy. If the same researchers are being favoured by the media, the mediated image of "science" can become distorted. This was especially discussed during the COVID-19 pandemic, when some researchers, using their academic titles, commented on COVID-19-related topics outside of their specific fields (Hiilamo, 2022).

With this in mind, the inclusion of non-native-speaking academics may be a challenge. As there are already obstacles to engaging scientists in public communication (see, e.g., Searle, 2013; Rödder, 2012), the lack of a local network and the need to adapt the message to the (unfamiliar) local setting may further limit such scientists' willingness to communicate, unless they receive adequate support. As an example of such support, we mention a *Science Night Live!* event organised at the Finnish Science Centre Heureka, whose aim was to integrate foreign scholars working and living in Finland with Finnish media, decision makers, companies, and third-sector organisations (Niemi, 2023).

Curiously, there is a significant difference between Estonia and Finland in people's perceptions of the communication skills that researchers have. According to the Eurobarometer survey (European Commission, 2021, p. 185), half of Finns believe that scientists are bad at communication, whereas in Estonia, it is only a third. However, in both countries, universities make efforts to provide all researchers with public communication skills and expand their communication departments, mirroring global trends. Thus, there is no need to always concentrate on the same commentators in the media.

National Policies and Debates Consider the Position of Minorities Within the Science Communication Framework

The previous section discussed the tensions created by the role of English as the lingua franca in the international scientific community. This section discusses the situation regarding minority languages within Estonia and Finland, mainly the position of Russian and Swedish in science communication, as well as several smaller minority languages in Finland.

The Finnish national strategy for science communication (2013) emphasises science and knowledge as the foundation of the Finnish welfare state, democracy, trust, and openness, as well as the basis for success in the future. This strategy takes the fragmentation of audiences into consideration, but it does not reflect the increased multilingualism of Finnish society. A similar Estonian strategy (Eesti Teadusagentuur, 2019) makes only one mention of other languages, namely in admitting that Russian-language schools have less access to science education study materials and science communication activities, following which the strategy sets the aim of improving the situation.

Due to its status as a national language, Swedish is used at all levels of Finnish society. Finnish Public Broadcasting Company YLE's television news is produced daily in Finnish, Swedish, Sami, Russian, English, Finnish sign language, and in plain language. Russian is also widely used in Estonian society, and much information is available in Russian, but it cannot be used for official purposes. The Estonian Public Broadcasting Company ERR produces television news in Estonian, Russian, and Estonian sign language.

In Finland, the use of Finnish, Swedish, and English seems to be the most common combination of languages on websites related to science and science communication, such as the science centre Heureka's website. In Estonia, Estonian, Russian, Finnish, and English are common combinations (e.g., on websites of museums). However, universities and government institutions tend only to display information in Estonian and English. This is also the case for the Estonian Research Council, which coordinates national science communication activities in Estonia and awards annual science communication prizes. In a political move to increase incentives to learn Estonian, the Minister of Research and Education, Tõnis Lukas, announced in September 2022 that the non-Estonian (i.e., English and Russian) content on the ministry's website would be reduced to a bare minimum in order to provide incentives for non-Estonians to learn and use Estonian (Tolmats, 2022).

After Russia's 2022 attack on Ukraine, Estonia also decided to move towards ending Russian-language basic education. Since the attack, the role of the Russian language has likewise been debated in Finland, since one argument in this conflict has been the supposed mistreatment of the Russian-speaking population in Ukraine. Some Russian-speaking basic education classes will end. On the other hand, the biggest newspaper, Helsingin Sanomat, started to publish online news in Russian in order to tackle fake news produced by Russian troll factories.

Another event that made these countries pay attention to communication in minority languages was the COVID-19 pandemic. In Estonia, behaviour patterns indicated that the Russian-language community was less informed about the virus and had less trust in the authorities, for example regarding vaccines (Escudero & Maadla, 2023). In Finland, the infection rates were recorded to be higher in newer immigrant communities, specifically among Russian, Somali, Arabic, and Kurdish-speaking people. While a lack of information is one explanation, higher infection rates might also be due to larger family sizes and jobs that demand physical contact with people (Rantavaara, 2020; see also Holmberg et al., 2022). Responding to the infection rates, the most multilingual area in Finland, Helsinki, delivered COVID-19 information in 10 different languages, including Russian, Somali, Arabic, and Chinese. Since the Estonian science barometer showed that trust towards scientists is lower among the Russian-speaking community, the Estonian government also made extra efforts to reach the Russian-language community with up-to-date information, since many people within that community still followed Russian media channels.

Conclusions: Balancing Between Languages, Topics, and Audiences and the Importance of Inclusivity

According to various barometers, the level of public trust in science is high in both Estonia and Finland (Ainsaar et al., 2020; Varpula, 2022). While the survey results are opaque regarding the mechanisms that create this trust, we argue that the processes outlined in this chapter can provide some understanding of the relevance of language choices for trust. Part of this result may be attributed to the successful navigation of small countries' dilemma of balancing the use of different languages to achieve the best relationship with both international and domestic stakeholders.

Most Finnish actors within science (communication) fulfil the minimum criteria: information is delivered in the official national languages, Finnish and Swedish, and in English. However, municipal health authorities are obligated to deliver health information in many different languages and to use interpreters, if needed. Wealthy agents, such as the Kone Foundation, have the resources to act in several languages on their websites, while most of the small foundations, learned societies, and associations involved in science communication have limited resources.

In Estonia, most communication in the field of science and public engagement occurs not only for practical reasons but also to strengthen science's position in society. While the basic needs of other language communities (i.e., mainly the Russian-language community and the international English-language community) are taken care of, their use is restricted mainly out of fear that Estonian is threatened if other languages are used. The Russian-language community gains more attention and empathetic communication during times of crisis but is generally expected to adopt Estonian. In universities, the debates about uses of English and Estonian reflect the balancing act between aspirations towards global impact and safeguarding the national language, which forms a core part of Estonian national identity.

Since Russia's invasion of Ukraine in February 2022, the role of the Russian language has become more tense. For instance, the modern art museum Kiasma in Helsinki, which has all its information texts also in Russian, Chinese, and Japanese, had to explain its language politics to the public and tell visitors that it still wants to include ordinary Russian-speaking people who are not guilty of the war. In addition, in Estonia, we have seen how institutions quickly mobilised the ability to provide information in Ukrainian.

Essential questions in small linguistic areas include whether to teach and publish in small national languages or in English and what languages researchers and science communicators should use when communicating with different audiences and the public. However, the question of what kinds of investments are made in science-based basic education is probably the most crucial one: Who is included and who misses out? How can trust be built from the very beginning?

Science communication practices are tightly bound to general education, information policies, and the costs of basic, second and university education, museums, and libraries. In these two countries, even university education is mainly free and funded by the state (no tuition fees, and student loans are guaranteed by the state).

Therefore, we see that the discussions around English as a language of science and higher education mirror small countries' dilemma of seeking a balance between international relevance and local impact. Following House (2014), we agree with a more compromise position to English as lingua franca, which suggests neither demonising global English nor welcoming it uncritically; English as lingua franca is an open resource for everyone who wants to engage with other persons internationally.

The linguistic variation used in science (communication) is heterogeneous and reflects the rapidly changing societies' varying linguistic practices. Although translation technologies are developing very quickly, communicating science in different languages requires professional human resources. As translation from one language to another, per Juri Lotman's semiotics (Lotman, 1999), is a fertile process for linguistic innovation, monolinguistic science risks reducing the capacity to generate paradigm-changing knowledge. The challenges of mediating specialised knowledge to audiences with different levels of specialisation is an often-overlooked challenge for translators and communicators (Raffo, 2016).

All in all, we aim to encourage a more language-sensitive research agenda on diversity and trust. Even though previous research has established that language and trust are connected, there is still a striking research gap (Tenzer et al., 2014), especially concerning different disciplines and context-specific trust models in multilingual societies.

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13

Understanding Dialogic Relationships in Digital Science Communication

Adán Lerma-Mayer

Introduction

In the post-truth era, social media blur facts and opinions, spreading misinformation and weakening expert credibility. This leads to a rise in false narratives and distrust in science, creating a space where alternative epistemic realities flourish (Hughes et al., 2014; Lewandowsky et al., 2012; McIntyre, 2018). Gounaridis and Newell (2024) note that 15% of the U.S. population denies climate change, with higher rates in certain counties, even in states like California with broad acceptance of climate change. Social media, by promoting content based on user beliefs and political affiliations, exacerbates this divide, creating echo chambers that deepen distrust in external information (Nguyen, 2020).

The rise of epistemically weak contexts, marked by widespread misinformation and belief-based echo chambers, presents a challenge for

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science communication. Addressing groups with beliefs opposed to scientific consensus—such as anti-vaccine, climate change denial, or alternative medicine advocates—requires tailored communication strategies that acknowledge and navigate these complex informational landscapes. This chapter aims to refine science communication theory by examining dialogues in epistemically weak contexts and identifying biases that hinder them. It begins by defining these contexts on social media, suggests dialogic relationships as a solution, and introduces a model addressing cognitive, sociocultural, and technological biases, underscoring identification as the first step to overcoming them.

Epistemically Weak Digital Context

Social media is now a primary platform for discussing scientific topics and controversies such as vaccines and climate change, demonstrating that audiences are not passive recipients but active participants in science communication (Bucchi, 2008; Einsiedel, 2008).

Social media tailor content to individual preferences, fostering echo chambers where personal beliefs may overshadow scientific facts (Kitchens et al., 2020; Pariser, 2012). This shift erodes trust in experts and the epistemic strength of science, with misinformation from various sources, including celebrities, gaining traction over verified scientific knowledge (AlMansour et al., 2014; Hughes et al., 2014; Lewandowsky et al., 2012; Metzger et al., 2010; Pérez Michel, 2013). Such dynamics pose significant challenges to democracy and science communication, as critical discussions on platforms like Instagram, YouTube, and Facebook often proceed without regard to scientific evidence or authoritative expertise (Hara & Sanfilippo, 2016).

Online credibility is often judged by non-epistemic factors such as upvotes or endorsements from like-minded users, not by the authority or expertise of the source (AlMansour et al., 2014; Metzger et al., 2010). People tend to remember agreeable information without recalling its origin, perpetuating misinformation even when corrected (Lewandowsky et al., 2012; Thorson, 2015). Despite easier access to diverse sources, many resist updating their beliefs when presented with new evidence (Dredze et al., 2016; Hannak et al., 2014).

In digital media, science communication faces a challenge where truth and authenticity may come secondary to popularity and ideological alignment, creating a context of epistemic weakness. Digital platforms reward content for its popularity rather than its accuracy, leading to the formation of 'filter bubbles' (Pariser, 2012), where users are exposed primarily to information that confirms their existing beliefs. This phenomenon limits the reach of scientific information, preventing it from engaging diverse audiences effectively.

Nguyen (2020) provides insightful distinctions between 'epistemic bubbles' and 'echo chambers' that could apply to science communication. While both phenomena emerge in weak epistemic contexts, they operate differently. 'Epistemic bubbles' arise from a lack of diverse opinions and may collapse when exposed to new information, whereas 'echo chambers' actively exclude opposing views, fostering deep mistrust of external information. Echo chambers pose a greater challenge than epistemic bubbles as they solidify misinformation by maintaining distrust towards science, media channels, and proponents of scientific evidence. Within these echo chambers, trust is confined to members who reinforce scepticism, making it exceedingly difficult to challenge entrenched beliefs (Nguyen, 2020). Consequently, effective communication of scientific knowledge is hindered as dissenting voices are systematically discredited and marginalised.

Given the challenges in the current information environment, where scientific facts struggle to influence those with entrenched pseudoscientific beliefs, it is critical to evaluate the efficacy of science communication. These challenges raise questions about whether science communication can only reach those within its echo chambers or if it can also address non-scientific beliefs. Exploring ways to engage with diverse echo chambers is essential. Breaking through these barriers may be achievable by promoting dialogic relationships online, focusing on two-way conversations and authentic exchanges of views.

Digital Dialogic Relationships

Trust, essential for successful social interactions, requires confidence in another's actions, such as safeguarding something valuable (Baier, 1986). It becomes an implicit component of a relationship once established (Goldenberg, 2023). For science to be trusted, it must be seen as epistemically reliable (Goldenberg, 2023). However, challenges like science's inherent imperfections (Solomon, 2021), its complex societal relationships (Slater et al., 2019), scandals within the scientific community (Goldenberg, 2023), and influences of geography and religion (Krause et al., 2019) have led to scepticism towards science, evident in vaccine hesitancy and climate change denial. Despite attempts to rebuild trust, such as through science cafes (Ocobock & Hawley, 2020), I suggest that science communication should pursue a different type of relationship to address these concerns, adding to the theoretical understanding of the field.

Dialogue in science communication represents a multifaceted aspect of human interaction, diverging from the traditional deficit model that portrayed audiences as passive recipients of information. Instead, dialogue emphasises the active engagement of the public in scientific discourse, acknowledging the role of the public in knowledge creation, from receiving information to actively participating and co-creating knowledge (Bucchi, 2008; Einsiedel, 2008). However, the idealisation of dialogue has faced criticism, recognising that different communities engage in diverse forms of dialogue and that experts may struggle to maintain a dialogic approach (Felton et al., 2023; Reincke et al., 2020; Zorn et al., 2010). Various conceptualisations of dialogue in science communication exist, including a role in citizen science (Wagenknecht et al., 2021), negotiation and application of scientific findings (Trench, 2008), and conveying facts, concepts, and emotions (Van der Sanden & Meijman, 2008).

I propose a nuanced understanding of dialogue that adopts an interdisciplinary approach, combining insights from humanities scholars and social scientists. This perspective aims to illuminate our dialogic interactions within digital media, offering a comprehensive view on how dialogue unfolds online. By bridging various disciplines, we can better understand the complexities of digital communication and foster more effective dialogues in the realm of digital media.

In the twentieth century, philosophers Martin Buber, Jürgen Habermas, and Hans-Georg Gadamer offered profound insights on dialogue, positioning it as a unique aspect of human interaction. Unlike other forms of communication, they viewed dialogue as an authentic encounter between individuals who fully acknowledge each other's presence. Buber (1937/2017) emphasised dialogue as the cornerstone of human relationships, while Gadamer et al. (1977) saw it as a conduit for human connection and the discovery of truth. Their perspectives elevate the concept of dialogue beyond mere two-way communication, offering a deeper, more philosophical understanding than typically found in science communication literature.

Within the realm of communication, two distinct types of relationships emerge: non-dialogic and dialogic. Non-dialogic relationships, which include pragmatic or instrumental interactions, such as those between teachers and students or within therapeutic contexts, are characterised by underlying power dynamics, pragmatic gains, and the instrumental use of others. These relationships are framed by objectives where interactions serve specific purposes, such as decision-making, utility maximisation, guiding group values, or shaping personal narratives (Buber, 1937/2017; Gadamer et al., 1977). Habermas elaborates on this by introducing teleological, strategic, normative, and dramatic speech acts, which are communicative actions aimed at achieving certain ends, thus objectifying the other in the process. The essence of these interactions is transactional, where one party seeks to gain something from the other, treating the other more as a means to an end rather than as an end in themselves (Habermas & Redondo, 2010).

Contrastingly, these philosophers advocate that dialogue facilitates transformation within the participants, achievable only through tolerance, empathy, and unconditional trust. For Habermas, such an interaction is termed 'communicative action'; for Buber, it's an 'I-Thou' relationship; and for Gadamer, it is referred to as a 'conversation'. These forms of dialogue necessitate truthfulness and a shared language. Buber highlights dialogue as a reflection of our humanity, a space where individuals genuinely meet, understand, and mutually influence each other, acknowledging and respecting the other's presence (Buber, 1937/2017). It is an interpersonal connection that transcends mere exchange, offering new experiences and understandings (Gadamer et al., 1977; Habermas & Redondo, 2010). Dialogue, in this sense, is not just about communication but about enriching the human experience through meaningful interaction.

Twenty-first-century theorists agree on a nuanced view of social media communication. Sally McMillan (2002) outlines four online communication types, with only the fourth, mutual dialogue, embodying true two-way communication, where power is equally shared, allowing both parties equal opportunity to engage and influence the discourse. Similarly, Dominique Wolton (2008) and Vivian Romeu (Sánchez et al., 2012) differentiate between superficial information exchanges and deeper interactions that necessitate overcoming linguistic, political, and cultural barriers. This deeper communication, rooted in coexistence, tolerance, and openness, fosters a genuine dialogue that acknowledges and appreciates the presence of the other, moving beyond mere exchange to embrace intersubjectivity.

Despite varying terminologies across disciplines, theorists converge on distinguishing between two fundamental types of communicative relationships: superficial, non-dialogic ones, driven by pragmatic goals; and dialogic relationships, characterised by mutual respect and an intersubjective process demanding patience, tolerance, respect, and acceptance. Historically, science communication has leaned towards non-dialogic, paternalistic approaches, simplifying information dissemination. This perspective suggests a shift towards prioritising dialogic relationships in science communication, advocating for encounters that foster mutual understanding for effective knowledge transmission. This approach transcends mere two-way communication, emphasising the relational aspect where both participants actively exchange information.

In the post-truth era, where truth and trust are paramount, digital media challenges us to rethink the creation of trustworthy communication and its impact. Dialogic relationships, essential for navigating this landscape, demand an understanding of society's epistemically weak context, where distance from science is common, and information is often judged by popularity and ideological alignment. For science communication, fostering dialogic relationships could address the challenges of this asymmetrical, epistemically weak context. Achieving these relationships begins with identifying biases affecting digital communication. This approach views communication on social media as a complex, interconnected phenomenon, with dialogic participants operating within cognitive, social, cultural, and digital frameworks. A proposed three-pronged model aims to identify barriers to mutual understanding and strategies to transcend the weak epistemic context.

Dialogic Digital Communication Model

Traditional communication models, with their linear progression from sender to message, medium, and receiver, oversimplify the communication process (Sapienza et al., 2015). This perspective fails to capture the complexity and subjectivity inherent in communication, where senders and receivers are influenced by their motives, beliefs, and sociocultural backgrounds, and messages are crafted and interpreted within these diverse contexts (Nisbet & Kotcher, 2009; Scolari, 2008; Wolton, 2008). Recognising the complexity and subjectivity of communication, the proposed model shifts away from linearity, viewing dialogic encounters as multifaceted interactions embedded in a network of simultaneous and interconnected processes. It is a model that underscores the complexity of communication, situating both actors and their messages within a broader, dynamic context to better understand and address the biases that shape digital communication.

This model identifies three biases—cognitive, sociocultural, and technological—that influence digital communication. Rather than insurmountable obstacles, these biases are tendencies that can impact communication if not addressed. The aim is to foster dialogic relationships in science communication by understanding these biases collectively, a perspective not fully explored in previous studies that often focus on individual biases (Fig. 13.1).

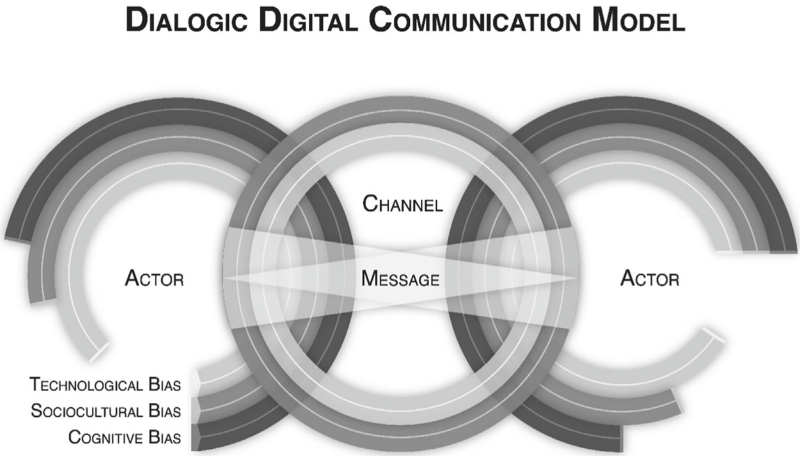

Fig. 13.1 Dialogic digital communication model. Each actor, the channel and the message in the communication process is surrounded by the three identified biases. This shows an interconnected and simultaneous communication flow representing the complexities of digital communication

Cognitive Bias

The cognitive bias in the dialogic relationship model highlights how individual thought processes, influenced by Gastón Bachelard's concept of 'epistemological obstacles' (1948/2000), impact the reception of knowledge. This bias involves the personal framework of beliefs, values, emotions, and information that affects how messages are perceived and understood on social media, influencing how individuals respond to, interpret, and evaluate both scientific and non-scientific communication.

The study of cognitive biases is extensive, and in science communication, this has been widely investigated by M. C. Nisbet. He identifies the need to focus on *framing* communication products of science in frameworks that facilitate understanding by the receiving public. Both physiological and psychological barriers can constrain the process (McIntyre, 2015; Nisbet, 2009; Nisbet & Kotcher, 2009; Nisbet & Mooney, 2007).

Cognitive biases are used to act quickly, access and store information, deal with too much or too little information, or when meaning is not found (Hughes et al., 2014; Knobloch-Westerwick et al., 2015; Metzger et al., 2010; Xue & Phelps, 2004). Traditionally, it is assumed that people are *homo-economicus*: we are aware of our preferences, we choose coherently with our predilections, and we always have a particular objective. In other words, we are rational beings (Thaler & Sunstein, 2009). Prospect theory, developed by Daniel Kahneman and Amos Tversky in 1979, exposed the existence of three heuristics when making decisions: *anchoring, availability,* and *representativeness* (Kahneman, 2013). Subsequently, other biases have been identified such as *confirmation bias* (Allum, 2010; Knobloch-Westerwick et al., 2015; Zollo et al., 2015), the *truth effect* (Lewandowsky et al., 2012), and *backfire effect* (Peter & Koch, 2016). For a more comprehensive understanding of cognitive biases see Buster Benson and John Manoogian's Codex (2016).

Contemporary theories accept that we are not as rational as previously thought. We receive information and decide upon this information via two cognitive systems: *reflexive* and *automatic* (Thaler & Sunstein, 2009). The first one regulates logical decision-making—slow thinking—but this is not our default setting. Regularly, the automatic system is in charge so we do not stop to analyse, question, and investigate the information and messages we emit or receive. We make use of a series of heuristics, which are widely applied to any situation to make quick decisions, although their use is not always the most appropriate (Thaler & Sunstein, 2009). This means that senders and receivers are neither rational entities nor *econs*. Rather, we are *homo sapiens*, subject to avoidance of mental effort and belief in a prodigious memory, even if it constantly fails. Many of our decisions are based on past events. So what we consider as true, logical, or empirical evidence will depend on the epistemological framework that each of us has. When confronted with different frames, communication is likely to suffer.

The cognitive aspect of dialogic relationships focuses on the epistemological traits that either facilitate or hinder dialogue, encompassing individuals' ways of thinking, reasoning, and reacting. This includes the use of fallacious arguments, personal attacks, and emotional responses, which are influenced by what individuals perceive as knowledge. Participants enter discussions with preconceived notions and cognitive processes that shape their engagement. Effective science communication requires an understanding of these cognitive biases, not only in others but also in ourselves, to tailor messages that resonate and facilitate meaningful dialogue.

Sociocultural Bias

Sociocultural contexts significantly influence the communication process, marking sociocultural biases as the second key variable in dialogic interactions. These biases encompass the broader ecosystems and cultural backgrounds of participants (Serrano et al., 1982), affecting how messages are crafted, shared, and interpreted on social media. Factors like ideology, the digital divide, language, and popularity norms can hinder effective communication. Technology, though a sociocultural product itself, is treated as a separate entity in this model due to its unique role in transcending and reshaping cultural and social boundaries.

Much has been studied in fields outside of science communication that should inform the way communicational products and dialogic relationships are fostered. Herbert Blumer, in *Symbolic Interactionism, Perspectives, and Methods* (2009), clearly exposed the sociocultural impact on communication. The meaning of things comes from the interaction with other individuals in a society and culture, determining their reaction to the world. How objects are modified or manipulated depends on an interpretive process. In this sense, meaning and knowledge depend on not only the cognitive framework of the communication actor but also their culture and society (Blumer, 2009). The social and cultural aspects of the communicational act have been widely studied too. In the 1990s, Jesús Martín-Barbero articulated a model of the social and cultural mediations of mass communication, which are also present in social media, such as history, society, geography, politics, family, school, politics, and economy (Domínguez Gutíerrez, 2006; Orozco, 2012; Scolari, 2015).

For discourse analysis, the extra-cognitive aspects that condition communication are conceptualised as the situational context. Tuen van Dijk et al. (2008) proposes that speaking or writing is always a social act. To him, ideology is to the group what heuristics are to the individual: it is the structure that accepts or rejects new information and allows the coordination of social practices. They are actions, goals, norms, values, and social positions that separate one community from another but unite people within each one, giving them a common identity with a social and cultural grammar (van Dijk et al., 2008).

The digital divide, defined as the possibility of having access to networks, electronic inclusion, and technological empowerment due to race, sex, ethnicity, religion, class, age, and other roles or social positioning (Caballero & Contreras, 2013), creates a disparity in knowledge acquisition or a *knowledge gap*: 'who people talk to rather than how often they have discussions may be the factor in determining the acquisition of knowledge' (Su et al., 2014, p. 370). This epistemic gap is exacerbated by government decisions, institutional, business, and media actions (Lewandowsky et al., 2012), as well as the education of digital skills (Van Laer & Van Aelst, 2010).

Aside from the individual's cultural and societal constraints, the rules, values, and affordances of each site create a platform's own culture. On pages like *Wikipedia*, expertise (specialised knowledge) and consensus are highly valued, while, on sites like Twitter or YouTube, popularity rules. From a critical history of social media perspective, José van Dijck (2013) understands that it is necessary to consider external circumstances in social networks to study them. In her research on four digital social media, the author identifies two major ones: techno-cultural constructs and socio-economic structures. For example, the system implemented to increase visibility based on popularity—also known as the *like economy* (Gehl, 2015)—is a central characteristic of connectivity culture on the web. The popularity principle, as José van Dijck calls it, implies that the user decides what information is worth transmitting by what is upvoted or shared by others and not its epistemic strength or certainty (2013).

Language is also considered within the sociocultural bias because it conditions communication success (Curran et al., 2016). On the one hand, the web's *lingua franca* is English since it is used 80% of the time (Beale, 2012). This creates a language divide that prevents all Internet users from accessing all information. On the other hand, each platform can develop its vocabulary and modify the meaning of certain words.

An analysis of Facebook and Twitter has shown how users and platform owners, along with technical programming needs, have modified the language and meaning of words (van Dijck, 2013).

Likewise, the structure of a digital group or topology has an impact on communication (Christakis et al., 2010). The number and distribution of nodes (people) and edges (connections) determine information transmission. According to their research, a network has a high transitivity if there are many connections between users, allowing information to transit quickly and widely. Nonetheless, modules can be formed within a network, and this prevents the circulation of information from becoming polarised. In other words, the groups' structure creates echo chambers.

Additionally, the message is not neutral. Graciela Reyes (1995/2007) explains the complexity of understanding any message in two steps: first, it is complicated at an explicit level, since you have to decipher its theme, vocabulary, sender, and the circumstances in which it was issued. Then, you have to interpret the implicit part of the message. The meaning of the messages, which is negotiable, falls on the person, not on the facts, opinions, tastes, or values they are trying to communicate.

As Blumer (2009) explains, social interaction is a formative process of human behaviour because the work of one actor affects that of another. It is a situation of constant feedback and, to comprehend it, it is necessary to understand the world of the participants in the dialogic process: a polarised group will give a particular meaning to a message, which might differ greatly from what other groups understand.

For science communication, addressing sociocultural biases means recognising the diverse non-cognitive contexts individuals navigate online, including language barriers, ideological differences, digital divides, knowledge gaps, and the influence of popularity. To foster digital dialogic relationships, it is essential for science communication to understand and mitigate these biases in its approaches. Without such efforts, communication is likely to resonate only within existing social and cultural networks, failing to engage those outside them in meaningful dialogue.

Technological Bias

The model includes a third critical variable: technological bias, shaped by the algorithms, interfaces, protocols, and default settings of digital platforms. Similar to how urban architecture influences city life, digital architecture impacts online dialogue, user interactions, and the culture of digital spaces. The design and functionality of each social media platform, influenced by the intentions of its creators and its users' behaviours, along with its explicit or implicit rules, condition the nature and dynamics of digital communication.

Digital architecture is framed by the cognitive and sociocultural biases of the engineers and owners of digital networks. However, once they are released to the users, these algorithms, protocols, and designs determine the communication processes that occur within them.

Carlos Scolari (2004) carried out an extensive study on the interfaces of different Internet sites and how, although they seem neutral, they have a generally implicit theoretical weight that conditions the information that is presented. There are two types of interfaces on a platform: external and internal. The first is the visible one with which the common user interacts directly. The second is hidden and only the owners have access to it. From the internal interface, changes are made to the external one, conditioning communication acts (van Dijck, 2013). For example, a news site decides whether interaction with other users is allowed, whether users are able to remain anonymous or need to register, or whether payment is required to access or share information, but also whether verifiable and factual sources are required to comment or publish. Digital platform interfaces are also closely related to the principle of popularity, previously discussed: a digital platform can be designed to ostentatiously display the most popular videos, the most retransmitted messages, the comments with the most likes, or the most factually correct content. This has consequences on the type of information that users receive and the type of relationships that can be formed.

Apart from the interface, there are algorithms and protocols. The first is a list of instructions defined to calculate functions (van Dijck, 2013). They are the steps written in code that a programme must follow to execute a certain action, such as solving a problem or doing a calculation.

Protocols are a group of rules that force users to act in a certain way and intervene in communication. Both are usually obscured from the analysis since they tend to be proprietary information, empowering business owners and presenting a challenge to those dabbling in their research. However, something that contemporary algorithms have in common is a predilection for *active* users (those who comment, share, and upload information) above *lurkers*. Each platform uses different algorithms that must be comprehended as best as possible to understand how dialogue can happen (van Dijck, 2013).

The *default* design on a platform also has an impact on what can be communicated. When we enter a site for the first time, we find everything we can do ordered in a certain way, a scheme decided by the owner together with a group of experts to facilitate certain behaviours that are sought to be reinforced. For example, Facebook establishes by default that posts are sent to all contacts, instead of just some friends. Although the design of the sites is constantly changing, the affordances rarely change.

A private company's site is generally established to increase the visibility of advertising and, therefore, monetary gains, not the interconnectivity or sociability of users, as they often claim (van Dijck, 2013). Business and technical decisions are involved in the design of the interfaces, the algorithms, and the protocols, conditioning dialogue on social media. To create science communication products on the web, practitioners need to be aware of these limitations and how they condition all relationships that are formed within. The 'culture of connectivity', as José van Dijck (2013) has named it, favours economic gains over social and dialogical participation.

While the implications and possible practical suggestions of the dialogic digital communication model go beyond the scope if this chapter, this model serves as an initial step in addressing biases and fostering dialogic relationships in communication. However, adopting a dialogic approach would require prioritising one-on-one interactions over mass communication strategies, which would require significant time investment without guaranteed outcomes. Moreover, successful dialogue requires mutual willingness to engage, a challenge within echo chambers where trust and openness are scarce. Thus, initiating dialogue on social media involves more than mere presence; it requires effort to build trust and relationships.

Emphasising the importance of this approach, especially in combating science denialism and pseudoscience, it is clear that effective science communication goes beyond simple message transmission. It necessitates a deeper connection between communicators, recognising the shared humanity that underlies dialogic interactions. This principle guides towards more meaningful science communication, where understanding and mutual respect are as crucial as the information exchanged.

Conclusion

In the current post-truth and disinformation landscape, social media platforms enable the rapid spread of unverified information, fostering environments where alternative facts thrive, insulated by echo chambers. This weak epistemic foundation undermines trust in experts and complicates persuasive communication on contentious topics like pseudoscience. Science communication, constrained by adherence to facts and truth, finds itself at a disadvantage against psychologically appealing, but factually unsupported, messages.

Addressing these challenges necessitates the cultivation of dialogic relationships, which involves recognising and navigating cognitive, sociocultural, and technological biases. Cognitive biases affect how information is received and interpreted, based on individual beliefs and emotions. Sociocultural biases—including ideologies, language barriers, and digital divides—shape community formation and information flow online. Technological biases, embedded in social media algorithms and interfaces, influence how information is presented and consumed.

Identifying these biases is a critical step towards establishing dialogic relationships in science communication. By understanding the constraints of digital communication, including the sociocultural and technological frameworks that shape interactions, strategies can be developed to promote effective dialogue. This involves creating communication products that are accessible and resonate within diverse sociocultural contexts and critically assessing the technological infrastructures that guide online discourse.

As we consider the feasibility of meaningful communication on social media, adopting an interdisciplinary approach to address these digital communication complexities becomes crucial. The proposed model aims to offer a comprehensive understanding of digital communication challenges and opportunities, advocating for a nuanced approach to science communication in the digital age.

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14

Portraying Pesticides: An Application of Construal-Level Theory in Online News Coverage of Glyphosate

Claire Roney and Edoardo Anziano

Introduction

In 2015, the International Agency for Research on Cancer determined that the herbicide glyphosate, found in the ubiquitous Monsanto weed-killer Roundup, was "probably carcinogenic to humans" (FAO, 2015, p. 14). Two years later, a series of internal documents dubbed the "Monsanto Papers", which revealed that the company had manipulated scientific research to ignore the carcinogenic effects of its glyphosate-based products, including Roundup (Hakim, 2017; McHenry, 2018; U.S. Right to Know, 2022). Subsequent research detected traces of the herbicide in humans (e.g. Schütze et al., 2021), animals (e.g. Faria et al., 2021; Motta et al., 2018), and food (e.g. Bøhn et al., 2014). Journalistic investigations into the side effects of pesticides in Europe documented

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that glyphosate had negatively impacted farmers' health, even when using personal protective equipment (Horel & Foucart, 2017; Neslen, 2022). Despite mounting evidence, European authorities have decided to maintain its current hazard classification (European Chemical Agency, 2022) and continue to permit its use in the environment until the end of 2033 (European Commission, 2023).

The news is a primary source of information to understanding the (un)seen environmental forces shaping daily existence (Boykoff, 2009) and is crucial to guiding societal perceptions of science (Hmielowski et al., 2014). Journalism has the power to inspire societal action towards environmental sustainability and justice (Bloodhart et al., 2015; Olesen, 2008), but the media have been criticised for politicising and polarising science through conflicting frames that exacerbate societal trust in science (Chinn et al., 2020; Hart & Feldman, 2014). Additionally, societal trust in science is in part dependent on trust in the communication itself (Weingart & Guenther, 2016), and studies show that society desires certainties from journalists reporting science news despite its inherent uncertainties (Maier et al., 2016; Post et al., 2021). This poses a unique challenge to how journalists cover topics like the carcinogenic effects of a categorised non-carcinogen. Trust in science is an evolving and growing issue in the literature. Global societies maintain high levels of trust in science (Cologna et al., 2024), but scholars worry that conflicting portrayals of science are contributing to attitudinal polarisation over salient issues like climate change (Boykoff, 2007). This prompts the importance of examining how coverage of debated health and environmental consequences is delivered to audiences through popular mediums—namely, digital news articles (Newman et al., 2022).

This chapter examines Trope and Libermans' (2010) construal-level theory (CLT) of psychological distance and applies it to French and German online news coverage of the herbicide glyphosate. CLT posits that construals influence perceptions and behaviours such that higher levels of construals indicate greater abstractness and can increase perceived distance, whereas lower construals indicate greater concreteness creating proximity. This is exemplified spatially when news coverage asserts wildfires are affecting Europe (abstract; Snippe & Romano, 2023), versus France (more concrete; EurActiv, 2022), then southwest

France (more concrete; Bauer-Babef, 2022). Climate change communication and CLT research, for example, find that lowering psychological distance increases intention towards self-efficacy and support of pro-environmental policies among respondents (e.g. Chu, 2022; Chu & Yang, 2019; Duan & Bombara, 2022; Singh et al., 2017).

Such findings indicate that the construals employed in news articles about glyphosate affect how audiences perceive health risks and contamination of their environment. However, not all media is trusted equally (Weingart & Guenther, 2016), and conflicting portrayals in pluralistic media environments likely influence behavioural intentions towards personal use of the herbicide. Additionally, Covid-19 research suggests news coverage with low sensationalism of high-risk health issues fails to alert audiences to developing dangers (Mach et al., 2021). In line with CLT, construals across the four dimensions that are low, or a combination of high and low construals that balance out, may fail to alert readers to the dangers of glyphosate. Focusing on the European context, this exploratory study inspects online news coverage about glyphosate from international outlets in Germany and France as countries that use similar amounts of pesticides (FAO, 2020), but are comparatively different. France has a legal association to support pesticides victims (Phyto-Victimes, n.d.), and it maintains the highest number of legal cases concerning pesticides in the world (234) of which 60 are connected to glyphosate (Justice Pesticides, n.d.). Examining headlines and images of articles as salient elements of a digital news story (Bucher & Schumacher, 2006), this exploratory study methodologically contributes an adaptation of Duan and colleagues' (2017) CLT scale of images to examine both headlines and images to analyse the construals applied in glyphosate news coverage. The question being investigated: To what extent were construals applied in French and German online news coverage of the herbicide glyphosate? The literature consists broadly of climate change communication studies, and this research adds nuance by examining a niche health and environmental news topic.

Literature Review

CLT describes that the further an object is from a direct experience, the more abstract it is and the greater the level of construal it retains, and vice versa, in a bidirectional relationship (Trope & Liberman, 2010). These construals can be measured in four dimensions: time, space, social, and hypotheticality (Trope & Liberman, 2010). Previous research on environmental news coverage is limited, potentially due to the lack of such coverage existing in the past as news organisations prioritised other issues, like conflict (Djerf-Pierre, 2012; Harcup & O'Neill, 2001). Environmental events also progress at a crawl (Boykoff, 2007), and while journalists are proficient in tracking the proliferation of consequences, the reporting has been found to lack deeper connections to relevant social, political, and cultural issues—vital to garnering societal awareness (Callison, 2021; Hutchison, 2012).

Contemporary research has prioritised climate change communication, experimenting with psychological distance and finding support for Trope and Lieberman's (2010) bidirectional assertion: abstract messaging leads to abstract mental construals (Chu, 2022), and concrete construals shorten perceived temporal, spatial, and social distances to climate change that increase behavioural intention towards mitigation (Duan et al., 2022). This may be in part due to emotional mechanisms—where lowering psychological distance evokes concrete emotions, and greater psychological distance increases abstract emotions—that impact intent towards climate change mitigation and policy support (Chu & Yang, 2019). Such findings have led to recommendations that policymakers concretise their communication to gather societal support for sustainable policies (Singh et al., 2017). However, some scholars postulate that CLT studies do not consistently align with bidirectional findings between construals and behaviour (McDonald et al., 2015; Schuldt et al., 2018), contending that "simply proximising" will not increase engagement with climate change (Brügger et al., 2016, p. 125).

Examinations of construals in climate change news coverage concur that reducing psychological distance has utility in promoting sustainable behaviours and increasing belief in climate change (Bloodhart et al., 2015) but advance that there is merit in communicating distant impacts as well (Spence et al., 2012). Perspectives of construals are considered to be egocentric (Liberman & Förster, 2009; Trope & Liberman, 2010), but research has also found that farmers use a mixture of non/egocentric construals to inform decisions towards mitigation and adaptation towards climate change (Haden et al., 2012; Schattman et al., 2021). It is this mixture that may offer the most effective means of communicating about scientific phenomena, as it mirrors real mental processes that reflect the plasticity of climate change (Hochachka, 2019). However, Mach and colleagues (2021) suggest that low sensationalism of news stories can falsely create impressions of low risk in health hazardous situations such as the Covid-19 pandemic. Journalists may alter their representations of science according to news values and the partisan agenda of newsrooms (see Ahern & Formentin, 2016), further dividing trust in science owing to trust in media (Weingart & Guenther, 2016).

Many CLT and communication studies have examined construals in imagery alone, as elements that shape perceptions of saliency, efficacy, and belief (O'Neill, 2013; O'Neill et al., 2013). Visuals of environmental consequences have been notoriously tricky to render (Boykoff, 2007; Dahl & Fløttum, 2017), with many phenomena progressing in ways that are invisible to the naked eye that suggest the imagery is inherently abstract (i.e. greenhouse gases; see DiFrancesco & Young, 2011). Climate change visuals, by contrast, are iconic (O'Neill & Nicholson-Cole, 2009). Climate change has been visualised largely concretely (Duan et al., 2017; Smith & Joffe, 2009), but studies find that the visuals rarely promote self-efficacy or saliency (Metag et al., 2016; O'Neill et al., 2013). This may be due to emotional interactions with concrete imagery that encourage sustainable behaviours through concrete, negative emotions for visually literate groups (Duan & Bombara, 2022) but may backfire for conservative or sceptical groups (Chapman et al., 2016; Duan et al., 2021; O'Neill & Nicholson-Cole, 2009).

While contemporary CLT research has focused on climate change visual and textual communication (e.g. Duan & Bombara, 2022; Feldman & Hart, 2018), studies have rarely inquired into the construals of visuals and text together, such as found in the headlines and images of digital news articles. The image and headline of a news article constitute the most salient elements of that article, acting as a cue to the reader of its overall message (Bucher & Schumacher, 2006). When aligned, images and text can inspire similar emotions across the ideological spectrum (Feldman & Hart, 2018), but if disjointed, they can signal different narrative directions that clash with audiences' meaning-making processes (Dahl & Fløttum, 2017; DiFrancesco & Young, 2011). Considering the theoretical context of CLT, image-language dissonance of digital news articles may present conflicting construals to viewers that influence their trust in the information, health risk perspectives, and later behaviours, warranting this empirical probe.

Data and Method

This study conducted a quantitative content analysis of construal levels in glyphosate-related news article images and headlines from French and German outlets. Online news remains a primary source of information in France and Germany (Newman et al., 2022) and although a non-native language, articles in English are accessed by local populations (European Commission, 2012). As an issue debated at the EU level, it is important to analyse international coverage accessible to all Europeans. Three news outlets were chosen per country for their prominence, digital platforms, and English-language accessibility through convenience sampling. For France, the highest-circulated newspaper *LeMonde* (Statista, n.d.), state-owned broadcaster France24, and *TheLocal.fr* were selected. For Germany, the widely-circulated magazine *Der Spiegel* (Britannica, n.d.), broadcaster Deutsche Welle (DW), and *TheLocal.de* were chosen. Online news articles were the sampling units, aggregated from the above newspapers using the key word "glyphosate" and a Google search engine operator between 2017, when the Monsanto Papers were released, and 2021, the last available calendar year of coverage.

Data collection yielded 198 articles: 42 from French outlets and 156 from German outlets. Articles served as the units of data collection, and images and headlines in the articles as the units of analysis. The measurement tool was developed for text and still images. We assume that videos are different and untested criteria would apply to videos that are outside the scope of this study. Thus, articles without pictures or containing videos were removed. To ensure relevance to the topic of study, article headlines that did not include one or more of the following keywords were removed: "pesticide", "glyphosate", "weedkiller", "herbicide", "Monsanto", and "Roundup". Additionally, articles that were not written in English, published by alternative outlets, or labelled as opinion articles were discarded. The final sample resulted in a total of 42 articles: 10 articles in the French sample ($n_{\text{France24}} = 8$; $n_{\text{LocalFR}} = 2$); 32 in the German sample ($n_{\text{DeutscheWelle}} = 27$; $n_{\text{DerSpiegel}} = 3$; $n_{\text{LocalDE}} = 2$). Most of the French and German articles were published in 2019 ($n_{\text{France}} = 6$; $n_{\text{Germany}} = 13$), followed by 2018 ($n_{\text{France}} = 3$; $n_{\text{Germany}} = 10$). The French sample contained one article from 2021, but not 2017 or 2020. Conversely, the German sample contained articles from 2017 ($n = 4$) and 2020 ($n = 5$), but not 2021.

The researchers manually coded construal levels in article images, then headlines, adapting a scale developed by Duan et al. (2017) to assess the construal levels in images. Eleven categorical variables assessed the attributes and construal levels in images. Two categorical variables captured the image's source (i.e. journalist; newspaper; wire service; stock image; company) and theme (i.e. human; nature; industry; human and nature; nature and industry; human and industry; nature, human, and industry) (Duan et al., 2017). Nine categorical variables examined the construal levels in images. Three of the nine variables related to the images' attributes, whether the image was: photograph (+1) or infographic (−1); colour (+1) versus black-and-white (−1); depicting a consequence or impact (+1) increasing saliency, or a cause (−1) (O'Neill et al., 2013). The remaining six variables measured construals along the four dimensions in both headlines and images; however, the two attribute variables solely relevant to images (i.e. photograph versus non-photograph, colour versus black-and-white) were removed for headlines. The temporal dimension was measured through two variables: presenting the topic as an incident (+1) (e.g. "France bans dozens of glyphosate weedkillers"), or constant and stable (−1) (e.g. "Farming without glyphosate") (Trope & Liberman, 2010); and the presence (+1) or absence (0) of time. The spatial dimension was indicated by the presence (+1) or absence (0) of a location (Trope & Liberman, 2010). The social dimension was measured first through the presence (+1) or absence

(0) of names; second, in portraying ordinary people (+1) (e.g. local vintner opposed to pesticides), who might strengthen viewers' connections to the topic (Duan et al., 2017), versus public figures (−1), who may undermine saliency by making the story about the individual rather than the topic (O'Neill et al., 2013). Not being from the contexts of study, if the authors were unsure of an individual's status as ordinary or public, the researchers relied on photo captions as a contextual clue. A zero was given for the absence of humans altogether. Lastly, the hypothetical dimension was considered concrete if a reality was presented (+1) (e.g. a farmer in the field), or abstract if depicting a prediction (−1) (e.g. graphic of drones spraying pesticides) (Trope & Liberman, 2010).

Following coding, the researchers created three new quantitative variables: a total image score from summing the image categorical variables together; a total headline score summing the headline categorical variables; and an overall article score consisting of the sum of the image and headline scores. Images could score between −6 (very abstract) and + 9 (very concrete) with a neutral value of + 1.5 (neutral). Headlines could score between −4 (very abstract) and + 7 (very concrete), or + 1.5 (neutral). Articles had the possibility of scoring −10 (very abstract) to + 16 (very concrete), with a neutral score of + 3. The following section presents results from statistical analyses conducted with SPSS that describe the data and explore potential relationships between images and headlines in articles from the respective counties, as well as meaningful differences between coverage in the two samples.

Analyses

Beginning with the French image sample ($N = 10$), visuals tended to be more concrete than abstract on average across the four dimensions ($M = 2.70$, $SD = 1.06$). Most images were sourced through a wire service ($n = 9$) with the remaining produced by the outlet ($n = 1$). Many of the images portrayed humans ($n = 4$), industry ($n = 3$), or a mixture of nature, humans, and industry ($n = 2$), but rarely nature itself ($n = 1$). All French images were photographs in colour. Images often portrayed a cause ($n = 6$) versus an impact ($n = 1$), with 3 images depicting neither.

Time was absent from all images and interpreted as stable ($n = 8$). In the spatial dimension, a location was presented once. Names were also rarely observed ($n = 3$) in the social dimension, but when showcasing humans, ordinary individuals were favoured ($n = 5$), or not depicted at all ($n = 4$). All French images depicted reality.

The average French headline ($N = 10$) leaned towards concreteness across the four dimensions ($M = 4.80$, $SD = 1.69$). Headlines more often described an impact ($n = 9$). The temporal dimension was described incidentally ($n = 9$), but time was rarely presented ($n = 2$). Locations were frequently mentioned in headlines ($n = 9$), as were names ($n = 9$), but humans were as likely to be described ($n = 4$) as not mentioned ($n = 4$). In congruence with French sample images, all French article headlines indicated a reality.

Summing the image and headline construal scores, the French articles ($N = 10$) scored moderately concretely on average ($M = 7.50$, $SD = 2.27$) with an equal number of articles ($n = 2$) scoring an 8, 9, or 10, respectively. A Pearson's R correlation test assessed the relationship between the construal levels in French sample images and headlines, finding a weak, positive, and non-significant relationship ($r = 0.34$, $p = 0.343$, CI [−0.37, 0.80]). The lack of statistical significance may be due, in part, to the small number of cases in the French sample ($N = 10$).

The German sample images ($N = 32$) leaned towards concreteness as well, but less so compared to French image construal scores ($M = 2.22$, $SD = 1.31$), which may be due to the higher number of cases in the German sample. The images were similarly sourced from wire services (87.5%), with 6.3% sourced from a company, and 3.1% respectively by a journalist or a stock image. German sample images were themed around industry (46.9%), nature and industry (21.9%), or featured a blend of nature, humans, and industry (15.6%). All of the images were in colour, and almost all were photographs (93.8%). Similar to the French sample, the majority of German images depicted a cause (65.6%). Images did not present time, but depicted a stable temporal scene (87.5%). Locations were also absent from all of the images, but names were noticeably present (46.9%). Humans were not depicted in many of the images (71.9%), but when they were, individuals were ordinary people (28.1%). Most images depicted reality (93.8%), but 6.3% presented a prediction.

The German sample headlines ($N = 32$) also had a higher average of concreteness ($M = 3.50$, $SD = 1.59$). The headlines described impacts (96.9%), and although time was absent (93.8%), headlines often were reported as incidents (90.6%). Locations were more likely to be absent (56.3%). Names were mentioned often in headlines (78.1%), but humans were not (81.3%). When individuals were named, public individuals were more likely to be described (12.5%) than ordinary individuals (6.3%). While 75% of the German sample headlines expressed reality, 25% relayed a prediction.

Overall, German articles ($N = 32$) scored somewhat concretely on average ($M = 5.72$, $SD = 2.25$), with 25% of articles scoring a 6 and 25% a 7. A Pearson's R correlation test found a very weak, positive, and statistically non-significant relationship between the construals applied in German images and German headlines ($r = 0.19$, $p = 0.288$, CI [-0.17, 0.51]), also potentially due to its small sample size.

To test for meaningful differences between the countries and their construal scores, Welch's t-tests of unequal variances were implemented to account for their different sample sizes ($N_{\text{France}} = 10$; $N_{\text{Germany}} = 32$). The first test found that on average French images were not significantly different ($M = 2.70$, $SD = 1.06$) to German images ($M = 2.22$, $SD = 1.31$) ($t(18.48) = 1.18$, $p = 0.994$, CI [−0.37, 1.34]). A subsequent Welch's t-test of French and German headlines found that French headlines were also not significantly different on average ($M = 4.80$, $SD = 1.69$) to German headlines ($M = 3.50$, $SD = 1.59$) ($t(14.35) = 2.16$, $p = 0.866$, CI [0.01, 2.59]). A final Welch's t-test of French and German article scores did not find that French articles were significantly different ($M = 7.50$, $SD = 2.273$) from German articles on average ($M = 5.72$, $SD = 2.25$) ($t(14.930) = 2.169$, $p = 0.819$, CI [0.03, 3.53]). The lack of statistically significant findings may be a result of the uneven distributions of German and French cases, despite attempting to account for it by employing the test of choice.

Discussion

This exploratory study conducted a quantitative content analysis of construal levels in digital news articles about glyphosate from international French and German outlets to explore how glyphosate was conveyed to broader audiences amidst its approved use after findings of its carcinogenic properties. Collectively, the average construal scores of sample images ($\bar{x} = 2.33$) and headlines ($\bar{x} = 3.81$) were found as somewhat concrete across the four dimensions. Concrete indicators were often absent in both images and headlines, particularly in the temporal, spatial, and social dimensions, that may have improved the salience of and engagement with the topic among audiences (Trope & Liberman, 2010) and indicated the greater health risk and dangers of glyphosate. Additionally, headlines and images were found to be mismatched in their construals, leading the authors to several ruminations that are shared below and interpreted with caution due to the convenience sample, low external validity, and statistically non-significant findings. The researchers attempted to bolster the design and internal validity of the study by drawing from relevant literature (e.g. Chapman et al., 2016; Duan et al., 2017; O'Neill et al., 2013; Trope & Liberman, 2010) and advance suggestions for future research, as given below, to improve on its limitations.

Meaningful differences were not found between the construal-level articles' scores from the two countries ($p = 0.819$). While France reported higher average concreteness in articles compared to Germany ($M_{\text{France}} = 7.50$, $M_{\text{Germany}} = 5.72$), this may have resulted from the French sample's lower sample size, skewing the results ($N_{\text{France}} = 10$, $N_{\text{Germany}} = 32$). Interesting nuances appeared in the mixture of construals in headlines and images where concreteness was indicated in similar dimensions, but for different variables. Considering the temporal and spatial dimensions as an example, French and German images never depicted times, and rarely locations (2.4%), but headlines frequently referenced times (9.5%) and locations (54.8%). Experimental studies find strong support for these dimensions that share a bidirectional relationship with salience and perceived efficacy, suggesting that this sample's readers may have been disengaged by the frequent absence of information overall, but most especially in images (Chu, 2022; Liberman et al., 2007). Moreover, in the social dimension, individuals appeared in 64.3% of images, but headlines rarely referenced people (28.6%). Duan and colleagues (2017) proffer that audiences feel more connected to human subjects in imagery, and ordinary people may increase trust levels across socio-political divides in coverage of uncertain topics (Chapman et al., 2016). With greater editorial choice in selecting visuals for a story (DiFrancesco & Young, 2011), it is striking that individuals were missing from more than a third of sample images, when consumers are part-and-parcel of pesticide use (35.7%), paving space for further research into editorial choices behind imagery in environmental news.

The mixed construals seem to indicate a missed opportunity for journalists to concretise glyphosate with readers, and by doing so, bring their attention to its dangers. Alternatively, the construal mixture may speak more simply to the varying practical capacities of what an image is able to capture versus what a headline can express. Hansen (1994) highlights that specialist journalists, as opposed to mainstream reporters, have different considerations of their audiences and may be more attuned to nuances of concrete and abstract information. For example, time was absent and viewed as stable in all images ($N = 42$), but digital images are static (i.e. stable) unless set in motion (e.g. GIF). Compared to images, headlines more often described coverage in terms of an incident (90.5%), suggesting that where one element lacked concreteness, the other supplied it, performing a balancing act. Future research should delve into these balancing acts to understand how journalists' perceptions of scientific topics translate to construals applied in subsequent coverage. Additionally, experimental research should seek to explain how interpretations of scientific information and trust in science are influenced by construals when accounting for predispositions. Motivated reasoning research in climate change highlights that individuals interpret new scientific information according to prior beliefs that may deepen divisions over trust in science (Kahan, 2017). Trust in science also appears to interact with overarching trust in institutions and general political satisfaction, shaping expectations of journalists that translate to expectations in performance (Riedl & Eberl, 2022).

Conclusion

How journalists cover health and environmental consequences shapes readers' interpretation of its importance, but scientists worry that journalists are not communicating about science credibly (Tahir, 2023), exacerbating rifts in societal trust in science. The image-language dissonance of construals in headlines and visuals of a news article may play a part in this exacerbation by signalling mismatches to readers that reinforce dis/trusting perceptions of media, and influence risk perceptions (Dahl & Fløttum, 2017; DiFrancesco & Young, 2011). However, further research is needed to contextualise these suggestions, ideally generalising results to better understand construal applications in science communication from pluralised media environments to understand how partisan coverage of contested science shapes attitudes towards science (Mach et al., 2021). Our study contributed nuanced findings to ongoing CLT research in the media, demonstrating that niche topics are not always reported as concretely, and may constitute a missed opportunity for journalists to concretise public interest topics to readers and build trust by making them aware of the adverse health effects of popular products.

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15

The Evil Corporation Trope: An Analysis of Popular Science-Fiction Films

Michael A. Poerio and Erik Stengler

Introduction

In 1910, Thomas Edison's Edison Manufacturing Company produced the first film adaptation of Mary Shelley's novel, *Frankenstein* (Dawley, 1910; Shelley, 1818). As in Shelley's, 1818 novel, this short film directed by J. Seale Dawley depicts Doctor Victor Frankenstein using science to create unnatural life, and then shunning his creation who jealously exacts revenge by tormenting the scientist. Over a hundred years later, science-fiction films are still telling stories where unethical uses of science cause dramatic conflict.

However, scientific wrongdoings in these stories are not limited to the actions of single, rogue scientists using science unethically, and in the last fifty years, we have seen an increase in films that portray the larger

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institutionalized powers of corporations as the culprits who commit problematic uses of science (Allan, 2016). We identify this trend in science-fiction as the evil corporation trope. In science-fiction, this trope is the depiction of corporations, and the characters who act as representatives of a corporation, using scientific discoveries and technological advancements in unethical or immoral ways to pursue self-interested agendas. For example, in 1973's *Soylent Green*, directed by Richard Fleischer, Soylent Industries violently attempts to stop a New York detective from revealing that their popular green food wafers are made from processed human flesh (Fleischer, 1973). This story-telling device has been observed by others before. In her 2016 article for *The Atlantic*: "How the 'Evil Corporation' Became a Pop-Culture Trope", Angela Allan wrote about the many examples of science-fiction novels and films that include evil corporations within their narratives (Allan, 2016).

With the prevalence of this trope in science-fiction, film audiences are receiving rather unflattering depictions of corporations and the scientists that develop technology for them. These negative representations of corporate scientific and technological endeavors can shape audiences' trust toward actual science. Dr. David A. Kirby, professor of science communication, writes in *Lab Coats in Hollywood: Science, Scientists, and Cinema*, about the concept of virtual witnessing, where people can view activities, such as the scientific process, indirectly through media (Kirby, 2011). For Kirby, even fictional film can allow audiences to virtually witness science because, he writes, "…the images on the screen appear "realistic" within narratives designed to highlight this realism" (Kirby, 2011, pp. 27–28).

Virtual witnessing offers many opportunities for science communication and transparency. Televising the 1969 NASA moon landing allowed the greater public to virtually witness humanity's first steps on the moon, which only Lance Armstrong and his fellow astronauts on the Apollo 11 shuttle could experience in person. But virtually witnessing fictitious depictions of science can lead to misconceptions about the scientific process. How many more people have viewed blockbuster science-fiction films than viewed the day-to-day operations in a real laboratory?

Science-fiction can use social commentary and allegories about issues or anxieties that the filmmakers wish to express, using fictional characters and situations to comment on the real world. The anxieties toward the use of science and technology that can be identified in science-fiction films that follow the evil corporation trope are virtually witnessed by film audiences.

We explore the use of the evil corporation trope in popular science-fiction films and report the findings of a content analysis of a selection of science-fiction films in order to better understand the characteristics indicative of this trope, considering the implications of these findings for trust in science. We seek to identify reoccurring depictions of science and technology that audiences virtual witness and which we believe have the capacity to undermine public trust in science and technology.

Literature Review

With the prevalence of anxieties surrounding corporate use of and control over science and technology in society, it is not surprising that these kinds of anxieties are also seen and depicted in cinema. Besley et al. (2017) describe a study that they conducted that found that participants expected less research integrity and honesty when scientists collaborated with or were funded by companies such as Kellog's. While the authors note that collaborations where companies fund or support scientific research have led to many positive developments, the results of their study indicate that many participants were less trusting of industry involvement anyway. Fried (2020) reported on Edelman and Pew Research Center studies that found a decline in public trust for tech companies, including distrust in artificial intelligence and distrust in tech companies' roles during the 2020 US presidential election. However, Dill and Wilderding (2021) reported on another Edelman study in 2021 that found that fifty-four percent of people polled in the United States trust business, which probably includes more types of industry than exclusively corporations, while fewer trust other institutions. The results of these studies indicate a complicated relationship between people and corporations and that oversimplifying the public's attitude toward corporations should be avoided.

Cases and Methods

We set out to select films that (a) were regarded as significant to the genre of science-fiction, (b) were popular with audiences, and (c) included corporations or characters that were leaders of corporations that interacted with their film's main characters.

To find science-fiction films that were highly regarded within their genre, five articles published in popular online publications that listed or ranked science-fiction films were used (Fowler, 2018; Hersey & Nicholson, 2021; Libbey, 2017; Travis & White, 2021; Wired, 2020). Each film that appeared in these lists was added to an excel sheet.

To find films that were popular with audiences, we used a sorting tool on the *Internet Movie Database, IMDb.com,* to create a list of the top fifty science-fiction films based on user ratings, whether positive or negative (IMDb, n.d.). These films were added to the same excel sheet. In order to qualify for analysis, a film needed to have been listed at least three times among the five articles and *IMDb.com* list. In creating this criterion, we felt that requiring a film to be listed only two or more times would not be enough to determine that a film was popular with audiences, and that requiring a film to be listed four or more times was too restrictive a criterion.

Finally, films that were listed three or more times were researched based on their plots to make sure they met the criterion of having a corporation or corporate leader that interacted with the film's main characters.

Six films were selected based on these criteria. In order of release date: *Alien,* directed by Ridley Scott (1979), *Blade Runner: The Final Cut* directed by Ridley Scott (2007), *RoboCop,* directed by Paul Verhoeven (1987), *Terminator 2: Judgment Day*, directed by James Cameron (1992), *WALL-E*, directed by Andrew Stanton (2008), and *Ex Machina*, directed by Alex Garland (2014).

In addition, we included *Blade Runner 2049*, directed by Denis Villeneuve (2017). *Blade Runner 2049* did not meet the aforementioned criteria, as it was not listed at least three times between the five articles and *IMDb.com* list, but it was chosen to be part of the sample because it offered a unique opportunity to examine how the depiction of corporate power over futuristic technology changed over a long period of time both within a fictional universe and within the real world. Uniquely for film sequels, *Blade Runner 2049* was released thirty-five years after *Blade Runner* and took place thirty years after the events of the original film (Scott, 1982; Villeneuve, 2017).

Our content analysis used the framework described in Lothar Mikos' "Analysis of Film", where Mikos lists five "levels" that comprise a film, which can be explored for a systematic analysis of a film: content and representation; narration and dramaturgy; characters and actors; aesthetics and configuration; and contexts (Mikos, 2013). Mikos' theoretical approach to qualitative analysis was used because we believed that his five "levels" are sufficient for a holistic analysis of all aspects of a film to gain knowledge as close to objective truth regarding a film's intentions and execution as possible. Using Mikos' approach, we performed a content analysis of each of the selected films. This analysis included viewing and taking extensive notes on each film using Mikos' five levels as a framework, and by using the most readily available version of each film's home media release (2013).

The content analysis of each film using Mikos' five levels was designed to answer whether a film used "the evil corporation trope"—defined for the purposes of this analysis in this chapter's introduction—and was determined based on the corporation's actions and use of science and technology, and relationships between the protagonists, antagonists, corporations, and the characters related to the corporations (Mikos, 2013). Each film's corporation was explored based on its role as a business and institutional power holder within the societies the film's characters belong to, and on the relationship between the corporation and main characters throughout each film. To gain insights into the decisions made by the filmmakers in how they depicted the corporations in their films, supplemental materials, including audio commentaries, interviews, and behind-the-scenes books where filmmakers, actors, and crew discussed their intentions for how characters or settings were depicted, were included in the analyses as well.

Analysis: The Evil Corporation Trope

First, we summarize here how each film uses the evil corporation trope to give the reader enough context for the more complex patterns found between these films later in this chapter.

In *Alien,* Weyland-Yutani misleads the crew of *The Nostromo*, the company's cargo ship, into investigating a derelict vessel that contains the eggs of the dangerous Xenomorph alien, which they want to collect a sample of and study. One alien attaches itself to and impregnates a crewmember who dies when it forces its way out of his chest and begins hunting down the rest of the crew. The corporation uses their android Ash, to act as the vessel's science officer and prevent the rest of the crew from harming the alien because the corporation wants to study the alien. One survivor, Ellen Ripley, discovers Ash's true identity and kills the Xenomorph, stopping Weyland-Yutani's plans and saving herself from a violent death. In *Blade Runner: The Final Cut*, Tyrell Corporation manufactures replicants, artificial humans who have no rights and are sold as slaves. Tyrell Corporation creates these enslaved people with four-year life spans, and some are implanted with false memories to trick them into believing they are natural-born humans.

In *RoboCop*, Omni Consumer Products purchases the Detroit Police Department and uses the body of fallen police officer Alex Murphy to manufacture a robot police officer as part of an initiative to replace the striking human officers employed by the corporation. Vice President of the corporation, Dick Jones, hires a crime boss to create an increase in crime to drive up demand for the corporation's robot police force. In *Terminator 2: Judgment Day,* it is revealed that Cyberdyne Systems stole parts from a destroyed terminator cyborg, sent back in time by the artificial intelligence Skynet, to create the technology that would ultimately allow them to receive an exclusive military contract with the United States military. Through this contract, Cyberdyne creates Skynet, which becomes "self-aware" and causes a nuclear holocaust that kills billions of people around the world. In *WALL-E*, Buy-N-Large corporation sends humanity out into space for seven hundred years after making life on Earth unsustainable and deciding that clean-up work was not worth the effort. Humanity is kept in a socially isolated and sedentary lifestyle until they are inspired by the robots WALL-E and EVE to retake control of their lives from the artificial intelligence that the corporation left in control of humanity.

In *Ex Machina*, Nathan Bateman, founder of BlueBook, a tech corporation, tricks an employee into engaging in a social experiment with an artificial intelligence he designs to be as human-like as possible. Bateman hacks into every camera and microphone in the world to steal data for his experiments and abuses the artificial intelligences he imprisons. Finally, in *Blade Runner 2049*, Wallace Corporation succeeds Tyrell Corporation as the producers of replicants. Replicants are still enslaved, and new artificial intelligences, called Jois, are now available even to replicants to purchase. Founder Niander Wallace attempts to discover how to manufacture sexually reproductive replicants through kidnapping, torture, and murder.

The application of the evil corporation trope is unique in every film but there are also identifiable patterns between many, or all, of the films analyzed that provide us with a deeper understanding of how this trope is applied to science-fiction films. These patterns are described in greater detail below and are important in understanding the types of issues or anxieties toward corporations' use of science that audiences virtually witness through popular science-fiction films. Evidence of the patterns described is listed to justify the claims made in this chapter, but for the sake of brevity, not every example from any of the seven films is included here.

Conflict Between Protagonists and Corporations

A conflict between the corporation and the main character of the film is a key element of the evil corporation trope. Indeed, in each of these seven films, the protagonists cannot reach their goals without engaging in direct conflict with the corresponding corporations. Therefore, audiences who are engaged with the films' stories and characters must side either with the protagonists or with the corporations. The protagonists or corporations cannot succeed unless the other fails. Many of these films use characters who are associated with the corporations and invested in the corporation's pursuits to personify their ambitions. Sometimes these characters are the leaders, presidents, CEOs, etc., and other times they are lower-level employees or assets. These corporate leaders set the agenda of the corporations, while these lower-level employees or assets, called corporate surrogates throughout this chapter, enact the agendas of the corporations.

For example, in *RoboCop*, Dick Jones is the Vice President of Omni Consumer Products, a corporate leader, and tries to kill RoboCop after the robotic police officer discovers Jones' corruption. In *Alien,* Ash is a robot sent by Weyland-Yutani to work against the crew of *The Nostromo* and bring back a Xenomorph specimen. Ash, a corporate surrogate, tries to kill Ellen Ripley after she discovers that Ash received orders that the crew of the ship are "expendable" in the efforts to bring the specimen back to the corporation.

The common pattern of portraying characters in leadership roles or who carry out the will of the corporations in these films as villains, antagonistic toward the protagonists, shows that audiences of these films are exposed to make a negative value judgment on them. This negative perception will automatically and unconsciously be attached by these audiences to the science or technology they are using to achieve their (evil) goals.

Self-Actualization through Opposition to Corporations

It was surprising to discover that most of these films also include themes about sentience, and what makes someone "alive", through the use of artificially intelligent characters. Many of the protagonists are directly associated with the corporations, as employees or are actually manufactured by their corporations. These characters reach a turning-point throughout their film's narrative where their goals are unaligned with their corporations: Ellen Ripley is an employee of Weyland-Yutani in *Alien*; RoboCop is property of Omni Consumer Products in *RoboCop*; Rick Deckard and Rachael are Tyrell Corporation replicants created by

Tyrell Corporation in *Blade Runner: The Final Cut*; the Terminator is built by Skynet in *Terminator 2: Judgment Day*; WALL-E and EVE are built by Buy-N-Large in *WALL-E*; Caleb is an employee of BlueBook and Ava is an artificial intelligence created by CEO Nathan Bateman in *Ex Machina*; and K is created by Wallace Corporation in *Blade Runner 2049*. In all films except *Alien*, the main character is an artificial intelligence designed by the evil corporation of their films. These artificial intelligences are robots, cyborgs, or artificially created and bioengineered humans. In every instance, the protagonist characters, who are artificial intelligences created by the evil corporation, take agency over their own lives by taking it from the evil corporations.

These characters gain their humanity through the process of separating themselves from the corporations' goals and pursuing their own aspirations. WALL-E and EVE, in *WALL*-E, become friends and find a new happiness by stopping Buy-N-Large from holding humanity in captivity out in space. Ava, in *Ex Machina*, kills Nathan Bateman and escapes his compound before he destroys her memory so that she can enter into human society and no longer be isolated from the world. RoboCop in *RoboCop* regains his former identity as Alex Murphy through his conflict with Omni Vice President Dick Jones and hired crime boss Clarence Boddicker. The Terminator in *Terminator 2: Judgment Day*, originally built to exterminate humanity by Cyberdyne's Skynet, learns the value of human life and sacrifices itself to save humanity from its creator. Deckard, who learns he is a replicant at the end of *Blade Runner: The Final Cut,* runs away with Rachael, another replicant, to protect her from the blade runners who would kill her for running away from Tyrell Corporation. *K*, in *Blade Runner 2049*, saves Ana from being kidnapped and studied by Wallace Corporation for being a naturally born replicant, claiming agency over his life from the oppressive society he lives in. These characters achieve self-actualization by resisting the scientific endeavors of their corporation or by resisting the identity imposed on them by their corporations as a technological product. This is another example of how these films portray corporations as irresponsible caretakers of science and technology.

Comeuppances for the Corporations

Another pattern found among many of these films was corporations or the characters aligned with the corporations, leaders, and surrogates, facing some punishment or comeuppance by the end of their films. These comeuppances are manifested either as the failure of a corporation's or its leader's unethical goals, or as the death of the leaders or surrogates. Eldon Tyrell, leader of Tyrell Corporation in *Blade Runner: The Final Cut*, is murdered by Roy Batty, a replicant who escaped enslavement. Niander Wallace, leader of Wallace Corporation in *Blade Runner 2049*, fails to discover how to produce sexually reproductive replicants. In all seven films, the corporations' unethical plans backfire and instead of gaining some kind of power, property, or profits, they lose power, property, or profits. The one partial exception to a corporation receiving a form of comeuppance is in *RoboCop*, which is more satirical in how it handles the conflict between protagonists and corporations. In the film, RoboCop exposes and kills Dick Jones, preventing Jones' coup attempt at Omni Consumer Products. RoboCop saves the head of Omni Consumer Products by killing Jones and is still the property of the corporation at the end of the film. Jones' plans for using the power of the corporation for his own goals are thwarted, but the audience is left presuming that the unethical actions of Omni's remaining leaders will continue. The one exception for a corporate surrogate or leader dying as a result of their misdeeds is Miles Dyson, in *Terminator 2: Judgment Day*, who is the lead programmer of what would eventually become the genocidal Skynet artificial intelligence for Cyberdyne Systems. When the time traveling Terminator informs Dyson that his work at Cyberdyne will lead to a human holocaust, Dyson sacrifices his life to break into Cyberdyne and destroy all materials associated with his work to save humanity.

In *WALL-E*, Buy-N-Large loses its power over humanity when its artificial intelligence AUTO is defeated by Captain McCrea and humanity returns to Earth to abandon the life Buy-N-Large constructed for them in space. In *Alien*, Weyland-Yutani loses its spaceship, *The Nostromo*, the cargo the ship was carrying, and its robot Ash when Ellen Ripley kills the Xenomorph, thereby preventing the corporation from obtaining it. With these comeuppances for the corporations, their leaders, and surrogates, these films depict consequences for the corporations' unethical actions, which are punished, according to the traditional "good triumphs over evil" narrative that film audiences expect. Trust in science is undermined when it is portrayed to audiences as a tool of the wicked, and when those that use it for selfish purposes are punished.

Production of Weapons and Militaristic Violence by the Corporations

It is also important to analyze what industries these corporations operate in to generate revenues and what they manufacture. It has already been touched on that many of the corporations in these films produce artificial intelligences and humans to maintain power or generate revenues through the manufacturing of sentient life, but many of these corporations also produce weapons. In *Alien*, Ripley speculates that Weyland-Yutani want a Xenomorph to study for their weapons division. Omni Consumer Products manufacture military grade weapons and Dick Jones exclaims, "We practically are the military!", to crime boss Clarence Boddicker whom he arms with said military grade weapons in *RoboCop* (Verhoeven, 1987, 1:19:43). Cyberdyne Systems gains an exclusive contract to produce the United States' stealth bombers and the Skynet missile defense system that ultimately wages war against humanity in *Terminator 2: Judgment Day*. These films depict their corporations as being key players in a military industrial complex and their production of deadly weapons negatively impacts the worlds of these films. In *Alien,* Ripley loses all of her crewmates due to Weyland-Yutani's pursuit of Xenomorph-based weapons development, the people of Detroit are terrorized by criminals armed by Omni Consumer Products, and humanity is nearly wiped out by Cyberdyne's Skynet missile defense system. These corporations are depicted with alarmingly low value for human life compared to generated revenue for themselves. Audiences are presented with fictional futures where technology is unethically used to create deadly weapons that corporations unleash for their own agendas at the expense of society.

Evil Corporations and Female Bodies

In many of these films, misogyny and abusive control over female bodies was found to be a thematic element to how the films portrayed their corporations as villains. In both *Blade Runner* films, women replicants are enslaved sex workers. In *Blade Runner: The Final Cut*, Pris is described by the LAPD's Chief Bryant as a "pleasure model" for "military clubs" in colonies across the galaxy (Scott, 2007, 14:54). Tyrell Corporation created Pris with the expressed purpose of selling her to the military as a concubine. In *Blade Runner 2049*, several replicant enslaved sex workers are seen outside of a brothel trying to seduce the film's protagonist, K. Niander Wallace. The film's corporate leader is obsessed with hunting down the first naturally born replicant so that he can study her and learn how to produce replicant women with the capacity to reproduce. In the film, he murders a replicant woman minutes after she first gains consciousness by driving a knife across her uterus, calling it "The dead space between the stars", and signifying that she is meaningless to him without the ability to sexually reproduce (Villeneuve, 2017, 41:45). Wallace Corporation also sells holographic artificial intelligences called Jois. These Jois are advertised across Los Angeles as young, attractive women that can be purchased and owned. Even the film's protagonist, K, owns a Joi whom he treats as a wife. Jois have even less agency than replicants in this film's universe, being lower in the caste system since enslaved replicants can purchase Jois and because they cannot, without their owner purchasing additional products, even leave their owner's home.

In *Ex Machina*, Nathan Bateman, leader of the BlueBook Corporation, builds several artificially intelligent robots inside his secret research facility. Each of these robots is built to be a young and attractive woman. Bateman runs tests to determine if these robotic women are sentient and free thinking. The latest robot, Ava, points out the hypocrisy that she must prove her sentience while no human is expected to do the same. Ava is kept confined in a cell and uses Bateman's employee, Caleb, to help her escape before Bateman reformats her electronic brain, which would essentially kill her. Bateman remarks that while he is scrapping her brain, he will continue using her body, saying, "But the body survives, and Ava's body is a good one" (Garland, 2014, 1:05:59). Bateman placing a higher value on the female bodies of the robots he creates than their brains is consistently shown throughout the film. Another of his robots, Kyoko, cannot speak English, which he tells Caleb is to prevent her from sharing his secrets, and he orders her to cook, clean, and perform sexual acts for him. Bateman creates these robots with female genitalia, and the way that Kyoko mechanically begins to undress Caleb the moment he touches her suggests that Kyoko has been programmed, or socially conditioned, to associate any physical touch with a cue to perform sex on a man. Designing artificial intelligences with genitalia and then denying them their personhoods is exploitative, and the film provides enough evidence that Nathan sexually abuses Kyoko. These artificially intelligent robots are treated as Bateman's property. Security footage shows earlier models begging to be freed and clawing at security doors until their hands literally fall off. Ultimately, Ava and Kyoko must kill Bateman to allow Ava's escape from the compound and her entrance into society.

Both the *Blade Runner* films and *Ex Machina* depict corporations run by men that capitalize on exploiting misogyny. *Ex Machina* also shows men making unilateral decisions on artificially intelligent women's personhood. In all these films, the value of these manufactured women is placed mostly on their bodies, and that value is determined based on how these bodies can be exploited by men.

Discussion

The seven analyzed films have been shown to depict various forms of unethical uses of science and technology for audiences to virtually witness. These films virtually simulate realities where corporations have used science and technology to exert power over people and cause a detrimental impact on society. With these seven films spanning a thirty-eight-year period, the prevalence of this anxiety over corporate control of science and technology has proven to be endurant. While it would be foolish to outweigh entertainment media's influence of public trust in science over political and economic influences, these films' negative portrayals of the use of science have let audiences virtually witness corporations as untrustworthy holders of scientific power.

Trust in science and scientists is incredibly important for a functioning society. The COVID-19 pandemic put that trust to the test, with misinformation competing with truth (Ferreira Caceres et al., 2022). Most (2021) lists many of the popular myths that surrounded the COVID-19 vaccine in 2021 and countered them with the best available evidence at the time, proving these myths to be fabrications. One myth that Most (2021) debunked focused on the perceived quickness with which the vaccines were made available and the belief that the vaccines were rushed into market without the proper testing. The propagation of misinformation like this is dangerous, and scientists and journalists who rigorously debunk these untruths, or work to create more science communication, work to give the public accurate information and restore trust in science professionals (Moorhead et al., 2023; Weitkamp, et al., 2023).

The theory that the COVID-19 virus originated in the Wuhan Institute of Virology and was not created in nature, through the wild bat populations in Wuhan, gained enough popularity that even the President of the United States at the time, Donald Trump, espoused the theory, despite both the evidence that the virus originated naturally and the historic precedent of deadly viruses being created in nature rather than laboratories (Kormann, 2021; Singh et al., 2020). Despite the lack of historic precedent of laboratory viral outbreaks, films and other media depicting dangerous viruses accidentally emerging from secure laboratories are abundant. *Resident Evil*, directed by Paul W.S. Anderson (2022), may be one of the most popular films depicting a deadly virus leaked from a lab, in this case operated by the evil Umbrella Corporation. The film series spawned from *Resident Evil* has earned over 1.2 billion dollars worldwide in box-office sales alone, as of October 2023 ("Box Office History", n.d.).

Of course, it is important to note that political maneuverings, such as then President Donald Trump's claims to possess evidence supporting the Chinese lab leak conspiracy theory, have a more immediate impact on specific examples of mistrust in science than that of a film (Singh et al., 2020). Still, any way that films, especially those that have become culturally significant, can influence the perceptions of science and the trustworthiness of scientists is worthy of analyzing and understanding.

The anxieties over corporations' uses of scientific and technological advancements that are depicted in science-fiction films that use the evil corporation trope are not always as extreme as laboratory leaks, and these anxieties can be more reflective of real issues in the world. For example, *Blade Runner 2049* and *Ex Machina* were both released in the 2010s and both depict issues of misogyny and artificial intelligence creation. Both films depict futures where corporations either profit from or plan to profit from bringing to life young, sexualized, artificially intelligent women as consumable products. Today we see voice assistant artificial intelligences like Alexa, Siri, and Cortana that are produced and sold by the Amazon, Apple, and Microsoft corporations, respectively, to serve users as kinds of virtual assistants. These virtual secretaries are given typically female gendered names and are set to speak with female sounding voices as their defaults (Steele, 2018). Steele (2018) explains how both Alexa and Cortana were designed to be female because Amazon and Microsoft decided after research and testing that designing their voice assistant products as female would be most preferable to their consumers, and Steele raises issues of how these decisions could reinforce harmful gender biases.

Conclusion

These seven science-fiction films follow the evil corporation trope by depicting corporations that act unethically and create conflict for the main characters of each film. The corporations control the most sophisticated scientific and technological advances available within the realities that these films depict and use them to pursue agendas that sacrifice the well-being of others for their own personal gain. The exploratory study of these films allowed for a careful study of the similar themes, character types, and narrative choices shared between some, or all, of these analyzed films. Corporate leaders and surrogates represent the worse traits of the evil corporations, synthesized into characters that interact with, and most often conflict with, the protagonists and their goals. The corporations always engage in conflict with the films' protagonists and the resolutions of these conflicts typically involve some form of comeuppance for the corporation itself, its leaders, and surrogates. These corporations are violent and in nearly every case are closely tied to official militaries or private armies, either producing or using weapons. Many characters within these films are artificial intelligences, created by corporations that the artificial intelligences must then fight against to realize their personal goals and gain some form of self-determination.

These representations of science and technology, used to forward the unethical business practices of the corporations in these films, can influence public attitudes toward the actual use of science and technology by real-world institutions.

Distrust in science and technology can have societal implications, like public health issues during a global pandemic. Societal biases or problematic norms can also influence the output of scientific and technological endeavors, such as the various corporate "artificial intelligence" virtual assistant products like Siri or Alexa that are programmed to sound like women due to the assumption that this is more appealing to consumers (Steele, 2018). The relationship between science and society is important, and understanding science-fiction's role in this relationship can perhaps lead to better communication that builds trust in science.

Future work in investigating media communication and media's impact on trust in science could take the results and analysis presented here and further identify common tropes seen in science-fiction films, or wider media, to gain a more complete understanding of what conventions and tropes are popularly used to depict science and technology in science-fiction. Another line of research might be to focus on a more quantitative approach, to assess whether this trope is prevalent in sci-fi filmography and what are its effects (e.g., with a more experimental approach).

The most recent film analyzed here was *Blade Runner 2049*, released in 2017. Investigating the use of the evil corporation trope in newer films, and investigating what patterns and themes exist within these newer films would help in our understanding of how this trope is being applied more currently. Further indentification and subsequent content analysis of tropes used in science-fiction films will help in our understanding of what interpretations of science and scientists audiences interact with then they engage with popular media.

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Part III

Trust in Science Communication

16

Trust and Mistrust in Science: Beyond the Binary

Brian Trench

The Trust Deficit

Concern about public trust in science pervades the practice, policies, and research of science communication. Addressing perceived shortcomings in trust in science has become a guiding principle of many science communication initiatives and programmes. It is widely assumed not only that public trust in science is a problem, but also that science communication can provide solutions.

The discourse around public trust in science echoes longer-standing diagnoses of declining or deficient trust in political and other institutions. Antonio Guterres, United Nations General Secretary, spoke in 2020 of "deep and growing global mistrust" as one of four priority issues for the UN (UN News, 2020), continuing to restate this theme over the following years. Again in 2023, he told foreign ministers meeting at the UN in New York that international institutions need updating and the

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planned Summit of the Future, scheduled for September 2024, was “a unique opportunity to help rebuild trust” (UN News, 2023).

In corporate marketing and public relations, the long-standing concern with trust is often focused on brand awareness or managing reputation. It has also been expanded to consider the “trust portfolio” of organisations, encompassing criteria such as accountability, credibility, integrity and legitimacy (Borchelt & Nielsen, 2014). The communications consultancy Edelman has tracked attitudes over two decades through its Trust Barometer, buttressing this work with crisis talk: “Lack of faith in societal institutions triggered by economic anxiety, disinformation, mass-class divide, and a failure of leadership brought us to where we are today—deeply polarized” (Edelman, 2024). We shall return to consider the academic literature on political trust and its generally under-appreciated relevance to public trust in science.

Among the prominent examples of science communication oriented to increasing public trust is that of the American Association for Advancement of Science (AAAS), which declares as a key priority in its public engagement programme “building trust between scientists and engineers and broader communities across the nation” (AAAS, n.d).

The Science Media Centre (SMC) was established in Britain after the much-cited House of Lords Science and Technology Committee’s report (2000) referred repeatedly to the crisis of public trust in science. The SMC’s mission declared the “overall goal … to help renew public trust in science by working to promote more balanced, accurate and rational coverage of the controversial science stories that now regularly hit the headlines” (Rödder, 2015, p. 390). The SMC had in its planning consultations heard from social scientists who suggested that the supposed crisis of trust could be embraced as an indication of increasing maturity and confidence among the population. However, the movers of this project decided to opt for the crisis approach, noting that “the declining trust in and respect for scientists is a worrying development, which can contribute to exaggerated fears that threaten to undermine public support for scientific progress” (Rödder, 2015, p. 395).

The International Science Council established a project on the Public Value of Science as part of its 2022–24 Action Plan; it too showed awareness of the options to be balanced and made a similar choice. It noted, on the one hand, "levels of public trust in science remain relatively high", but with greater emphasis, "trust in science is contested and fragile. This in turn feeds new expressions of science denialism, casts doubt on the need for scientific understanding and interpretation, and threatens evidence-informed decision-making" (International Science Council, n.d.). It is noteworthy, however, that an extended analysis prepared as part of this project (Ishmael-Perkins et al., 2023) shifts the emphasis from the public deficit to what it calls the "contextualisation deficit" of science. This relates to the ways in which science situates itself within society. The ISC report states that "the current analysis of resistance to science, or lack of public trust in it, is also too often linked with individual deficits of knowledge or dysfunction in rational decision-making" (p. 17). We shall see further critiques, both recent and historical, of the deficit views underlying anxiety about public trust in science.

Several recent European Commission-funded projects on science communication started from a position that trust in science is declining and needs to be, and can be, rebuilt. Two projects, TRESCA and ReTHINK, declared that they were looking at "how science communication as a practice can build towards public trust" (Tresca, 2020). Another project, Peritia, stated as a point of departure that "we aimed to enhance trust in a better democratic governance for the future of Europe"(Peritia, 2023). Similar to the case of the International Science Council mentioned above, these opening positions were qualified by the project process. Peritia project participants referred later to the *alleged* (my emphasis) crisis of public trust in science (Gundersen et al., 2022) and project participant Shane Bergin (2023) introduced a commentary on disrupted public trust in science by observing that "understanding how trust is established, absent or broken is essential if we are to do better when faced with global challenges including climate change, biodiversity loss of public health emergencies" (p. 8).

The more recent Ianus project (2024) seeks to strengthen "warranted trust in science, research and innovation at a systemic level". It declares that "the trustworthiness of science is a vital issue. In order to restore a trusting relationship between science and society, they must be brought closer together" but also adds that "trust in science and science-based innovation is never a given, nor should it be", even allowing space for "appropriate scepticism" (Ianus, 2024).

What these examples over a span of more than twenty years illustrate is that the trust-deficit approach to science communication still has a hold but is being questioned. We shall examine this further in the following section.

Persistent Prescription

The available data on levels of public trust in science indicate that, broadly, those levels are static or rising across scores of countries and have been boosted by the Covid-19 pandemic. Public attitude surveys have been a key element of the study of trust in authority, in institutions, professions and brands. They also have a long-standing role in the discussion of public trust in science. Notwithstanding the limitations of public attitude surveys, and specifically of general questions on trust (see Besley & Tiffany, 2023), the evidence of stable or increasing public trust in science across many and very diverse cultures is fairly consistent and must have some meaning. Despite this, however, the talk of "crisis of trust" or "climate of mistrust" persists and the agents of distrust, e.g., in relation to climate science denial, get disproportionate attention.

In the international science communication community, where the survey data are generally well known, there is a rising interest in public trust in science as a policy and research issue, and this is generally accompanied by assumptions and prescriptions about the role of science communication in boosting public trust in science. Intemann (2023) argues that the goals of science communication include, for example, providing reliable and relevant information, but also facilitating trust in science which "may require being attentive to those aspects of science that might bear on epistemic competency, moral reliability and the public interest …[also] about the ways in which that knowledge was produced and why those methods are reliable" (p. 354). These factors in the scientific enterprise are mentioned recurrently in discussions of science's trustworthiness.

The normative approach to public trust in science and to science communication's role around it is widespread in the communities of science communication. Contributions to the biennial conferences of the PCST (Public Communication of Science and Technology) Network that bring researchers, educators, and professional practitioners of science communication together are an indication of the preoccupations of those communities at a given time. The number of abstracts of conference contributions referring to trust has increased in recent years: these totalled 13 for the 2016 conference, 22 (2018 conference), 45 (2021 conference) and 52 (2023 conference). The following phrases are drawn from these abstracts; as these are provisional summaries of conference contributions that may or may not be developed further, no formal citations are given:

- It is important to create opportunities for scientists to communicate with the public and develop trusting relationships with consumers.
- [Survey] results consistently show lower trust in research in the humanities compared to natural sciences, medicine, or technology. This is worrying given the instrumental role insights from the humanities have in solving societal challenges such as migration, security, or climate change.
- Trust is a prerequisite for achieving a meaningful dialogue and to foster collaboration between researchers and other stakeholders.
- The programme had a very positive impact, boosting students′ capability to integrate new communication skills … helping to strengthen their trust in science.
- There is work to do in terms of building trust in AI research. However, a positive shift in perceptions of trust towards researchers after attending a Think-In demonstrates that this method of engagement can be effectively used as a way to increase trust.
- To gain trust and remain relevant, the scientific community has increased its efforts to engage in dialogue with society.
- State-authored disinformation erodes trust and undermines scientific consensus.
- Communicating science underscores the critical role it plays broadly in our society and can build trust and credibility between scientists and

publics, lead to authentic and meaningful collaborations to solve problems, and shine a light on the process of science, making it inclusive and accessible.

The recurrent emphasis on public trust in science as a problem or a challenge has echoes of much earlier concerns about scientific literacy that were prominent at the dawn of contemporary science communication, and which were identified and critiqued as representing a deficit model. Over the years since then, various deficits have been ascribed to the publics for science, including in literacy, awareness, understanding and information. The common ground in these assumptions is that society is deficient in relation to science, and the scientific community and its allies need to—and can—redress this deficit. The recent preoccupations with public misperceptions, and with the effects of misinformation and disinformation, have further reinforced such "deficit" views.

English sociologist of science Brian Wynne is commonly credited with the naming of the deficit model of science communication. He and Steven Yearley, also a sociologist of science, rang warning bells about the then-emerging concern about public trust in science in the early 2000s. Yearley wrote (2000) that seeing public distrust as a problem to be solved reduced it to an issue that only has to do with the public, but "trust is an indispensable component in the creation and passing on of scientific knowledge; it is not restricted to lay audiences for science, and it is not a feature that can be technically manipulated to promote high-trust conditions" (Yearley, 2000, p. 158). Wynne was more directly critical (2006) of the agonising over public mistrust, urging "more reflection and discussion about the ways in which institutional science is itself implicated in the 'public mistrust of science' problem, instead of repeatedly projecting the blame onto incompetent publics, irresponsible and misinforming media, and non-governmental organizations, as well as other convenient scapegoats" (Wynne, 2006, p. 212).

Nobel physics prize winner Giorgio Parisi (2023) demonstrated the persistence of such deficit thinking when he extrapolated from personal attacks on him during the Covid-19 pandemic that "people are becoming more and more suspicious of scientists" and he worried that "if citizens do not trust science, we will not be able to fight global warming, infectious diseases, poverty and hunger, and the depletion of the planet's natural resources", Also writing about respect and trust for science, but taking a position that put the responsibility on the scientific community rather than the public, the editor of the journal *Science* observed that "many scientists think the challenge has largely to do with science communication, which is certainly important. But first, the scientific community must begin to conduct itself in the same manner that it is asking of the public, and that means treating everyone in the scientific community with respect" (Thorp, 2024). This observation gives a particular expression, apparently based on personal experience, to Wynne's claim above that "institutional science is itself implicated in the 'public mistrust of science' problem".

Mistrust Gone Missing

Agonising over public mistrust has not typically extended to giving it detailed attention: advocacy for greater public trust in science has tended to ignore or dismiss it. Trust is commonly presented as on–off, present or absent; in this representation, trust resembles faith or belief, rather than something that is considered and open to conversation. Appeals for unquestioning trust in science serve political or ideological purposes: authorities urging populations to "follow the science" during the Covid-19 pandemic echoed interest groups in relation to contested climate science.

Science communication research and discussion on trust have tended to treat evidence of weak or absent trust as the central problem and evidence of increased trust as the objective. Even in the growing literature on trustworthiness, looking at the factors which may make science and scientists deserving of trust, the prevailing normative approach is maintained, and the research is oriented to, a practice of improving and increasing trust.

Naomi Oreskes's *Why Trust Science?* (2019), a common reference in current research and debate, offers compelling examples of how science can go wrong, but the author gives no attention to possibly warranted mistrust. She states that she "never assumed that trust in science is always or even usually warranted" (p. 141), and she has a qualified answer to her main question: science deserves trust on account of its self-correction over time—"*if the community is working as it ideally should"* (my emphasis) (p. 142). That is, as Oreskes herself says, a "substantial qualification", especially considering her compelling examples of how science may work other than it should.

Goldenberg (2023) also draws attention to behaviour by scientists that may be perceived as untrustworthy and create conditions for "fragile" trust in science but, like Oreskes, does not consider that mistrust might be warranted. Reviewing Oreskes's book, Gadagkar (2021) suggests that, beyond the questions Oreskes asks, "we should also ask two additional questions, namely why scientists trust science outside their domain of expertise and why scientists may trust or mistrust science inside their domain of expertise", (p. 1466). This acknowledges the role of mistrust within science, an action which should, one would have thought, lead to acknowledging its place when considering public trust in science.

There are some recent indications of this being done. Three social psychologists (O'Brien et al., 2021) explored how the kind of blind trust that we have been referring to as faith may leave people vulnerable: "The conclusion of our research is not that trust in science is risky but rather that, applied broadly, trust in science can leave people vulnerable to believing in pseudo-science". In this context, the authors state the need to foster public trust in "the healthy scepticism inherent to the scientific process" (p. 12)—in other words, foster trust in mistrust. A report for the Royal Netherlands Academy on the "pandemic academic" (KNAW, 2022) also opens up this paradox in a comment that "the processes of science, and in particular its inherent processes of constant scrutiny and scholarly debate to ensure the quality and robustness of research findings, can be the sources of both trust and mistrust" (p. 21).

Scepticism has an historically honoured role in the conduct of science: the motto of the Royal Society, an institution whose establishment in 1660 is a marker of the emergence of modern science, was, and remains, *Nullius in verba* (Take nobody's word for it). In science, trust and mistrust are not dichotomously, but rather dialectically, related—one is contained or implicated in the other.

Parallels in Politics

The analogies between trust in science and trust in government or politics are imperfect, as with all such analogies, but both relate to trust in institutions, reputation and social standing that is invested at a distance. Both are thus different from interpersonal trust in friends, family, or colleagues, but in political trust there are more likely to be interactions that influence the character and the consistency of the trust. Electors can express trust and mistrust of parties and politicians through voting; in some cases, they may have direct contact with representatives that reinforces or damages trust. On the other hand, their experience of politics may mean that some citizens opt for a generalised distrust of political institutions and actors that also extends to other institutions—including those of science—perceived as part of the same elite.

Science and scientists are in general at further remove from citizens than are political actors. They enjoy an inherited epistemic and moral authority within public culture. Through direct public communication in digital media in recent times, however, scientific institutions and individual scientists are open to greater scrutiny that may affect trust and mistrust. Opening scientists' workings and their personalities to wider public view, as has happened through digital media and was further amplified in the Covid-19 pandemic, increases interactivity in citizens' trust judgements. These circumstances emphasise the need for differentiation, and for fluid categories, of public trust in science, similar to what has been developing in discussion of political trust.

In the scholarship of political trust there has been a recurrent debate on whether or not there is a crisis of trust, but attention is also given to mistrust and distrust. The co-editors of a handbook on trust in politics (Van der Meer & Zmerli, 2017) suggested that trust is a "glue" and "oil" in the system but also that "mistrust plays an equally important role" (p. 1), being associated with vigilance and accountability. Political theorist and trust specialist Russell Hardin (2006) reminds us that distrust was long ago seen as a constitutive element of liberal democracy. A gender-oriented study of political trust (Bunting et al., 2021), deploying focus group research, posits that trust, mistrust and distrust can be seen as a family, rather than in polarised opposition; the authors suggest that mixed methods are required to do more adequate research on the topic. Jennings et al. (2021) also adopt the 'family' label in their analysis of attitudes to Covid-19 and associated compliance with government public health regulations during the pandemic when they comment that "the concept of trust may thus be more effectively perceived and analysed as a family with trust, mistrust and distrust as its members" (p. 1177). They note that Lenard (2008) had earlier defined mistrust as "a cautious attitude towards others; a mistrustful person will approach interactions with others with a careful and questioning mindset" whereas distrust denoted "a suspicious or cynical attitude towards others" (p. 313).

Political scientist Pippa Norris questions prevailing assumptions underpinning accounts of trust in *In Praise of Skepticism—trust but verify* (2022a). The book's sub-title picks up a Russian proverb that US President Ronald Reagan liked to quote at USSR President Mikhail Gorbachev as they sought to cool the Cold War.[1] In a presentation to the World Association of Public Opinion research conference in November 2022, Norris said "normative assumptions about trust's beneficial consequences and [the] focus on trustworthiness" (Norris, 2022b) needed to be challenged and rejected a simplified account of trust issues, proposing instead a typology of public attitudes that distinguishes sceptical trust, credulous trust, sceptical mistrust, cynical mistrust. She thus validates some mistrust as being on a par with some trust.

Turning this kind of thinking towards science, and on the basis of a cross-country study (Poland and Portugal) of attitudes to scientific information on climate change and vaccines, Rowland and colleagues (2022) discern, in discussions with citizen groups, expressions of unquestioned confidence, justified trust, reflexive trust and active distrust.

[1] Oreskes attributes the phrase to President Reagan himself in a frontispiece to Why Trust Science?

They comment that "this typology differentiates trust from distrust and considers lower levels of trust the result of a reflective vigilance" (p. 1420).

Reflecting on the collective experience of the Covid-19 pandemic, US science communication researchers Krause and colleagues (2021) argue that "much of the science that emerged during the pandemic was and is surrounded by significant uncertainties. Forceful arguments that we should all trust the science about the novel coronavirus implicitly suggest that there have been consistent, undisputed scientific facts available for us to trust, and that there is therefore no reason to be sceptical of scientists' claims other than personal anti-science sentiments" (p. 229). They conclude that "stable and broad trust is prerequisite for evidence-based policy-making in enlightened democracies, but both too little and too much trust is democratically dysfunctional" (Krause et al., 2021, p. 230).

This and other examples cited above call into question not just the public trust deficit that has underpinned much of the policy and practice around this topic but also the common binary view of trust and its opposite, be that absent trust, mistrust or distrust. Lukić and Žeželj (2023) challenge this binary with reference to the ideology of scientism—the belief that science can answer all relevant questions better than any other form of knowledge—and with the observation that "if trust in science is a dimension with one pole being unjustified distrust in science, that is, science skepticism, its other pole would not be justified trust in science, scientists, and scientific institutions, but rather uncritical and automatic acceptance of scientific claims" (p. 2).

Pandemic Repercussions

The Covid-19 pandemic has contributed to the unsettling of blind faith in science. It brought science-in-the-making to wide public visibility, possibly affecting longer-term science itself, and thus what it is that citizens are asked to trust, as well as illuminating variations in how trust is given or not. Science may be represented to public view, and thus to trust judgements, as an accumulated body of verified knowledge, as a set of institutions dedicated to producing more such knowledge, as a sequence of discoveries, as an activity governed by robust self-regulation, as a community of communities that compete and cooperate under those norms and rules. In the pandemic it has been seen in all of these aspects, which calls further into question the relevance of seeking to measure trust in "science" in general.

Retrospectively, at least, it appears plausible to suggest that the science held up for public view has been an idealised science, one that conforms to norms that are often disregarded in daily practice. Peters (2022) suggests that this has been the case for scholarship of public understanding of science and science communication; he writes that researchers "may be biased in their research … by an idealised image of 'pure' science" (p. 256). Peters notes that researchers in the field tend to assume "as default that science deserves trust … we should be more interested about how well citizens' trust or distrust judgements are informed by knowledge, reasoning and good judgement rather than simply lament about the lack of trust" (p. 257).

John Ziman (2000), a physicist turned philosopher of science, found it necessary already over two decades ago to draw attention to "real science" as distinct from idealised science. Ziman described contemporary science as "post-academic", in which "every research claim is labelled with the names of interested parties outside the research community", and he asked, "Can the traditional web of mutual trust be maintained under such circumstances?" (p. 175). Weingart (2022), two decades later, suggests that it cannot. He writes that the attention-seeking corporate communication of universities—the traditional centres of scientific endeavour—displaces trust as the social binding and adds: "The known dependence of trust on the absence of special interest and the identification of science with the common good should be reason for concern" (p. 294).

Science is still very largely presented to the public as being governed by robust internal scrutiny and characterised by disinterested, collegial collaboration. In the Covid-19 pandemic, science's trustworthiness was apparently boosted by being seen as benevolent, cooperative, transparent, even humble. But with all of these criteria there are opposites also in play: science and scientists can be malign, competitive, secretive and arrogant. Add to this the undeclared conflicts of interest, the non-replicability of a large portion of reported experiments (e.g., Ioannidis, 2005), the hype about revolutions and breakthroughs, the failures and biases of peer review, the rise of predatory publishing and conferences, the regular retractions of papers (e.g., as tracked by retractionwatch.com) give us many plausible grounds for mistrust in science, even if it is focused on specific circumstances or instances. If science is worthy of trust when it is working *as it ideally should*, following Oreskes's argument, it may merit mistrust when it is *not working as it ideally should*.

From the perspective of publics, and through greater transparency, as has happened during the Covid-19 pandemic, we have been given insight into the collective process of science, and the means by which science makes its achievements, and thereby to evidence of disagreement in science. Trust and mistrust within science *and* applied to science can be complimentary. In relation to public trust in science individuals and groups may move position over time and in changes of circumstances. Our inclination towards trust may be stronger in some situations and weaker in others. Moments of mistrust can co-exist with a disposition of generalised trust. There have also been occasions of organised mistrust, some of them analysed and even celebrated in science studies as expressions of lay expertise. The correction to prevailing views in the medical-scientific establishment on HIV/AIDS in the 1990s that came from mobilisation of affected communities is rightly remembered as a progressive shift (Epstein, 1995), not a dreadful moment of crisis of expertise.

Filling the Space

There is much space between total trust and determined distrust of science and we need the concepts and tools to grasp what might be found there. First, however, two important distinctions:

- Mistrust and distrust may usefully be considered to refer to different objects somewhat on the lines of the distinction commonly made between misinformation, as inadvertently misleading, and disinformation, as deliberately false; this would suggest applying mistrust to a withdrawal of trust that is specific to an issue or circumstance, and may be reversed, and distrust to a deliberate denial of trust that is general and fixed;

- The distinction between scepticism and cynicism needs to be reaffirmed, in particular, because it has been blurred in the climate change debate, where scepticism about and denial of the evidence for climate change sometimes appear interchangeable; the sceptic questions the basis of claims and may be persuaded with additional evidence or argument and the cynic dismisses claims outright as well as the evidence and authority on which they are based.

Some commentaries on public trust in science adopt phrases such as "warranted", "well-placed" or "legitimate trust" from political theory. However, these terms tend to be defined unsatisfactorily in circular manner, e.g., as trust in institutions or people who are trustworthy. Further, they modulate trust in ways that can only be validated after the fact, on the basis of the actions of the trustee in whom the trust was placed.

This circularity of definition relates to an assumed reciprocity in the relationship. But, as we have mentioned earlier, science and its institutions are remote from the large majority of lay publics and take their place alongside other agencies of power and privilege. In dialogical or participatory science communication settings, *some* members of *some* lay publics may have opportunities to examine science's workings more closely, to question individuals or groups within scientific communities. These opportunities do not extend to the public in general and thus may have infinitely small effects on trust in general.

Changing conditions require more attention to the plurality of publics, the articulation of various categories of trust, and the recognition that mistrust and distrust are more than the absence or weakness of trust. The following four categories of trust are intended to represent the publics' perspectives on the trust judgements they make, rather than the supposed validity of those judgements from a science-centred point of view:

- Total trust—an act of faith in and deference to the authority of science as a disinterested source of reliable knowledge; this position is associated with science fandom, or belief in, and love for, science, as displayed on t-shirts or advocated by science promotion agencies.[2]
- Conditional trust—a general inclination to accept science's authority but with occasional questioning of specific claims, seeking assurance on the basis of science's workings; this is close to the "informed trust" advocated by Oreskes (2019, p. 60) who states, "it is fair to ask: What is the basis for any scientific claim?" (p. 141).
- Selective mistrust—scepticism about aspects of science such as overproduction of publications, and dissent from tendencies or positions within science, such as biological determinism; this may be the basis of a critique of science that reaffirms its own standards.
- Determined distrust—deliberate, maybe cynical, denial of science's intellectual leadership role on the basis that it is conducted dishonestly or is distorted by self-interest or external influences; this position may be associated with a propensity to accept conspiracy theories.

There are, no doubt, further nuances that could be added in the interstices of these categories. For example, selective mistrust may be based either on empirical factors, such as a too-small sample; emotional factors, such as dislike of individual scientists or particular institutions; or personal factors, such as having come across contrary information or views. But even this rather limited scheme of four positions could take us beyond the simplistic view of trust as on or off, strong or weak. Mixed methods research deploying a scale of possible trust positions, such as that outlined above, could give us a much richer picture of public attitudes, including their changes over time or in particular circumstances. Such research would likely provide detail on how conditional trust and selective mistrust relate to above-average levels of attention to scientific ideas and information, and how total trust may be associated with lower levels of active engagement.

[2] "Believe in Science" and "Love Irish Research" have been slogans of Science Foundation Ireland (SFI) and the Irish Research Council, the principal funders of research in Ireland and, in SFI's case, the state's agency in promoting public engagement with science.

Comparative and qualitative studies armed with differentiations of trust, mistrust and distrust can uncover how such attitudes are formed and how firmly they are held. But even the superficial acknowledgement of the paradoxes in play should be sufficient caution to science communication communities of research and practice to pay closer heed to the varieties of public trust in science.

Conclusion

Our starting point in this chapter was a critique of a prescriptive view of science communication as called upon to fix the perceived problem of weak public trust in science. We have drawn attention to the limits and errors of prevailing views of public trust in science as a singular and deteriorating relationship. Neither public nor science are singular entities, nor, as we hope to have shown, is trust. We have sought to go beyond a dichotomous view of trust and non-trust, showing the continuity, or at least co-existence, of trust and mistrust in certain forms and conditions. One of the abiding achievements of science communication research is to have mainstreamed the idea of plural publics. To a differentiated view of publics, we need to add a differentiated view of trust.

In this context, science communication needs to continue on its path of critical self-reflection, asking how does science communication represent science as trustworthy or not. As we have seen, trust has been elevated to the crucial, or least a special, aspect of the public perception and appropriation of science. The means and forms of public communication of science can contribute to that. The stories told of science in formal science communication may tend towards an idealised view, in which science continuously produces benefits for society. The display of discovery after breakthrough, after revolution, may well induce fatigue and mistrust. The pumped-up promotion of science and its authority as the only valid way of knowing the world may deservedly earn distrust. Scientism, an ideology based on deference to the authority of science, has been identified as a main contributor to the erosion of that authority (Kitcher, 2011).

Science communicators may see it as risky to adopt a realistic view of science as collective effort and uneven process, sometimes erring or obsessive, occasionally forced to check back and correct itself. But the population-scale lesson in science-in-the-making that the Covid-19 pandemic has brought appears to have enhanced science's trustworthiness through greater transparency. The pandemic experience was also one of amplified social conversation around science, as experts openly differed with each other, and lay publics sought to make sense of such differences, and of flattening curves, reproduction rates, and population immunity.

A view of science communication as the social conversation around science (Bucchi & Trench, 2021) includes in its scope many different kinds of interactions and exchanges between many different kinds of groups and communities. The conversation may be prompted by scientists' interventions, but it is not limited by these. If it loops back to scientists, and they are able and willing to add detail and insight to the conversation, then such communication may well affect public trust. Such influence may well be independent of whether or not that is the stated purpose of science communication.

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17

Resources, Valuation, Trust: Sharing in Stem Cell Research

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Introduction

In biomedicine and science more broadly, and within academia and beyond, 'openness' has increasingly been promoted (International Science Council, 2020; Leonelli, 2023; OECD, 2015; UNESCO, 2022). These efforts relate to 'opening up' for those undertaking research in order to encourage and enable more sharing and collaboration, and for those who might benefit from the research, for instance patient and donor groups, in order to foster more engagement (Levin et al., 2016).

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Together, they are premised on the hope, and often the assumption, that more openness will facilitate increased productivity, transparency and trust in scientific research (Mirowski, 2018).

Openness itself has been defined and understood in multiple ways (Levin et al., 2016). Thus, it is important to consider how openness as an aspiration is enacted in particular contexts. One significant component of openness involves the broader availability and sharing of resources produced and used in scientific research, including data, knowledge, tools and materials. Decisions about whether and how to make them available are affected by a range of factors and processes, including disciplinary norms and institutional landscapes (e.g. on model organisms as research resources, see Ankeny & Leonelli, 2021). Relations of trust also play a significant role, with respect to both scientific researchers and the groups who play a vital role in providing these resources (e.g. donors of biological materials). These factors, processes and relations collectively shape prospects and possibilities for openness (Leonelli, 2015; Leonelli & Tempini, 2020).

In this chapter, we explore researcher conceptualisations of trust, communication and openness in scientific research. Specifically, we analyse these dynamics by considering how particular resources are valued through practices, using stem cell research in Australia as a case study. As such, this analysis is performed using a socio-material conceptualisation of science communication, one in which the role of these resources, and how they are valued, is foregrounded. Specifically, these resources are analysed as mediators in communication among various actors involved in scientific research. We examine two related processes. The first involves how material resources (e.g. stem cell lines) are valued in distinct, but related, ways by stem cell researchers compared to more text-based resources (e.g. data or knowledge). This comparison requires taking into consideration a range of dynamics that shape the scientific enterprise, from tensions between competition, collaboration and commercialisation, to ethical obligations and commitments. The second involves considering how the valuation of these resources informs relations of trust, sharing, communication and collaboration between researchers. This type of valuation also includes accounting for responsibilities and duties on behalf of patient and donor groups, both formally through institutional ethics requirements but also more informally and personally.

Empirical insights are drawn from interviews with stem cell researchers in Australia, conducted as part of a research project investigating the potential for greater openness in Australian stem cell research. Overall, we demonstrate how scientific resources in this field are valued in multiple and sometimes conflicting ways, and how these differences shape the contours and possibilities for open and collaborative science for stem cell researchers.

Openness, Valuation and Trust: A Brief Review

Within the life sciences, and science more generally, there has been increasing interest in and support for more open research practices and forms of communication and engagement (Leonelli, 2023). Broadly, openness has been understood to include a wide range of potential meanings and activities, including increased availability of and accessibility to research outputs, deeper cooperation and collaboration between researchers and other interested parties, more transparent peer review, and the widespread dissemination of outputs beyond research contexts (Levin et al., 2016; Mirowski, 2018; Vicente-Saez & Martinez-Fuentes, 2018). There are several factors and dynamics which might further shape these meanings and activities; for example, institutional incentives, tensions between collaboration and competition given resource constraints, obligations imposed by funding sources, and navigating norms in industry-academia partnerships (Evans, 2010; Fischer & Zigmond, 2010). Finally, how openness is imagined and realised will differ depending on the particular scientific field or discipline in question; these will shape norms around, for example, who is typically involved in collaborations, and what resources are produced, exchanged and circulated. Therefore, a uniform or broadly applicable approach to implementing openness is either not possible or not normatively desirable (Levin & Leonelli, 2017). Instead, openness must be observed and examined through the context-specific practices of particular 'moral economies' in science (Daston, 1995; Kohler, 1995).

Trust plays a significant role in how openness, collaboration and communication occur within any particular field of scientific research (Sonnenwald, 2007; cf. Ankeny, 2020). Trust within scientific research communities has been conceptualised in multiple ways (summarised in Table 17.1). For example, Barber (1987) distinguishes between two different sets of norms that govern perceptions of trustworthiness. Firstly, there are 'cognitive' norms, which encompass expertise and technical proficiency; in this sense, incompetence might constitute a breach of trust. Secondly, there are 'moral' norms, which relate to the fulfilment of collectively recognised obligations and responsibilities, such as those associated with legal requirements. These norms might be transgressed through, for example, fraud. Sonnenwald (2007) also acknowledges the importance of 'affective' trust—the rapport and connections forged between individuals in a research project and community. This form of trust helps to consolidate the relationships in a scientific group, leading to more cohesive collaboration. Finally, 'epistemic' trust, enacted through virtues like "sincerity, openness, honesty and transparency", has been emphasised as important for communicating with non-scientist publics (and perhaps scientists as well), although this has also been critiqued (see John, 2018, p. 75). Together, these conceptualisations—cognitive, moral, affective, epistemic—highlight some of the forms of trust that are present among members of scientific communities that affect communication and collaboration.

This chapter builds on these conceptualisations by providing a framing of trust, communication and sharing that revolves around the resources that are produced, circulated and used in concrete scientific research contexts. If a significant component of openness is centred on access to and availability of resources, then examining openness in practice, through understanding and observing sharing, communication and collaboration, requires considering how and why these resources become available (or fail to do so) to varying extents. This focus in turn requires considering processes and dynamics of valuation.

Recently, there has been increasing interest in exploring more dynamic, emergent and contingent approaches to thinking about value

Table 17.1 Different forms of trust within scientific communities (adapted from Barber, 1987; John, 2018; Sonnenwald, 2007)

Form of trust	Description	Example
Cognitive	Expertise and technical proficiency	Reliably providing knowledge and know-how to a research project
Moral	Fulfilment of collectively held obligations and requirements	Diligent awareness of and adherence to human research ethics standards and guidelines (e.g. respecting and maintaining consent and privacy of research participants)
Affective	Rapport and connections developed and consolidated among members of a research community	Building positive, mutually beneficial relationships over time among members of a lab or research group
Epistemic	Communicating with scientists and non-scientists in good faith	Engaging in open and transparent conversation with non-scientist groups about the importance of scientific research, how it is done, including its norms, and what its findings mean

by focussing on 'valuation'. Valuation is contrasted with value in that it is situated, enacted and realised in certain practices and contexts. For Muniesa (2011), valuation is a pragmatic action that

> should be understood in the sense of a process, a form of mediation, of something that happens in practice, something that is done to something else, and so forth; value is definitely not something that something just has. If value is something that something just has, then we need to ask: by virtue of what? (p. 32)

This conceptualisation offers a more nuanced and relational understanding of values and prompts reflection about how values emerge in practice and become meaningful factors for particular actors in certain circumstances. With respect to scientific resources, then, the "meaning of value is not to be found in the object that is being referred to, nor in the actors articulating it, but that it emerges from the practices in which this object is being referred to or valued" (Datta Burton et al., 2022, p. 392). The analytical utility of a valuation approach has been recognised both in considerations of openness in science (Levin & Leonelli, 2017) and in the life sciences and medicine more specifically (e.g. Datta Burton et al., 2022; Dussauge et al., 2015). Importantly, valuation practices draw on a range of logics (e.g. economic, epistemic or ethical) which may need to be compared or reconciled in relation to one another (Boltanski & Thévenot, 2006). Here, relevant practices would include, for example, dynamics around sharing and collaboration where stakes for openness are articulated, negotiated and decided upon.

The remainder of the chapter applies valuation as a conceptual foundation to examine openness as enacted through practices around trust, communication and sharing. Using stem cell research as a case study, it examines how this field's resources, and most importantly stem cell lines and data, become imbued with value through how they are used. Often, this value becomes apparent in decisions about whether to share them (or not) with others, and why. Because values are contingent and context-dependent, as they are enacted through processes of valuation, so too is trust. Therefore, trust may take on several valences—through evaluations of the trustworthiness of potential collaborators, institutions and even the resources themselves, to sentiments of obligation about being entrusted with particular biological materials from donors and patients. The following empirical insights aim to provide an illustrative account of the diverse enactments of trust that become visible through considering dynamics of valuation.

Stem Cell Research in Australia: A Case Study

In exploring the relationships between sharing, valuation and trust in stem cell research in Australia, the following empirical analysis draws on a subset of qualitative data collected as part of a broader collaborative research project drawing on expertise in stem cell research, science communication, bioethics, and law and regulation. This project explore the meanings and possibilities for openness in Australian stem cell research, both within stem cell research communities and their interactions and engagements with other interested parties, including patients and donors, policy influencers and the media.

This chapter will focus primarily on the interactions among stem cell researchers, primarily in academia. Specifically, it explores the research question: How does the valuation of materials and resources in stem cell science inform relations of trust among stem cell researchers? Insights were obtained through 46 semi-structured interviews that were conducted between July 2022 and March 2023. Informed consent was obtained beforehand, interviews lasted between 30 to 90 minutes (some interviews were shorter because of participant time limitations), and most interviews were conducted in-person, with the remainder taking place over Zoom. The interviews covered a range of topics and themes related to perspectives and practices around openness, broadly understood. These included: obtaining and sharing research materials and resources; entering into collaborations; the use and value of stem cell registries and/or banks; ethics, privacy and confidentiality in research; and public engagement and the public good. The interviews were audio recorded, transcribed and then qualitatively analysed using NVivo 14. This analysis involved iteratively developing a codebook among several members of the research group. Identities of interview participants have been anonymised, and each direct quote is accompanied by a designated reference number for each interview participant (e.g. RS01 = Researcher #1). Finally, interview participants were given the option to approve the use of their quotes in research outputs, and to make slight amendments to improve the clarity, but not change the meaning, of their quotes; some quotes below have been modified in this manner.

Valuation, Communication and Trust in Stem Cell Research

Stem cell research generates, and depends on, a range of resources to produce research findings and support work towards translational outcomes and therapies. On the one hand, there are resources including stem cell lines of various kinds, including embryonic stem cells and human-induced pluripotent stem cells. These stem cell lines might then be used to generate particular specialised cells (e.g. heart or brain cells) or organoids for experimental research. On the other hand, there are text-based resources, such as data. Often, these two types of resources—stem cell lines and data—are, to varying extents, interconnected; for example, genomic data can be obtained through sequencing the DNA of stem cells. But for the purposes of the following analysis, they will be treated separately in order to draw attention to differences in how they are valued. Finally, although there are certainly other resources that are important for stem cell research (e.g. reagents), it is hoped that focussing on the juxtaposition and comparison of these two types of resources will allow us to demonstrate the usefulness of valuation as a conceptual framing and approach to understanding trust in scientific research. The aim, therefore, is not to provide empirical insights that are representative, in some proportional sense, to the patterns of perspectives obtained from the interviews. Instead, the aim is to provide a snapshot of the diverse ways in which these two types of resource are valued in stem cell research, and the similarly diverse ways in which these valuations inform practices around trust, communication and sharing.

Stem Cell Lines

As mentioned previously, there are several types of stem cell lines. Embryonic stem cells (ESCs) were the main type used when the field was established. Currently, human-induced pluripotent stem cells (hPSCs) are predominantly used by contemporary researchers because they are perceived to be more useful for research whilst also being less ethically problematic. There are important differences between the two, especially with respect to provenance, ethics and regulations (Slack, 2021). For example, whilst ESCs are, as the name suggests, obtained from embryos, hPSCs may be reprogramed from a range of adult cells (e.g. skin cells). Stem cell lines derived from these latter sources are significantly less controversial than the former, and this difference accounts for how they are valued in different ways. This trend was notable in our interviews with stem cell researchers, most of whom conduct research using hPSCs.

Consequently, research with hPSCs will be the focus of the analysis in this section.

Stem cell researchers can obtain hPSCs in multiple ways. Firstly, many researchers produce their own lines, often using cells from donors. These lines are valued in several ways, affecting whether and how they are entrusted to other researchers who might request them for their own research or shared through collaborative projects.

For many researchers, the first consideration when making decisions about whether to share is having the permission to do so. As one researcher noted, "ethical concerns are so overwhelming" (RS10), so the permission to share their lines, determined by donor consent, is paramount. The consent processes consequently shape what research enquiries are possible using these lines; for example, it was noted by several researchers that there are generally more restrictions on using donor samples for commercial as compared to academic research. One researcher recognised that stem cell lines, compared to other resources such as reagents or tools, come with a 'human aspect' that means that they are a "special thing and it's, you know, it's connected to an individual on some level so you have to be a little bit more rigorous with being careful with how you share them" (RS04).

Other researchers were much more direct and explicit about how this 'human aspect' shaped their valuations, first in terms of the obligations of being entrusted with biological materials from donors, and subsequently with what this meant for who they trusted and were willing to share the cell lines with. For example, one researcher (RS42) articulated these multiple meanings of trust by noting that "people are willing to donate their blood for us to generate stem cell lines, because they trust us to then adhere to the ethical procedures and ensure that the cells get used in a way that they would be comfortable with". They therefore felt that "we're responsible for everything that happens with the cells always, so you do have to have a level of trust in your collaborators and your colleagues [that they] are going to use the cells and manage the data in a way that is appropriate". Here, although this perspective is an example of 'moral' trust as described earlier, there appear to be two valences of this trust being invoked—trust bestowed on researchers by the donors (being entrusted), and trust in their collaborators to do right by the researchers (and, therefore, to abide by the trust placed in them by the donors). Furthermore, and relatedly, there are clearly concerns about public trust in scientific research; carefully choosing with whom to collaborate and share materials is an important means for securing ongoing trust from particular publics (e.g. donors who enable research through providing biological materials).

Another researcher (RS09) invoked a related type of trust when noting that "we will be hesitant to perhaps distribute our donor lines to any country where we don't have a strong confidence in the legal system and the ethical guidelines that ensure the lines won't be misused and there'll be some restrictions on a person if they did breach those lines or some consequence". In this statement, trust relates not only to potential collaborators, but to the legal institutions in other countries that would provide oversight and sanction those who carry out unethical research. Together, these sentiments about responsibilities to donors affect how researchers might choose to share these resources.

For other researchers, beyond these initial requirements regarding donor consent, a more general, and generous, ethos of openness was emphasised. Material Transfer Agreements (MTAs) have become a standard means through which to enable the sharing of resources including stem cell lines. Within these agreements, a range of stipulations is negotiated and agreed upon, including ownership of the materials and the types of research for which they can be used (Whitton et al., 2019). However, for some researchers, there were differences in how these agreements were treated and relied upon to facilitate communication and collaboration, especially in the context of newer research partnerships as compared to more established ones. These distinctions illustrate the importance of differences in 'affective' trust between nascent and ongoing collaborations. For example, one researcher (RS22) compared how they perceive the role of MTAs in these terms:

> It's through this unspoken understanding because we know each other and there's this sort of understanding that you can trust them in how they're going to work with and handle the materials. And vice versa. Whereas the discussion about MTAs comes up sooner with newer collaborations.

Finally, there were some researchers who felt that the effort to produce stem cell lines, and then share them, imposed certain obligations on those who receive them. One researcher (RS01) described their ethos around sharing stem cell lines in the following way:

> We generously invest significant time and resources to provide collaborators with the cells needed for their experiments. Our commitment is a courtesy, and we appreciate collaborators who genuinely value and utilise the cells for research. However, some individuals are not very communicative and simply acquire the cells without a clear purpose, making it challenging to track their usage. When asked about the fate of the cells, vague responses such as "I forgot", "not working" and "not sure" are not conducive to a productive collaboration. In such cases, I am inclined to terminate the collaboration swiftly.

Here, trust resides more in the willingness and gratitude of a collaborator-recipient of stem cells to make effective use of them in their research, and not take for granted the effort, time and resources required to produce the stem cells. For this researcher, recipients should value these stem lines by making productive use of them and be willing to share updates about their use when prompted. Others invoked similar perspectives, but emphasised notions of care: "In case I know that the lab doesn't have the capacity to maintain the line healthy and doesn't have the knowledge to deal with the lines, so I might be hesitant. I just need to know that this lab can handle it properly and is also keen to learn if he can't, he or she can't" (RS24).

Finally, if researchers do not create their own lines, they will need to obtain cell lines from elsewhere. This could be from other researchers, whether through one-off requests or more ongoing collaborations, or through centralised biobanks and repositories, some of which are commercial in nature. However, some researchers deliberately sought to avoid obtaining lines from other researchers. For example, one researcher upholds that "Generally, as a rule, I'm not supportive of exchanging cell lines between labs because it can compromise their quality for research. For example, failure to follow basic principles of good cell culture practice is likely to lead to contamination with other unwanted microorganisms, impacting experimental reproducibility and reliability"

(RS27). Here, there is a lack of trust in the quality of other researchers' lines—that is, the practices around which they are generated and maintained, and even knowing which lines are which. Thus, these lines are valued less than those obtained from commercial sources. Complementary perspectives were expressed by another researcher who, in part, chose to rely on generating their own lines: "we can generate, like, those kinds of specialised cell types in our own lab, and we can watch them and we know what they are, and then we sort of trust those a bit better" (RS39). In these contexts, 'cognitive' trust is clearly an important factor. Here, valuations of the reliability of the practices which produce lines affects decisions about where to obtain these resources, and potentially demonstrates the limitations of sharing when trust in, and positive valuations of, quality standards with respect to stem cell lines are uneven, in part because there is currently no Australia-based system for registering lines.

Data

During the interviews, respondents were prompted to compare stem cell lines and data (including computational data resources based on cell lines) in order to gauge whether there were differences in how they were valued and whether this affected decision-making about sharing practices. Whilst for some researchers there were few significant differences between the two types of resources, others attempted to articulate clear distinctions. Here are examples of the latter from two researchers:

> So if people approach you for a resource like a cell line, they have a very specific project or a very specific use in mind that goes into the MTA. Everybody's very clear about what the plan is. By the time it comes to data, that plan may have changed and exactly what has been done and what has been generated may be quite different from the original plan. So I see them as distinct things. (RS23)
>
> Biological resources used primarily as a starting point for the research of others can be readily shared. However, data, which may potentially build on years of unpublished research, may require more involved conversations before sharing. (RS30)

One insight that is apparent from these two perspectives is the temporal dimensions of data as a type of resource and output. Over time, data may be modified, combined and subject to several distinct avenues of enquiry, enabling new insights, outcomes and bodies of work that substantially depart from what could be obtained from the stem cell lines from which they were derived. This distinction warrants separately valuing data-based resources, especially before publication. One researcher explained, "If it's unpublished, it's my practice and I think it's reasonable, not to just gift that out because, I mean, that's our bread and butter, our scientific output, we can't survive if you don't produce" (RS18). Another researcher echoed, "you're only going to share data with people that you genuinely trust" (RS23).

Broadly, there were two different sets of concerns with respect to valuing data, and subsequently who could be trusted enough to be provided with it, that emerged from the interviews. On the one hand, there were pervasive concerns about competition. Researchers repeatedly mentioned how competitive pressures—to publish frequently and in high-ranking journals, to acquire ongoing and sustained funding—at times constrained their willingness to share. Data, the 'bread and butter' mentioned above, is paramount. One researcher reflected on early conversations with a potential new collaborator that did not end up working out:

> They hardly spoke about their work. They just asked questions about our work and didn't share a lot. In our conversation I shared a bit about our studies, but from the little that they shared I worked out that they were doing similar work to us but not sharing their data. My thoughts were "No, this is not going to move forward—they are not interested in collaborating, they just want to get information." And I'm not sure if I would want to collaborate with them in the future as they were not open in their discussions and often I'm a very open person and discuss our work and our findings. Not that I expect the same level of openness from them, but you can sort of tell in the discussion how collaborative people are. I respect if someone tells me work from their lab that's unpublished and not out there and expect the same from them. (RS22)

This comment echoes Morrison's findings that burgeoning collaborations involving unpublished findings often require an "ethos of reciprocity" (2017, p. 11). Expressed another way, the ethos of reciprocity did not emerge because each researcher enacted differences in valuation. For the quoted researcher, data is valued as a means to build 'affective' and 'epistemic' trust in early collaborations, and thus its value, in this context, derives from at least partial disclosure about research interests and progress. For the other researcher in this unsuccessful nascent collaboration, this approach was evidently not the preferred one; instead, data is valued primarily as information on which to build scientific investigation and not as a means to build relationships.

On the other hand, valuations of data also revolve around concerns for respecting the privacy of patients and donors, another example of 'moral' trust. This process often requires building sustained trust with potential collaborators because "sharing the SNP [single-nucleotide polymorphism] data or any kind of genomic data … might reveal the identity of the patient" (RS24). With respect to patients and donors and trust, these perspectives about data differ in some ways from those articulated earlier with respect to stem cell lines. Whilst there is a similar sense of obligation and responsibility for being entrusted with these two types of resources derived from patients and donors, with stem cell lines, it was more about ensuring that their interests with respect to how the materials are subsequently used were upheld, whereas in the case of data, the concerns relate primarily to privacy and confidentiality. This example underscores how stem cell researchers see data as a distinct type of resource, where particular sets of concerns are at stake that have implications for how it is entrusted and shared with others. Despite these divergent valuations of stem cell lines and data, there is a shared underlying concern amongst researchers about public trust in stem cell science, and avoiding public perceptions of deception or misconduct that might compromise their research reputations.

Conclusion

Scientific research requires and produces a range of resources, from biological materials to data to published findings. These resources are not merely supplied or exchanged in transactional encounters. Instead, they play important roles in the ways in which researchers communicate and collaborate with one another. Efforts to promote more openness in science therefore require considering a socio-material conceptualisation of communication, one that highlights the important role of resources in particular scientific fields and contexts. Trust relations between researchers are especially significant when seeking to understand the possibilities for openness in scientific research.

In this chapter, these dynamics were explored using stem cell research in Australia as a case study. Through semi-structured interviews, researchers in this field articulated a range of perspectives and practices. For example, with respect to sharing stem cell lines, some researchers expressed feeling that they were 'entrusted' with donor lines, and thus were obligated to share them in responsible ways. Other researchers were somewhat distrustful of providing their lines to others, out of fear that these valuable resources would be neglected or improperly handled and not cared for. In these cases, it was the possibility of prospective recipients not valuing their labour and generosity—embodied in the act of sharing stem cell lines—that is perceived as a breach of trust. And still others expressed a general distrust of lines created by other researchers and were not confident that they were reliable enough to meet their standards. These articulations of trust and sharing do not provide a straightforward picture of openness. Instead, they offer a more complicated and nuanced one, in which varying trust relations lead to uneven patterns of openness within scientific fields, a complex ecosystem of dependencies and contingencies.

Furthermore, at times the valuation of research materials and resources had broader implications beyond the interactions and dynamics among scientific communities. On the one hand, stem cell lines were often valued as deserving of particular care and consideration because they had been donated. This understanding came with a heightened sense of responsibility and obligation to entrust cell lines to researchers who would put them to perceived appropriate uses. Data, on the other hand, was valued as a powerful potential marker of donor identity; here, researchers exercised caution and adopted a risk-averse approach to sharing. Nevertheless, in both cases researchers entrust and disseminate these resources based on their perceptions of, and respect for, the needs, rights and expectations of specific publics (in this case patients and donors).

Articulating this account of trust was possible through adopting a conceptual approach based on valuation, which highlights how values emerge from situated practices. Analysing the myriad valuations of objects, such stem cell lines and data, allows us to similarly pluralise trust in multiple forms. Moving forward, two future research directions could constructively build on the conceptual and empirical insights analysed here (although these are by no means the only ones that could be pursued). Firstly, our analysis was limited to two types of resources—stem cell lines (a biological resource) and data (an informational resource). However, as we noted earlier, there are other material resources that are critical for scientific research (e.g. tools and technologies), and these require comparative attention as well. Secondly, we focussed exclusively on the valuation practices of scientific researchers. Expanding the analytical purview to include the perspectives and practices of other interested parties—including regulators, clinicians, and patients and donors—could potentially reveal more complex and contingent networks of trust and sharing within broadened research ecosystems. If informed by a socio-material conception of communication and collaboration as developed in this paper, further research could reveal additional tensions and contradictions in various enactments of trust, and therefore permit more nuanced appreciation of the tenuous, precarious nature of openness in scientific research.

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18

Challenges in Defining and Measuring Trust and Distrust in Science

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Introduction

Trust is a fundamental aspect of human life that enables individuals to make informed decisions—whether it is using a specific company's product or telling a friend a secret, trust is required. The Covid-19 pandemic has clearly shown that trust in science is a field worthy of

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attention as trust in science can have life-saving consequences. Questions regarding trust in science are socio-scientific questions, which are inherently complex, making science-informed answers difficult—if not impossible—for laypeople to fully comprehend (Bromme & Gierth, 2021). Trust is needed when making decisions, such as wearing masks and keeping one's distance or whether or not to get vaccinated, since a profound understanding of medical procedures cannot be expected. Therefore, it is vital when socio-scientific expertise is required that people trust what they learn from scientists. While trust in scientists should certainly not include blind trust or overtrust (O'Brien et al., 2021), the problem that we are currently facing is a lack of trust in science or distrust. This is a significant problem as not only will a lack of trust hinder people from following potentially life-saving advice from scientists, but empirical studies show that distrust in scientists reduces one's willingness to be open to scientific innovations (Lewisch & Riefler, 2023).

In line with this, there is growing concern about an increasing distrust in science associated with the rejection of established scientific consensus (Lewandowsky & Oberauer, 2016). These developments indicate that there is a need for a well-defined and operationalised construct of distrust in science. While trust in science has been formalised from different angles and within different disciplines, distrust in science has not received the same level of theoretical and empirical attention. Although distrust in science is frequently mentioned in the literature, it is rarely assessed (Reif & Guenther, 2022). Distrust is often defined as the opposite of trust, which can be problematic if not distinguished. This oversight can lead to difficulties in measuring both trust and distrust and can hinder or even undermine theoretical conclusions and advancements.

The description and measurement of trust and distrust suffer from an inconsistency regarding the relation between the two constructs. They are sometimes treated as two sides of the same coin, while at other times they are considered as two distinct constructs. Additionally, trust and distrust are often not explicitly defined. When both constructs are understood as two sides of the same coin, it is not clear what is meant by "lack of trust" or "absence of trust". This section raises questions about whether there is a function to distrust that is not captured when trust and mistrust are defined along a single continuum. In this chapter, we outline and contrast two different perspectives of trust and distrust in science. This chapter provides definitions of trust and distrust in science and presents two perspectives: (a) trust and distrust in science are one variable on a single continuum; and (b) trust and mistrust in science are two variables on two separate continua. We then discuss measurement issues and provide recommendations for selecting the most appropriate measurement.

Definitions of Trust and Distrust

To illustrate the relationship between trust and distrust in science, we begin with a general definition. It is important to note that specific literature focusing exclusively on definitions of (dis)trust in science communication is rare. However, (dis)trust in science can be considered as a consequence of science communication (see Schäfer, 2016) which is why we argue that (dis)trust in science is a prerequisite for (dis)trust in science communication. Bhattacharya et al. (1998) provide a comprehensive overview of trust from the disciplines of economics, sociology, and psychology, formalising trust as follows:

> “Trust is an expectancy of positive (or nonnegative) outcomes that one can receive based on the expected action of another party in an interaction characterised by uncertainty”. (p. 462)

Trust, then, is a relational variable that describes the relationship between a trustor and a trustee, marked by the uncertainty of the trustor in predicting the intentions or actions of the trustee. This state of uncertainty means that the trustor accepts a particular vulnerability towards the trustee, as there is no possibility to control the trustee’s actions (Mayer et al., 1995). Distrust, on the other hand, can be defined as a negative expectation of another party’s actions (Bhattacharya et al., 1998; Lewicki et al., 1998). It is an alternative path to trust, where one reduces uncertainty (see Luhmann, 2017) by refusing to be vulnerable to another party’s actions. This decision to be vulnerable is influenced by situational inputs, leading individuals to determine a certain level of trust and distrust. These beliefs develop over time and form a cycle in which another party's actions feed back into the trustor's perceptions of the trustee (Dietz, 2011; Six & Latusek, 2023).

In the context of science, laypersons may experience great uncertainty when presented with scientific information and become vulnerable to believing false information as they lack the means to verify the information. Hence, laypersons face the risk of accepting information that might be incorrect or incomplete and taking actions based on it that may be useless or even harmful (e.g., drinking bleach to fight Covid-19). Due to the complexity and diversity of science and its disciplines, one cannot rely on one's own experiences or knowledge to determine whether something is true. The uncertainty leads to a state of vulnerability and a certain degree of risk, resulting in an asymmetrical relationship between laypersons and scientists (O'Doherty, 2023; Schäfer, 2016). Since laypersons have limited capacities to control the process of knowledge generation or fully comprehend scientific knowledge, they need to rely on experts (Bromme & Gierth, 2021), which means trusting experts by accepting this dependency (Schäfer, 2016). However, whether or not laypeople are willing to place this trust in experts depends on their expectations towards science.

How these expectations are formed, and thus influence whether laypersons trust or distrust science, depends on a set of encounters with science and scientists. Trust and distrust in science and scientists are often defined as multidimensional variables that occur on different levels. Reif and Guenther (2022) differentiate between trust in individuals like scientists (micro-level), trust in scientific institutions, such as universities or other groups of scientists (meso-level), and trust in science as a system (macro-level).

When people find themselves in situations where they need to rely on scientists (or scientific experts), they judge the other party's expertise, benevolence, and integrity (Hendriks et al., 2015, 2016), openness or transparency concerning the scientific process (Besley et al., 2021; Reif & Guenther, 2022), and (public) image (Reif & Guenther, 2022). These mechanisms apply to the micro-level but could also be valid for the meso-level, for instance, in evaluating specific groups of scientists. On a macro-level, trust can be defined as reliance, confidence, and dependence (Mousoulidou et al., 2022), for example, on or in science in general or in a specific area (e.g., climate science). For our definition, the individual must encounter diverse forms of "science" representation at each level described above (Reif & Guenther, 2022). Direct contact with scientists, researchers, and scientific institutions, as well as first-hand experiences, journalistic offers (e.g., "National Geographic"), and cultural representations of science (e.g., in books or TV shows like "The Big Bang Theory") are all valuable sources of information that shape a persons's level of (dis)trust in science. The sum of these previous contact points predicts people's overall expectations of science. The level of personal expectations, positive or negative, determines an individual's level of trust (or distrust) in science.

Two Perspectives on Trust and Distrust[1]

Over decades of trust research, different perspectives have emerged describing the relationship between trust and distrust. By now, the discussion on the relationship between trust and distrust has been going on for more than 30 years, with an increasing body of research stating that trust and distrust are two different constructs (e.g., Lewicki et al., 1998; Sitkin & Roth, 1993). However, some scholars argue that a complete lack of trust is synonymous with distrust, which appears to be the more traditional view (e.g., Schoorman et al., 2007). Schoorman and colleagues (2007) state that because trust and distrust are frequently described as polar opposites (for an overview, see McKnight & Chervany, 2001), there is no added value in treating them as distinct variables. Since one objective of this work is to address the question of whether trust and distrust (in science) are two sides of the same construct or two separate constructs, we will discuss the two different perspectives in the following (Fig. 18.1).

[1] For another differentiation of trust and distrust in science, see Chapter 16 in this book.

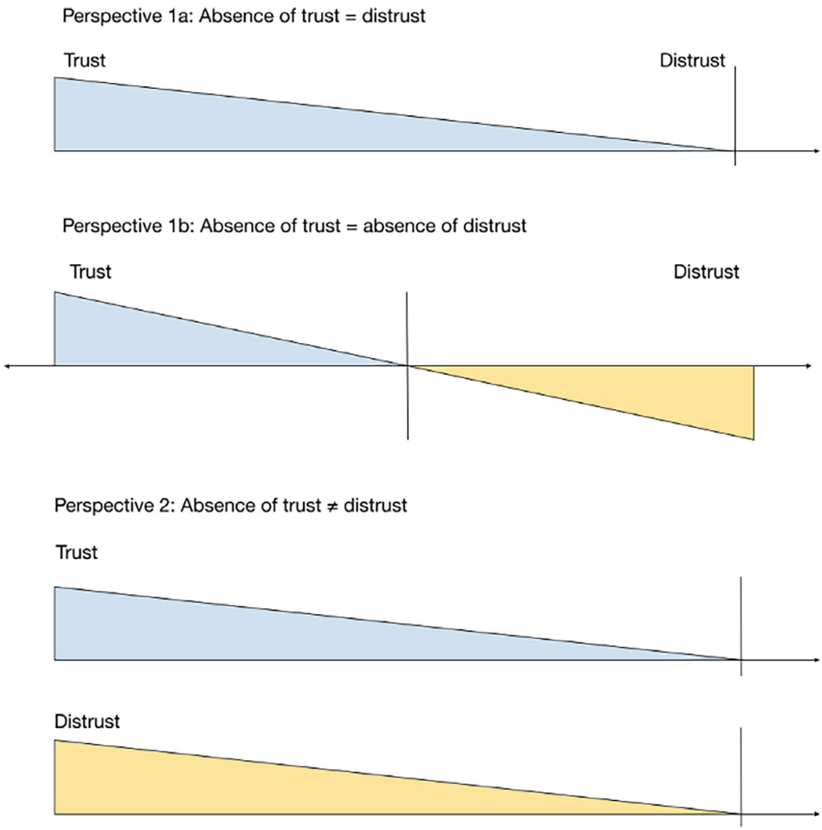

Fig. 18.1 Two perspectives on trust and distrust in science

Perspective 1: Trust and Distrust as Two Sides of the Same Construct

In a traditional view, distrust is defined as "the lack or absence of trust" (The Merriam-Webster online dictionary; Fig. 18.1, Perspective 1a). However, this perspective is insufficient to describe distrust because viewing distrust as the mere absence of trust denies that distrust has functions and purpose, like reducing uncertainty or decreasing vulnerability (Luhmann, 2017; Six & Latusek, 2023). Per definition, an absence of trust would be the absence of a positive expectation, while distrust is described as a negative (non-positive) expectation (Bhattacharya et al., 1998; Lewicki et al., 1998). However, we argue that not having a positive expectation is not the same as having a negative expectation. Thus, distrust is more than a mere absence of trust since distrust describes an active mindset, for example, that another party will cause harm somehow.

Another approach (Fig. 18.1, Perspective 1b) slightly alters this view: while remaining on a continuum, trust and distrust take on positive and negative values, respectively, and can be considered opposites of each other (see McKnight & Chervany, 2001). In this approach, distrust retains its functions of reducing uncertainty (Luhmann, 2017) or protecting oneself against perceived harmful events as one does not accept being vulnerable towards another party (e.g., Six & Latusek, 2023). Consequently, defining distrust solely in terms of the absence of trust does not do justice to the complexity of trust and distrust, as it denies the active functions of distrust (Six & Latusek, 2023).

Approaches locating trust and distrust as two poles of one construct (e.g., Bigley & Pearce, 1998; Lewicki & Bunker, 1996) do not consider the levels to which trust and distrust relate and the expectations someone might have. Schoorman et al. (2007) argue that trust is specific to a particular domain, thereby allowing a more granular view of the complexity of trust. This specification and focus addresses the criticism which defines trust and distrust as separate constructs (e.g., Lewicki et al., 1998). Once it comes to specifying the situation and the object to which trust is applied, the coexistence of trust and distrust is no longer possible (McKnight & Chervany, 2001). As soon as trust and distrust refer to the exact same property of a party, they are unlikely to exist simultaneously. Consequently, they must exist on the same continuum exist on the same continuum because they are functionally equivalent (Luhmann, 2017) (Fig. 18.1, Perspective 1b).

Imagine that someone trusts the expertise of scientist X, then the same person cannot at the same time distrust the expertise of that scientist. However, the person could distrust the benevolence of scientist X (see Hendriks et al., 2016). This means that trust and distrust at the same referential level are mutually exclusive and can only coexist if they do not refer to the same objective or expectation. Therefore, distrust of scientist X can only occur with a changed view of the circumstances or objective. The conceptual separation, thus, arises from the assumption that states of trust and distrust can coexist but becomes obsolete when one considers different dimensions of trust like expertise, benevolence, integrity, or transparency (Hendriks et al., 2016; Reif & Guenther, 2022).

Using a combination of interviews and card-sorting data, Saunders et al. (2014) examined the relationship between trust and distrust in the corporate context. They drew on the distinction of high/low trust/distrust proposed by Lewicki et al. (1998), which illustrates the parallel existence of trust and distrust as distinct constructs. Based on their results, they added the two subgroups of weak trust and distrust between the two external poles of high and low expressions of trust and distrust. Except for the combination of high trust and high distrust, they found corresponding evidence for the remaining combinations. In one case, the co-occurrence of weak trust and weak distrust is noted, reflecting support for Schoorman et al.'s (2007) argument that trust and distrust occur towards the same entity but not in the same context. However, when trust and distrust are applied to the same entity, and no distinction within the (positive or negative) expectations of a trustor is made, Lewicki et al.'s (1998) perspective of trust and distrust as distinct constructs is supported (Saunders et al., 2014, Perspective 2).

Perspective 2: Trust and Distrust as Different Constructs

In contrast to the first perspective, numerous scholars suggest that trust and distrust are distinct variables rather than two extremes on the same continuum (e.g., Lewicki et al., 1998; Luhmann, 2017; McKnight & Chervany, 2001; Sitkin & Roth, 1993; Van De Walle & Six, 2014) (Fig. 18.1, Perspective 2). Both trust and distrust are described as strategies to reduce uncertainty and increase certainty, respectively. However, the respective underlying mechanisms are assumed to be different. Trust is associated with positive mental states such as hope and confidence, while distrust is associated with negative states like cynicism or fear

(Lewicki et al., 1998; Luhmann, 2017; McKnight & Chervany, 2001). Consequently, trust is often described as a positive expectation of a person's conduct or motivations towards another party and distrust as a negative expectation of their conduct or motives (Lewicki et al., 1998; Sitkin & Roth, 1993). This is an important differentiation because positive and negative expectations are seemingly associated with unique emotions, cognitions, or behaviours (Lewicki et al., 1998; Saunders et al., 2014).

Another difference between trust and distrust is located in the distinct levels of activeness: a mere absence of trust does not imply an active expectation that another party has harmful intentions (Van De Walle & Six, 2014). Rather, a lack of trust indicates the absence of the expectation that another party will do good things. This anticipation is not the same as actively believing another party will do bad things. Hence, low trust and distrust could be regarded as passive expectations involving high cognitive uncertainty about another party's behaviour or intentions. On the contrary, high trust and distrust are active expectancies entailing low uncertainty that the other party will benefit or harm someone, respectively.

When trust and distrust are defined as different variables, a lack of trust/distrust could provide the space to develop active distrust/trust (see Lindenberg, 2000). This implies that having low trust/distrust can be a precondition for subsequent high distrust/trust, which may account for negative associations between the variables. However, it is not necessarily given that persons who do not trust another party automatically distrust this party. Some scholars even argue that trust and distrust can simultaneously coexist when treated as separate variables (Lewicki et al., 1998; McKnight & Chervany, 2001; Van De Walle & Six, 2014). In interpersonal relationships, simultaneous states of high trust and high distrust may be evident in experiences of ambivalence where someone has positive expectations about certain actions of another party and, at the same time, negative expectations about other actions of the same party (Lewicki et al., 1998). Such forms of simultaneous high trust and distrust may become visible in situations in which someone trusts another party but also controls their actions. In an empirical study on this topic, Saunders and colleagues (2014) found support for the two perspectives of trust and distrust as distinct variables but also that they are mutually exclusive. Although they found that some people have low trust and low distrust simultaneously, situations in which people have high trust and high distrust simultaneously are unlikely. They did identify rare cases in which people can have weak trust and weak distrust at the same time (see perspective 1). These findings suggest that trust and distrust are separate variables because they are associated with different expectations and affective states. Nevertheless, due to the negative relationship between trust and distrust, it is highly unlikely to have simultaneous high trust and high distrust in the same domain. These results can lead to different interpretations, and the authors themselves are divided in interpreting their results and refrain from finally concluding (see Saunders et al., 2014). It is for this reason that in our discussion of perspective 1, we appealed to this study. Nevertheless, the findings of the study indicate that trust and distrust should be located on separate continua (Fig. 18.1, Perspective 2), but they stand in a dialectical relationship. Separating the continua of trust and distrust makes it easier to think of them as two distinct—albeit mutually exclusive—variables associated with distinct causes and outcomes.

Classification of Previous Works on Trust and Distrust in Science and Science Communication

Turning to trust and distrust in science (communication), we also find different conceptualisations of the two variables, with a growing body of studies adopting the stance of trust and distrust as distinct constructs. Hence, in this part, we will contrast the two perspectives above and integrate them into the empirical landscape of trust and distrust in science. Ojala (2021) argues that trust and distrust in climate science are parts of distinct coping mechanisms to deal with anthropogenic global warming. On the one hand, trust-based coping involves relying on involved actors leading to a positive mental state, such as hope and behaviours like assuming personal responsibility trust-based coping. On the other hand, trust-based coping involves downplaying the consequences, doubting the existence of global warming, and actively resisting the necessity of taking responsibility. These different conceptualisations of trust and distrust involve distinct cognitions, affective states, and behavioural strategies that coincide with descriptions of trust and distrust as two different variables (Lewicki et al., 1998; Luhmann, 2017; McKnight & Chervany, 2001). However, in this example, it is equally likely that trust and distrust lay on one continuum from high distrust to high trust. In another study, Rowland et al. (2022) differentiate between trust and distrust in climate science as separate factors with distinct characteristics. Through qualitative interviews, they identified that a lack of trust can arise from misconduct, perceived inconsistencies, or contradictions by another party.

In contrast, active distrust is characterised by questioning the motives and intentions of other actors. This highlights the importance of distinguishing between a lack of trust in science and distrust in science. These findings align with previous research that differentiates between trust and distrust as distinct constructs (Lewicki et al., 1998; Van De Walle & Six, 2014) when assessed in a general context and not specifically to certain levels of (dis)trust Sarathchandra and Haltinner (2020) found that participants were sceptical and distrustful about the intentions of climate scientists, the applied methods and results of climate science, and the incentive structure (e.g., the influence of funders). Surprisingly, many participants still believed that politicians should rely solely on climate scientists when making policy decisions. This observation exemplifies simultaneous trust and distrust in science. However, we interpret this as simultaneous trust and distrust in different domains (Schoorman et al., 2007), rather than in the sense of Lewicki et al. (1998). Respondents' high level of distrust was additionally visible in the fact that they said that one should listen to ("real") science but that experts should be adequately vetted in advance ("trust but verify"; Lewicki et al., 1998). Meier and Krämer (2022) developed and validated a questionnaire assessing people's general science scepticism, defined as a disposition to doubt and distrust science, scientists, methods, and results. They discovered a large negative relationship between science scepticism and trust in science. Besides, trust in science and science scepticism shared unique variance in denying various scientific consensuses. This finding indicates that considering both trust and distrust, or scepticism including distrust, can provide a better explanation for why laypersons accept or deny scientific knowledge than only considering one of the two variables supporting the perspective of two distinct yet negatively related variables (Lewicki et al., 1998; Van De Walle & Six, 2014).

In sum, these examples demonstrate that trust and distrust in science (communication) are distinguishable by cognitive mechanisms (e.g., hope vs. doubt), are caused by different events (e.g., trust may decrease as a result of perceived misconduct, while distrust increases as a result of questioning the intentions of another party), and can exist simultaneously—albeit in different domains. For example, one may trust scientists to advise politicians well but still scrutinise their motives. However, it is unclear whether trust and distrust in science share a mutual continuum or are two separate yet negatively related variables due to the lack of empirical studies on this subject. As this might cause measurement problems, these are described in the following section.

Measurement Issues of Trust and Distrust in Science

Measuring trust and distrust in science can be challenging due to the various perspectives from which they can be viewed and defined. Therefore, it is of utmost importance to accurately define and assess trust and distrust in science to make reliable and replicable statements. This is essential for understanding the public's perception of science. One challenge in measuring trust and distrust in science (communication) is the lack of consistent definitions or a complete failure to define the constructs at all (Fage-Butler et al., 2022). Consequently, measurements of (dis)trust in science may vary significantly between studies or may not be adequate in addressing a specific research question. Similarly, Reif and Guenther (2022) argue that researchers often aim to assess either trust or distrust, but indeed measure the opposite variable. These problems make it difficult to draw clear conclusions about (dis)trust in science and render it impossible to empirically determine whether trust and distrust (in science) are distinct or the same variable. Other studies mix measures of trust in scientists working for universities and those working for the industry (e.g., Anderson et al., 2012; Ho et al., 2010), which might conceal underlying differences in people's perceptions. When measuring distrust and trust in science the context must be considered and evaluated to choose the appropriate measurement approach. Therefore, our first recommendation is to measure the specific construct that is used for the theoretical arguments (e.g., when the theoretical argument involves trust in science, trust and not distrust in science should be measured).

Although trust and distrust can be considered as separate variables, it is not likely for someone to have high trust and high distrust in the same aspect of one party simultaneously (see Saunders et al., 2014). Furthermore, the reasonable assessment of trust and distrust strongly depends on the given circumstances and how fine-grained the investigated matter is considered (Schoorman et al., 2007). A too-superficial assessment of trust and distrust in science may lead to conceptual and, thus, measurement problems. For instance, someone may expect that science benefits society in general (i.e. high trust in the benefits of science). Nonetheless, they may also hold the belief that scientific methods can be inaccurate (i.e. high distrust in scientific methods). When asked about their level of trust and distrust in science they may indicate both. Therefore, it can be inferred that trust and distrust are not interchangeable variables. In this instance, though, the superficial and uni-dimensional measurement of trust and distrust masks the discrepancy in trust and distrust scores that lie in different dimensions. Therefore, it can only be concluded that trust and distrust are domain-specific if asked specifically about them on different dimensions. It is unlikely that high or low trust and distrust co-occur within the same domain. Hence, it is crucial to measure trust and distrust accurately to determine whether they are two variables or one.

These arguments align with research indicating that trust in science and scientists is assessed with uni-dimensional scales or even single items, which can oversimplify trust and distrust as a multidimensional variable (Besley et al., 2021; Reif & Guenther, 2022). Consequently, our second recommendation is to define and measure trust and distrust in science using more detailed dimensions, depending on the specific question being asked.

When selecting measurements, it is important to consider both the appropriate perspective on the relationship of trust and distrust in science depending on the research objective and the careful selection of the measurements themselves. Examinations of scales that contain both positively framed items (indicating trust in science) and negatively framed items (indicating distrust in science), like the *Trust in Science and Scientists Inventory* (Nadelson et al., 2014), indicate problems concerning the factor structure. Although Nadelson and colleagues (2014) recommend using the scale as a uni-dimensional variable, recent studies have shown that it is multidimensional. For instance, Krüger et al. (2022) and Meier and Krämer (2022) re-examined the scale with exploratory factor analyses, revealing two higher-order factors that represent either positively or (previously reversed) negatively worded items. In both studies, the authors subsequently only used the positively framed items to measure trust in science. Similarly, Byrd et al. (2022) also used a subset of items from the original scale containing three positively and three negatively worded items and found a two-factor solution for this short version of the scale as well. These findings can be explained either by the fact that trust and distrust are two distinct variables (Perspective 2), that are not represented by a common latent variable. Alternatively, these findings can be explained by a frequently observed phenomenon where positively and negatively worded items load on different factors because of different response patterns (Dalal & Carter, 2014). Therefore, regardless of the definition of trust and distrust in science, researchers need to be cautious when combining items that measure trust and distrust in science. We recommend avoiding the use of (dis)trust in science scales that mix positively and negatively worded items.

We propose an alternative measurement method based on the provided definitions to supplement the frequently used approaches. For perspective 1, which views the idea of trust and distrust as two sides on one continuum, we suggest measuring trust and distrust in science on a bipolar scale with “I completely distrust science” on one end and “I completely trust science” on the other end of the scale. In this approach, it is essential to use a scale with a middle point to reflect the lack or absence of (dis)trust or indifference. To capture the possibility of someone having neither positive nor negative expectations towards science, we recommend using a scale with an odd number of response categories and labelling the middle point accordingly (e.g., “I neither trust nor distrust science" or "I have neutral feelings towards science"). Explicit labelling allows respondents to express agreement, disagreement, or indifference towards trust and distrust in science, as well as towards aspects, such as motives of scientists or science communication. In line with perspective 1, researchers should consider focusing on these sub-aspects depending on their objectives in measuring (dis)trust in science.

For perspective 2, which represents trust and distrust in science as two distinct variables, we propose using two different sets of items ranging from "I do not trust science at all" to "I completely trust science" *and* "I do not distrust science at all" to "I completely distrust science". This implementation allows us to capture, even though unlikely, simultaneously high levels of trust and distrust. Most fundamentally, the decision on how to measure trust and distrust must be anchored in the underlying theoretical perspective. This allows us to achieve a comparable norm for trust and distrust in science that can be used to further understand and develop the concept.

We want to emphasise that both options to measure trust and distrust in science are highly superficial and only appropriate to address general tendencies. For a more specific and detailed examination, measures accounting for the multifaceted nature of trust and distrust in science are needed. For this reason, we encourage further research that empirically explores the perspectives listed in this chapter to clarify the relationship between trust and distrust in science. Thus, we call for the development and usage of universal definitions of trust and distrust in science and the development and validation of scales that can be widely adopted to reduce the heterogeneity of measurement instruments.

Conclusion

This chapter aimed to provide an overview of different theoretical approaches to trust and distrust in science (communication) and to link these two issues of measuring the constructs. A final assessment of which of the two approaches is more likely to be correct is highly complex and is further complicated by a lack of empirical evidence. Based on the arguments presented in this chapter, we recommend that the following questions be considered when defining and measuring trust and distrust in science:

1. *Who or What Is the Object of Trust or Distrust?*

Measures of trust and distrust should be as specific as possible, and scholars should reflect on the respective level of detail. Neglecting the nuances involved in measuring trust and distrust in science can lead to significant complications that make it difficult to accurately assess trust, distrust, and their related dynamics. This, in turn, can undermine the validity of theoretical conclusions and any related goals.

2. *Which Measure of Trust or Distrust Is Adequate?*

Quantifying trust and distrust in science using improperly validated scales or oversimplified single-item measures causes multiple problems. We, therefore, encourage researchers to consider appropriate measures that reflect their objectives and to consider hybrid approaches that acknowledge the relationship between trust and distrust. Also, we encourage scholars to develop and validate scales for general use that can be widely adopted and eventually reduce the quantity and heterogeneity of measurement instruments.

3. *What Is the Focus of the Work?*

The question of how to define trust and distrust in science is complex and exceeds mere measurement. Regardless of the perspectives chosen for the measurement, trust and distrust are multifaceted constructs which reflect upon different actors, states, and expectations with unique functions. Therefore, scholars should avoid making statements about distrust when trust is measured and vice versa. Lastly, we would encourage scholars to investigate trust and distrust in science simultaneously, as this may lead to new insights and theoretical development.

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19

Trust Cues in Content about Science: How the Media Presents Female and Male Scientists Differently

Justin T. Schröder

Introduction

During the COVID-19 pandemic, science was enormously important to people's lives. Science had a significant impact on the behavior of people who wanted to protect themselves and others from infection, and science enabled the development of vaccines, which played a key role in fighting the pandemic. Despite female scientists being at the forefront of COVID-19 vaccine development, female scientists did not feature to the same extent as their male counterparts in related media coverage (Hubner, 2023; Joubert et al., 2023). This problem has persisted, with women continuing to be underrepresented not only in news coverage about COVID-19 (Araújo et al., 2022; Fletcher et al., 2021) but also in media coverage about science itself (Kitzinger et al., 2008a; Mitchell & McKinnon, 2019; Niemi & Pitkänen, 2017).

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Not only during crises, but also in the context of everyday life scientific information is becoming more and more important in an increasingly complex society (Hendriks et al., 2015; Vaupotič et al., 2021). *Public trust in science* helps to reduce this complexity (Giddens, 1990). In the field of communication research, *trust* is viewed as a relational variable that involves a minimum of two parties: firstly, a subject of trust, and secondly, an object of trust. Most people receive scientific information, or, indeed, come into contact with science, through (digital) media (European Commission, 2021; National Science Board, 2018; Wissenschaft im Dialog, 2021), which in the case of science communication act as intermediaries of trust, meaning that they mediate trust between a subject of trust (publics)[1] and an object of trust (science). Media do so by providing *trust cues*: linguistic components, such as language and characteristics, that serve as indicators of trust that public audiences can use to assess whether or not to trust science (Schröder et al., 2024).

Given the differences in the presentation of female and male scientists in science media coverage, it seems plausible that variations also exist in how trust cues are depicted for each gender. This is particularly significant because female scientists play a vital role in advancing scientific knowledge, and modern societies increasingly rely on information derived from this knowledge for daily decision-making and the management of crises. Furthermore, equitable presentation is important as female scientists are role models, especially for young women with the desire to become scientists (Kitzinger et al., 2008b). As such, it is crucial to investigate potential differences in media coverage of female and male scientists with regard to the portrayal of trust in science.

Therefore, the overarching research question of this chapter is: *How is trust in female and male scientists mediated differently in content about science?* To answer this question, a qualitative content analysis will be

[1] In this research, the terms "publics" and "public audiences" are used to account the constituency of the modern public sphere by linking diverse media types. This leads to "a multitude of overlapping publics of different sizes, lifespans, visibility, and impact, across a variety of online and offline communicative channels and platforms" (Bruns, 2018, p. 339).

applied to the most important sources of scientific information for German publics; thus, trust cues will be identified, with an emphasis on the differences regarding how they are used when referring to female and male scientists.

Theoretical Background

Female and Male Scientists in Science Media Coverage

Female scientists are significantly involved in scientific progress: Marie Curie discovered radioactivity, Ada Lovelace created the world's first computer program, and Ann Tsukamoto co-patented a process to isolate human stem cells. In general, gender diversity in science promotes novelty and innovation (Hofstra et al., 2020), contributing significantly to the enhancement of societal progress, problem solving, and crisis management. However, female scientists do not get the same recognition as male scientists; the under-recognition of women in media is known as the *Matilda effect*[2] (Knobloch-Westerwick & Glynn, 2013; Rossiter, 1993).

An imbalance in the representation of female and male scientists is also apparent when it comes to science media coverage (Araújo et al., 2022; Fletcher et al., 2021; Joubert et al., 2023; Kitzinger et al., 2008a; Mitchell & McKinnon, 2019; Niemi & Pitkänen, 2017). Drawing attention to this imbalance is crucial since most people receive scientific information, and get in contact with scientists, scientific organizations (e.g., universities or private research organizations), and the science system (Mayer et al., 1995), through (digital) media (European Commission, 2021; National Science Board, 2018; for a focus on scientists on X/Twitter, see Chapter 6). Given that journalism in general, and science journalism in particular, tends toward personalization, grounded in the news factor of a "human angle" (Amend & Secko, 2012; Guenther, 2019), scientists play an important role in science coverage. But female

[2] Named after Matilda J. Gage, an American suffragist and feminist critic by Rossiter (1993).

and male scientists are not represented equally in science media coverage, neither in terms of frequency of coverage (e.g., citation) nor in terms of the characteristics of how female and male scientists are portrayed (e.g., through stereotypes).

Evidence shows that female scientists are cited significantly less often in science media coverage than male scientists (GMMP, 2020; Kitzinger et al., 2008a). Additionally, men are often cited first, and when female scientists are cited, they are usually cited as a secondary source (Kitzinger et al., 2008a). These trends were observed across diverse media outlets (Kitzinger et al., 2008a), and they explain why science media coverage is dominated by the voices of male scientists (GMMP, 2020).

However, it is important to highlight that media representations of female scientists differ from those of their male counterparts not only in terms of frequency but also, to some extent, in their portrayal of stereotypes (Chimba & Kitzinger, 2009; GMMP, 2020; Joubert et al., 2022; Klaus, 1998; Lünenborg & Maier, 2012; Mitchell & McKinnon, 2019). This can be linked to discussions around *being a woman in science*, which implies a primary identification as a woman, rather than as a scientist. It also encompasses considerations related to *family and domestic responsibilities*, involving relationships and parental status, as well as the challenges of balancing family life with a scientific career; here, aspects like having children, childcare as well as cooking are discussed in connection with female scientists (Chimba & Kitzinger, 2009; Mitchell & McKinnon, 2019). Furthermore, the media tends to focus more on the *physical appearance and attractiveness* of female scientists than on that of their male colleagues—this includes, for women, discussions about femininity and sexuality (Chimba & Kitzinger, 2009; Mitchell & McKinnon, 2019). Notably, however, evaluations of *individual brilliance and determination*, that refers to the intelligence and motivation of scientists, appear to be more balanced between women and men. In addition, *teamwork and interpersonal skills* are described similarly for female and male scientists, with references to their communication, kindness, teamwork, and other interpersonal skills and aspects of social conscience (Mitchell & McKinnon, 2019).

However, differences in the representation of female and male scientists in the context of public trust in science have not yet been investigated for science media coverage. This issue is important as media are crucial components in the trust relationship between science and its publics.

The Trust Relationship Between Science and Its Publics

Whether taking medication when sick, commuting to work by car, or buying groceries for dinner at the supermarket, the influence of science permeates our daily lives. Hence, scientific information is not only important for addressing crises, such as the COVID-19 pandemic or climate change, but also for people's everyday decision-making (Hendriks et al., 2015; Vaupotič et al., 2021; for a focus on expertise in the COVID-19 pandemic, see Chapter 3). The public is increasingly reliant on science and scientific information (see Chapter 5 for "celebrity scientists" during the COVID-19 pandemic), and requires a mechanism for reducing complexity, which reinforces the importance of trust in science (Luhmann, 2014). As mentioned above, since most people come into contact with science through media (European Commission, 2021; National Science Board, 2018), these media act as intermediaries of trust, meaning that they mediate trust between publics and science through content (Bentele, 1994; Reif & Guenther, 2022). Given our focus on *public trust in science* (i.e., publics are the subject of trust), the concept of *epistemic trust* becomes particularly relevant. Epistemic trust pertains to trust in science as a reliable producer of valid and accurate knowledge. This extends to assurance of the inherent validity of scientific knowledge and to the reliability of science as a dependable source of information (Origgi, 2012).

We further define trust in science as a multidimensional construct that manifests itself in five dimensions that are also considered to be *reasons* to trust: expertise, integrity, benevolence, transparency, and dialogue (Hendriks et al., 2015, 2016; Reif & Guenther, 2022; Reif et al., 2024; Schröder et al., 2024; see also Chapter 20). *Expertise* illustrates science's capacity to identify, evaluate, and target problems by using specialized knowledge acquired through education, experience, and qualifications (in the respective fields of research). *Integrity* means the assurance of objectivity, validity, and reliability achieved through adherence to scientific standards and processes. The orientation of science toward ethical norms and moral values, as well as awareness of science's responsibility to society, form the dimension of *benevolence*. Additionally, science is expected to make research and corresponding scientific information publicly accessible, which results in the dimension of *transparency*. *Dialogue* refers to science participating in and enabling interaction with public audiences (Reif et al., 2024; Schröder et al., 2024). All dimensions of trust can potentially be referred to by trust cues, understood here as linguistic markers and characteristics that can be used by audiences to assess whether to trust science at the message/content level, i.e., written words (Schröder et al., 2024).

In digital media environments, this includes the epistemic risk associated with the potential exposure to incorrect or misleading information by emerging science communicators (Schröder & Guenther, 2024; Taddicken & Krämer, 2021). Journalistic and non-journalistic actors can equally communicate about science issues (see also Weingart & Guenther, 2016), including actors with various interests, such as politicians or public relations professionals (Weingart, 2017).

Currently, however, research on trust cues is lacking. As such RQ1 of this chapter asks: *Which trust cues in content about science can be (a) identified, (b) categorized, and (c) how can trust cues be connected to the established dimensions of trust?* Since we argued that female and male scientists are represented differently in news media, this might also be true in the context of mediated trust in science. For this reason, RQ2 asks: *Which qualitative differences exist in the use of trust cues between female and male scientists?*

Methods

Based on a general lack of research on trust cues connected to differences between female and male scientists, the present study uses an exploratory approach. To answer the RQs, a qualitative content analysis was conducted, aiming to reveal potential differences in how mediated trust in scientists varied by gender.

Sample and Selection Process

Since we aimed to identify as many trust cues in content about science as possible, we tried to include a broad spectrum of sources public audiences in Germany most frequently use to stay informed about science (European Commission, 2021; Wissenschaft im Dialog, 2021). Hence, we included journalistic (i.e., quality and tabloid media), right-wing populist, social (i.e., X/Twitter, YouTube, Instagram, Facebook), and other online media (i.e., blogs and news aggregators). Their content was collected in three constructed weeks (Hester & Dougall, 2007), starting on a Monday in March 2022, and ending on a Sunday in August 2022. This approach of data collection was used to secure a comprehensible and representative sample.

For this study, *journalistic media*, incorporating television (TV) newscasts (Public TV: ARD Tagesschau, ZDF heute; Private TV: RTL Aktuell, Sat.1 Nachrichten) and special science TV programs (WDR Quarks, BR Gut zu wissen), print and online newspapers (Frankfurter Allgemeine Zeitung, FAZ.net, Süddeutsche Zeitung, SZ.de, Bild, bild.de), weekly news magazines/newspapers (Spiegel, spiegel.de, Zeit, zeit.de), and specialized science magazines (Geo, P.M. Magazin, Spektrum der Wissenschaft) were selected. Furthermore, *right-wing populist, non-mainstream media* sources were included (epochtimes.de, jungefreiheit.de, compact-online.de). Moreover, several *social media* (Facebook groups: Wissenschaft aktuell, Harald Lesch Ultras, Fortschritt in der Wissenschaft; Instagram: @doktorwissenschaft, @universumsfakten, @don.medicus, @diewissenschaftlerin; X/Twitter: c_drosten, dfg_public, BMBF_bund, helmholtz_de; YouTube: MaiLab, Breaking Lab)[3] were considered. In addition, to incorporate online contexts more detailed than in previous research, we chose science blogs (scienceblogs.de, scilogs.de) and online news aggregators (t-online.de, web.de). Due to the extensive number of information sources included, multiple databases (e.g., Factiva and MediathekView) and approaches were used to generate the sample.

In total, $n = 5{,}262$ pieces of information were collected and manually checked to ensure that all material included (1) an object of trust (scientists, scientific organizations, and references to the science system) and (2) aspects that the coders considered useful for assessing whether to trust this object of trust—this, consequently, excluded plain descriptions of research and scientific information. Thus, the initial sample was reduced to $n = 763$ pieces of information about science. Next, a smaller representative picture of the material was produced for the qualitative content analysis: For this, a representative sample of the population was created for the first two weeks; it contained a large share of (online/print) journalism, followed by news aggregators, and (print/online) tabloid media. In the third artificial week, focus was placed on underrepresented media (i.e., TV sources, popular science magazines, populist media, blogs, and social media), with the aim of extending the trust cues identified. In total, a sample of $n = 158$ pieces of information was built.

Qualitative Content Analysis

Here, a qualitative content analysis was applied on articles and transcripts (e.g., YouTube, TV) with a deductive-inductive approach (Kuckartz, 2014). Deductively, we assessed formal criteria (source of information, media type). Inductively, we gathered the level of trust for each object of trust connected to science identified in the sample, i.e., we assessed whether the content referred to scientists at the micro-level, scientific organizations at the meso-level, or the science system at the macro-level.

[3] In this study, accounts for different science communicators are included: influencers (e.g., MaiLab), scientists (e.g., c_drosten), public science fundings (e.g., dfg_public), governmental institutions (e.g., BMBF_bund), and other research institutes (e.g., helmholtz_de).

Furthermore, we inductively gathered the gender of all objects of trust at the micro-level (female, male, other), as well as specific trust-relevant criteria, i.e., the trust cues (see model in Reif & Guenther, 2022; see also Schröder & Guenther, 2024). With this approach, we aimed to examine a wide variety of media content to identify a broad range of trust cues that are generally associated with science (RQ1). Subsequently, to address RQ2, we focused on all codes related to scientists (i.e., the micro-level). Hence, codes for scientific organizations (meso-level) and the science system (macro-level) were not considered for the comparison.

To improve the validity and reliability of the analysis, two independent coders conducted the qualitative content analysis after testing and adjusting the coding process over several weeks (Kuckartz, 2014). In the 158 coded pieces of media content included in the analysis, $n = 1{,}329$ trust cues were collected overall (which are the base for RQ1), with 136 of these pieces containing $n = 1{,}033$ cues connected to scientists at the micro-level (in order to answer RQ2).

The coders refrained from pre-defining the dimensions of trust (i.e., expertise, integrity, benevolence, transparency, and dialogue) and instead adopted an open approach to assess the information, allowing for inductive classification. This entailed coders summarizing their findings in their own words, copying and pasting relevant words or passages, and collecting thoughts on their coding more generally. Trust cues were iteratively summarized and condensed; hence, most trust cues were grouped into superordinate categories, though some constituted singular categories in themselves. To answer the RQs, we first looked at quantitative frequencies; however, since this is a qualitative study, these were only used as a guide to see which qualitative differences were worth investigating in more detail.

Results

We considered all coded trust cues ($n = 1{,}329$) to answer RQ1 and focused on the trust cues connected to the micro-level, i.e., references to scientists, to answer RQ2 ($n = 1{,}033$).

Identification of Trust Cues in Content About Science (RQ1)

For RQ1, a qualitative content analysis was used to identify trust cues in content about science. The inductively identified trust cues were condensed in superordinate categories of trust cues, which could, in fact, each be connected to one of the five dimensions of trust. Hence, we can refer to them as expertise, integrity, benevolence, transparency, and dialogue cues, depending on which dimensions the cues relate to. To answer RQ1, in the following, (a) the identified trust cues and (b) their respective categories will be described for (c) each dimensions of trust they are connected with.

Expertise cues refer to academic education, professional experience, and qualification. Academic education and professional experience are categories in themselves and do not have further subcategories, i.e., trust cues. Qualification, on the other hand, can be referred to by trust cues mentioning an academic degree, a professional position, an affiliation to an organization, a department or area of expertise, or reputational aspects.

Integrity cues include references to scientific standards and processes, methods of scientific quality assurance, and independence. Scientific standards and processes are discussed with trust cues referring to publications, descriptions, and explanations of research processes, and research collaborations, as well as the legal framework in which science can act, or working conditions in science. Furthermore, scientific quality assurance includes the discussion about corrections or revisions in research, peer review processes, continuity and permanence of research, and (un)certainties as well as limitations of research. Independence is addressed by trust cues referring to clients (often for contract research), funding sources, or further interests connected to research projects.

Benevolence cues address ethical norms in research, the social responsibility of science, and its benefits for society. Ethical norms do not have any further subcategories; social responsibility is referred to by trust cues communicating research-related risks, predictions made by science, and scientific assessments of public events and current affairs that provided a better understanding of these events for public audiences. In addition, benefits for society are referred to by discussing the social significance of science in general, discussing discoveries and breakthroughs, giving science-based recommendations, and making scientific information applicable to the everyday lives of people.

Transparency cues are connected to the accessibility of research results as well as the use of (in)comprehensible language, i.e., the use of simple words to explain scientific issues or, conversely, the use of technical jargon in research. There are no further expressions of these cues.

Regarding dialogue cues, public engagement in research is discussed, including media presence as well as the participation at public events. Media presence can be in journalistic media but also directly in social media or it can refer to other types of media presence, e.g., public relations content.

Qualitative Differences Between Female and Male Scientists (RQ2)

RQ2 asks to what extent qualitative differences in the portrayal of female and male scientists in content about science and in the context of trust in science, i.e., using trust cues, exist. To answer RQ2, we further analyzed the trust cues found at the micro-level ($n = 1{,}033$) with a special focus on gender; here, 297 cues are clearly connected to women and 487 to men.[4] In order to get an impression of where to start for the analysis of qualitative differences, we considered the distribution of trust cues. Overall, the order of prevalence of stated dimensions of trust remains consistent across female and male scientists: For both genders, the focus lies at expertise, followed by integrity, benevolence, dialogue, and transparency. Furthermore, the use of trust cues differs between genders

[4] It was not possible to identify individuals with other gender; hence, in the following we will only refer to female and male scientists. Further 249 trust cues were connected to groups consisting of female and male scientists or remained unknown.

within the dimensions of trust and within the subordinate categories. In the following, only qualitative differences will be discussed in detail.[5]

For female scientists, *expertise* is represented via expertise cues referring to their qualification, addressing, for instance, their department or area of expertise: "*Virologist* Sandra Ciesek" (Ganster, 2022 [FAZ.net, journalistic quality media]). This is similar for the presentation of male scientists but, additionally, their specific affiliation is emphasized more often than that of female scientists: "Fernando Maestre, an *ecologist of drylands at the University of Alicante*" (Pennisi, 2022 [SZ.de, journalistic quality media]). Professional experience of male scientists in nonacademic contexts is not given relevancy, whereas it is (albeit seldomly) mentioned for female scientists: "Lisa Kainz is 33, an agricultural scientist, and *works for the animal rights organization PETA* in Stuttgart" (Schipperges, 2022 [Zeit.de, journalistic quality media]).

For female scientists, *integrity* cues mainly refer to scientific standards through research processes that are described or explained (e.g., "Head of testing Christine Hentschel *cuts up various everyday objects, arranges the plastics by color, and weighs them on a precision balance. The centrifuged plastic-solvent mixture is evaporated in the gas chromatograph* […] *and forced through a tube with a carrier gas*" (Beller & Lauter, 2022 [GEO, journalistic specialized science magazine]), as well as the mention of overarching research goals: "Harrington now wants to work on a blood test for babies so that the enzyme can serve as a biomarker to determine the risk of sudden infant death syndrome. *'It is the hope that the results could lead to the development of a screening test in a few years,'* the researcher said in an interview" (Porwol, 2022 [Bild.de, journalistic tabloid media]). This is also the case for male scientists; however, integrity in their case is additionally indicated via quality assurance, discussing (un)certainties and limitations of research: "Christoph Reuter took a closer look at the meta-analysis and came to the conclusion *that many of the studies included had some methodological flaws themselves*" (Schwenkenbecher, 2022 [SZ.de, journalistic quality media]).

5 Trust cues are shown in italics in the examples. References are provided according to APA7 but media type is added for more context.

For scientists in general, *benevolence* is represented through addressing benefits of science and research for society—and is usually connected to male scientists differently than it is to female scientists. For female scientists, for example, benevolence is indicated via the assessment of public events and current affairs: "In a guest article for F.A.Z.-Einspruch, Wallrabenstein *called the plans for the expatriation of IS fighters 'boundlessly selfish in the literal sense of the word'. Germany is forgetting a promise it made after the Holocaust: 'to be a home for displaced persons and never to produce any again itself'*" (Grunert, 2022 [FAZ, journalistic quality media])". Furthermore, personal reasoning for benevolent behavior is discussed for female scientists, whereas this is almost never described for their male counterparts: "Research leader Dr. Theres Harrington *was driven by a stroke of fate: in 1991, she lost her son Damien to what is known as sudden infant death syndrome.* At the time, Harrington was an attorney, but had previously worked as a biochemist. […] three years later, a friend's child also died. '*That afternoon, I quit my job as a lawyer and returned to the world of medical research. That day, I made the decision to leave no stone unturned to solve the mystery of sudden infant death syndrome,'* Harrington writes on a crowdfunding page for the Sydney Children's Hospital Foundation […]" (Porwol, 2022 [Bild.de, journalistic tabloid media]). In this example, the role of being a mother and the career that resulted from her personal fate is discussed. This case is different for men; for them, benefits for society are expressed mainly in giving (science-based) advice and recommendations: "In view of the economic risks, *he* [Sebastian Dullien] *advocates for reducing dependence on energy supplies from Russia and doing so as quickly as possible–but not imposing an embargo in the short term*" (Pennekamp, 2022 [FAZ.net, journalistic quality media]). Personal aspects of male scientists such as being a father are not discussed at all.

The dimensions of *dialogue* and *transparency* do not show differences in their presentation between female and male scientists. Dialogues cues primarily refer to the media presence of scientists: "Professor Stefan Rahmstorf […], a welcome *expert on ARD and ZDF, and a regular author for Spiegel Online*" (Behrens, 2022 [jungefreiheit.de, right-wing populist media]). For transparency cues, gender differences do not appear while addressing linkages to external studies or research material that is rather gender-neutral (e.g., "Here is the link to the study"; Hoferichter, 2022 [SZ.de, journalistic quality media]), or using professional jargon, i.e., (in)comprehensible language (e.g., "The two Nobel laureates invented the general *CRISPR-Cas9* method a few months before Zhang, but Zhang described the application of *CRISPR-Cas9 in eukaryotes*" (@doktorwissenschaft, 2022 [Instagram, social media]).

Discussion and Future Research

By means of a qualitative content analysis of the most important sources public audiences in Germany use to stay informed about science, trust cues were identified which could, in turn, be categorized as well as assigned to the dimensions of trust: expertise, integrity, benevolence, transparency, and dialogue (Reif & Guenther, 2022). This corroborates contemporary research about dimensions of trust that are referred to in media content about science (Hendriks et al., 2015, 2016; Reif & Guenther, 2022; Reif et al., 2024; Schröder et al., 2024). It was found that most trust cues refer to scientists (micro-level), which is where the personalization tendencies of science journalism become apparent (Amend & Secko, 2012; Guenther, 2019). These identified trust cues were then compared between female and male scientists. In general, the imbalance in regard to the portrayal of female and male scientists found in previous research was substantiated in this chapter.

A more detailed consideration of media content revealed further similarities and differences in the use of trust cues connected to female and male scientists. For the dimensions of expertise and integrity there are only small differences in the way female and male scientists are portrayed. These two dimensions can be interpreted as part of the stereotype of *individual brilliance and determination* that refers to the drive and intelligence of scientists (Chimba & Kitzinger, 2009; Mitchell & McKinnon, 2019); according to previous research, differences between genders for this stereotype are small, a finding which also seems to hold in the context of public trust in science. Differences between female and male scientists are more prevalent for benevolence cues. Women are described in a more personal manner, and as more caring for society than men. In the example provided, the personal experience of the women is described as the reason why she is working in science; it should be noted that this is not only personal but can also be interpreted as part of her social conscience. Here, stereotypes of *being a woman in science* and *family and domestic responsibilities* as well as *teamwork and interpersonal skills* become visible. This stands in contrast to the use of benevolence cues for male scientists; men give advice in an unemotional and impersonal way and, therefore, appear stricter and more dominant. With regard to the remaining dimensions, transparency and dialogue did not show any differences between genders.

In our coding, only 297 cues were clearly connected to women and 487 to men, which corroborates previous research about the under-recognition of female scientists in the media (GMMP, 2020; Kitzinger et al., 2008a). In conclusion, it seems like there are small yet recognizable differences between the portrayal of female and male scientists when it comes to public trust in science, when focusing on the established dimensions of trust. The main differences are that personal details seem to be more present in descriptions of female scientists in the media compared to their male counterparts. Hence, this research shows that qualitative portrayals of female and male scientists in the context of trust in science align with previous research about stereotypes of scientists in science media coverage. This research, therefore, supports previous research on gender representation of scientists and shows that stereotypes are also replicated in the context of trust in science (Chimba & Kitzinger, 2009; Mitchell & McKinnon, 2019).

Even though this research used a qualitative approach, it seems like the under-recognition of female scientists in the context of public trust in science may be more apparent when analyzed quantitatively, based on the prevalence of female and male scientists in science coverage for which RQ1 provided some initial insights. However, this finding needs to be substantiated with a more comprehensive quantitative examination. As such, even though qualitative differences exist to some extent, future research should focus on quantitative analysis of the use of trust cues connected to female and male scientists, to examine whether similarities and/or differences in addressed dimensions of trust and corresponding aspects exist. Moreover, this would allow for comparisons across different media types and outlets. Additionally, it seems reasonable to include sources for trust cues, such as journalists or other scientists in the media, in this future research in order to reveal potential biases (see, e.g., Niemi & Pitkänen, 2017). It should be noted that the prevalence of trust cues in content about science does not allow any statements about the actual effect they may have on public audiences. Therefore, audience studies could be used to test the diverse effects of trust cues connected to female and male scientists and, furthermore, whether they are perceived differently across demographics and between genders in particular.

Since the research on trust cues is still in its infancy, there is a lot of research that needs to be done and the study presented is only a first steps toward a better understanding of public trust in science with a focus on media as intermediaries of trust.

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Identifying Groups of Trust in Science in South Africa and Germany: A Comparative Study

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Introduction

Public trust in science is among the critical variables for science communication as it is crucial to align the public's behaviour with scientific information—especially during crises such as the COVID-19 pandemic (Algan et al., 2021; Dohle et al., 2020; Plohl & Musil, 2021). A stable level of trust in science may increasingly be challenged by heterogeneous online content (e.g., Neuberger, 2014). This will potentially lead to the

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formation of diverse digitised publics (Bruns, 2023) and affect public trust in science (e.g., Weingart & Guenther, 2016). Nowadays, a large part of the public primarily obtains science-related information online—including content in journalistic online media and also social media (e.g., European Commission, 2021).

Although national differences may exist regarding the use of online media, perceptions of science and trust in science, the perspectives of Western countries often dominate science communication literature (Peters, 2022). This chapter tries to broaden the Western perspective through a cross-national comparison between South Africa (ZA) and Germany (DE). The two countries differ considerably in the demographic structure of the population (Statistisches Bundesamt, 2023; Stats SA, 2020), exposure to and attitudes towards science (e.g., Reddy et al., 2013; Wissenschaft im Dialog, 2021) as well as the use of social media (DataReportal, 2022). For example, the ZA population is significantly younger than the DE population and more actively uses social media—also regarding scientific topics.

After a brief section about the relevance of social media use for public trust in science, we will further elucidate the differences between the two countries as a basis for a cross-national comparison (see also Chapter 22). We will then present and compare results from online user typologies in ZA (n = 1,541) and DE (n = 4,440) based on different dimensions of trust in scientists (expertise, integrity, benevolence, transparency and dialogue orientation; Reif & Guenther, 2022; Reif et al., 2024b; see also

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Chapter 19). These groups are further compared regarding the frequency of contact with science via different information channels—including social media. We will discuss the findings with reference to national and cultural differences and the COVID-19 pandemic.

Trust in Science and the Use of Social Media

In recent years, the growing importance of online platforms, especially social media, and their implications for science communication have been the focus of extensive scholarly discourses. Within these discussions, there is a critical consideration of potential adverse impacts on trust in science, attributed to the multitude of actors and their respective strategic interests (Huber et al., 2019; Weingart, 2017; Weingart & Guenther, 2016). After all, the heterogeneity of online content (e.g., Neuberger, 2014) includes false information and conspiracy narratives that spread particularly quickly through social media (Mahl et al., 2022).

However, social media also facilitate access to and exchange with science (e.g., Taddicken & Krämer, 2021), contributing to more transparency and potentially strengthening trust in science (Reif, 2021). For instance, even among people with little interest in a scientific topic, such as climate change, digital science communication can raise awareness regarding the issue (Taddicken & Reif, 2016). Contrasting trends in the use of social media are thus emerging, which could be reflected in individual differences in one's trust relationship with science. Here, typologies provide a useful approach to consider the increasing individualisation on the group level. So far, studies about audiences of science communication found four to six population groups that differ regarding their attitudes towards science and exposure to scientific information. More specifically, groups with the most positive attitudes or—if considered as variable—the highest trust in science use more diverse ways of contact with science most frequently. In contrast, the groups with rather science-sceptical tendencies are the smallest groups with the lowest exposure to science and less diverse interactions with science (Guenther & Weingart, 2018; Schäfer et al., 2018).

Heterogeneous online content regarding science-related information increased during the COVID-19 pandemic, which can be considered the first major pandemic "in the era of widespread social media" (Eichengreen et al., 2021, p. 10). The World Health Organisation (2021) coined the phrase "infodemic", which describes the vast amount and spread of online information, including substantial misinformation. Therefore, a potential decrease in public trust in science was publicly and scientifically debated.

Comparison Between South Africa and Germany

Here, we will compare ZA and DE as they differ considerably regarding demographics, exposure to science (Guenther et al., 2022; Wissenschaft im Dialog, 2021), social media use and conspiracy beliefs (Ibbetson, 2021). With this approach, we want to highlight the non-western perspective.

General Structure and Demographics

ZA is located in the southernmost part of Africa and is considered a middle-income country. DE is situated in Central Europe, in the Northern Hemisphere, and is regarded as the world's third-largest economy. Despite being much smaller in land area, DE has a larger population than ZA (84 million compared to 60 million; Stats SA, 2020). The ZA population, however, is remarkably diverse regarding ethnic and cultural backgrounds, which is reflected in their eleven official languages, compared to the one official language of DE (German). Also, the two countries show interesting differences regarding the cultural dimensions defined by Hofstede (2011) that may be connected to public trust in science (see Huber et al., 2019). While DE is a highly individualistic country and high in uncertainty avoidance, it is low in power distance. In contrast, SA is a collectivistic country of low uncertainty avoidance and high power distance. Another significant difference is the age structure of the populations. ZA has a relatively young population and only a small proportion of people over the age of 60 (9%; Stats SA, 2020), the German population is ageing and has a much higher proportion of people over 60 (35%; Statistisches Bundesamt, 2023).

Exposure to and Role of Science

One of the significant differences between the countries is that ZA is characterised by large rural areas that are spatially as well as culturally distant from science (Guenther et al., 2018). Across the country, there are 26 public universities and considerable disparities in access to quality education when compared to the urban areas. In DE, education is generally free, and according to the German Federal Ministry of Education and Research (BMBF, 2023), almost 1,000 universities and research institutes exist throughout the country, reflecting a generally significant role of science and a strong emphasis on research and innovation.

According to the annual science barometer, people in DE held a consistently moderate level of trust in science until 2019. With the start of the pandemic, however, the percentage of respondents who stated a complete trust in science has quadrupled (9% in 2019, 36% in 2020), which indicates that the pandemic has been a pivotal experience for public trust in science. Three years later, the survey still shows a somewhat higher level of public trust in science compared to the 2019 values (Wissenschaft im Dialog, 2023). There is no comparable longitudinal data available for ZA. However, some studies note that the ZA public is considered unique regarding perceptions of science and technology, as people in ZA have more substantial reservations about science, the more they believe in the promises of science (Guenther & Weingart, 2016; Guenther et al., 2022; Reddy et al., 2013).

The Use of Social Media

Due to structural differences in access to the internet, the rate of social media users is lower in ZA (46%) compared to DE (87%). Nevertheless, in ZA, average daily social media use is more than twice as high (3 h

43 min) as in DE (1 h 29 min; DataReportal, 2022). The population of ZA also holds stronger beliefs in conspiracy theories commonly spread via social media. While 68% of the ZA population believes that secret organisations control the world, only 31% of the German population agrees with that statement (Ibbetson, 2021).

Based on these structural and cultural differences between the countries, we want to examine the following research questions (RQs):

RQ1: Which groups of trust in science can be identified among South African and German online users?
RQ2: How do these trust groups differ regarding the frequency of their contact with science?

Data and Method

Sampling

We conducted similar online surveys in ZA and DE on the public perceptions of science using online access panels (*Ask Afrika* for ZA, *YouGov* for DE). Several structural differences need to be mentioned, as they may have affected the data. The time of data collection for the ZA study was at the end of 2020 and, thus, at the beginning of the second wave of the COVID-19 pandemic. The German survey was conducted at the end of the fifth wave of the pandemic in March/April 2022. The sample sizes differ vastly (n_{ZA} = 1,624; n_{DE} = 4,824) because the DE survey was embedded within a larger project. Despite the eleven official languages in ZA, the questionnaire was only distributed in English. In DE, the survey was conducted in German. Regardless of the applied quota plans,[1] the ZA sample considerably deviated from the population (Stats SA, 2020), whereas the DE sample was representative for the quoted variables (Statistisches Bundesamt, 2023). It should be noted that the sample for ZA was significantly more highly educated (63%

[1] For ZA: Age, gender, province, geographical setting, population group; for DE: age, gender, region (federal state).

had a college certificate or university degree) than that for DE (30%). In the ZA sample, the mean age was 34 years; in the DE sample, it was 51 years (for detailed descriptions of the methods see Reif et al., 2024a, 2024c).

Measures

For both surveys, we used similar measures with 5-point rating scales to allow a comparison of the countries. Few differences, however, resulted from the translation of items and the measures being further developed in the almost year and a half between the two surveys.

In both countries, trust in science was measured (1) by four items addressing three different levels of trust in science as direct measures by asking, "*How much do you trust in…*": scientists in general (micro-level), scientists at universities and research institutes (meso-level 1), scientists in private companies/industry (meso-level 2) and science (macro-level). The response scale ranged from 1, "do not trust at all", to 5, "trust a great deal". (2) Our key measures of trust in science addressed the five theoretical dimensions captured as reasons to trust in scientists (micro-level, see also Chapter 19). Based on the research literature (Besley et al., 2021; Hendriks et al., 2015; Reif & Guenther, 2022; Wissenschaft im Dialog, 2021), we measured scientists' perceived expertise, integrity, benevolence, transparency and dialogue orientation with the public using the Public Trust in Science (PuTruS) scale with two or three items each in ZA and three items each in DE (Reif et al., 2024b). Each item was developed to complete the statement "*Scientists can be trusted because they…*" and could be answered with 1, "strongly disagree", to 5, "strongly agree". One example of an item to determine expertise was "*…are real experts in their particular fields*" for ZA ($\alpha = 0.72$)[2] and "*…are experienced experts in their particular topic*" for DE ($\alpha = 0.89$). Among other items, in both surveys, integrity was measured with the item "*…adhere to strict rules and standards in their work*" ($\alpha_{ZA} = 0.77$; $\alpha_D = 0.85$) and benevolence with the item "*…work for the common good*" ($\alpha_{ZA} = 0.79$; $\alpha_{DE} = 0.85$).

[2] Cronbach's alpha was used to measure the internal consistency (reliability) of the scale per dimension of trust in science.

One example of the transparency items was *"…regularly inform the public about relevant and important results of their research"* for ZA ($\alpha = 0.83$) this was slightly adjusted in the German sample to "*…inform the public about relevant results of their research*" ($\alpha = 0.82$). Similarly, measures for dialogue orientation differ slightly between the countries: e.g., "*…listen to public opinions on their topics and research*" for ZA ($\alpha = 0.79$), "*…listen to what the public thinks about their topic and their research*" for DE ($\alpha = 0.86$).

We also asked respondents, "*How often do you hear about science through the following?*" and offered an extensive item battery with diverse ways of being informed about science and scientific issues. For each type of contact, respondents stated how often they used it from 1, "never", to 5, "very often". The different types of contact with science were theoretically based on Reif and Guenther (2022), including direct contact with science (e.g., *conversations with scientists*; $\alpha_{ZA} = 0.84$; $\alpha_{DE} = 0.81$), contact via social agents (*conversations with others, such as family, colleagues or friends*), via journalistic media (e.g., *TV, radio*; $\alpha_{ZA} = 0.83$; $\alpha_{DE} = 0.79$), or social media (e.g., *blogs, social networking sites*; $\alpha_{ZA} = 0.85$; $\alpha_{DE} = 0.84$).[3]

Data Analyses

We used mean indices for the five dimensions of trust in science and conducted a latent profile analysis (LPA) with both samples in *RStudio* (*tidyLPA*). This method assumes the existence of an unobserved categorical variable dividing the population into distinct groups (latent profiles). Based on the selected variables, an LPA model identifies the appropriate number of latent profiles and clusters most similar cases. Our analyses revealed four distinct groups for ZA and five groups for DE. Due to missing values, the final sample size for ZA was $n = 1{,}541$ and $n = 4{,}440$ for DE. We calculated Analyses of Variance (ANOVAs) for the trust

[3] See Guenther et al. (2022) for further information.

measures to answer the first RQ to compare the means per country and group. We repeated the same procedure for the second RQ's frequency of contact with science.

Results

Groups of Trust in Science Among Online Users in ZA and DE (RQ1)

According to the means, respondents in the ZA sample reported higher trust in scientists in general ($M = 3.95$; $SD = 1.02$), scientists working at universities ($M = 4.08$; $SD = 0.97$) and science as a functional system ($M = 3.99$; $SD = 0.96$) than respondents in the German sample (about half a scale point, $M = 3.40, 3.57, 3.60$; $SD = 0.92, 1.00, 0.99$). In ZA, trust in scientists in private companies/industry ($M = 3.87$; $SD = 1.07$) exceeded the level in DE ($M = 2.93$; $SD = 0.97$) by a whole scale point. While people in ZA, in general, hardly distinguished between the levels, respondents in DE especially trusted in the functional system of science and university scientists but showed the least trust in scientists in the private industry.

Regarding the five dimensions that specify trust at the micro-level, ZA respondents reported higher agreement than DE respondents. For benevolence ($M_{ZA} = 3.74$; $SD_{ZA} = 1.06$; $M_{DE} = 3.12$; $SD_{DE} = 0.98$), transparency ($M_{ZA} = 3.59$; $SD_{ZA} = 1.00$; $M_{D} = 3.09$; $SD_{DE} = 0.95$) and dialogue orientation ($M_{ZA} = 3.53$; $SD_{ZA} = 1.11$; $M_{DE} = 2.97$; $SD_{DE} = 0.96$), the values in the ZA sample exceed the values in the DE sample by half a scale point. For integrity ($M_{ZA} = 3.73$; $SD_{ZA} = 1.04$; $M_{DE} = 3.37$; $SD_{DE} = 0.98$), the difference is smaller, and for expertise ($M_{ZA} = 3.74$; $SD_{ZA} = 0.89$; $M_{DE} = 3.69$; $SD_{DE} = 0.93$), there is no significant difference between the countries. Respondents in DE, therefore, differ considerably regarding the levels of trust in science and, taking a closer look at the micro-level, also regarding the dimensions.

The different trust groups we found for the two countries revealed some similarities but also differences in their patterns of dimensions of trust in scientists (see Fig. 20.1). For ZA and DE, the LPAs identified one group of people *fully trusting* science at the different levels with high values on the five dimensions, one group *highly trusting*, one *moderately trusting* group and one group that was *rather untrusting*. A fifth group was found for DE that was *untrusting*. In ZA, the *fully* and *highly trusting* shared a similar dimensional pattern. They especially agree that scientists can be trusted because they work for the common good (benevolence). They showed slightly weaker agreement with scientists' expertise and practices of dialogue with the public as reasons to trust them. For DE, the *fully trusting* especially differ in their patterns from the other groups identified. Their values on expertise are not as high in contrast to the other dimensions. For all other groups (*highly trusting* [DE], *moderately trusting* [ZA, DE], *rather untrusting* [ZA, DE], *untrusting* [DE]), expertise showed the highest values, while the other dimensions had lower values. The most considerable disparity between the agreement to scientists' expertise as reasons to trust them and the other dimensions emerged in the *rather untrusting* groups in both countries.

Considering the differences between the identified ZA and D trust groups as well as the demographic sample differences, we still wanted to compare the frequencies of the groups (see Fig. 20.1). In the ZA sample, the largest groups were the *highly trusting*, followed by the *fully trusting* and the *moderately trusting*. For DE, the *moderately trusting* formed the largest group, followed by the *highly trusting*. In ZA, the *rather untrusting* was the smallest proportion in the sample; in DE, the *untrusting* built the minority. The group of *rather untrusting* in DE was even slightly larger than the *fully trusting*. In sum, the most substantial difference in the distribution of the groups between ZA and DE was present for the *fully trusting* and the fact that the *untrusting* group found for DE was not identified in the ZA sample.

The Trust Groups' Contact with Science in ZA and DE (RQ2)

The groups varied in their trust assessments and frequencies of using diverse types of contact with science (direct, mediated by social agents, journalistic media and social media). The general tendency here was

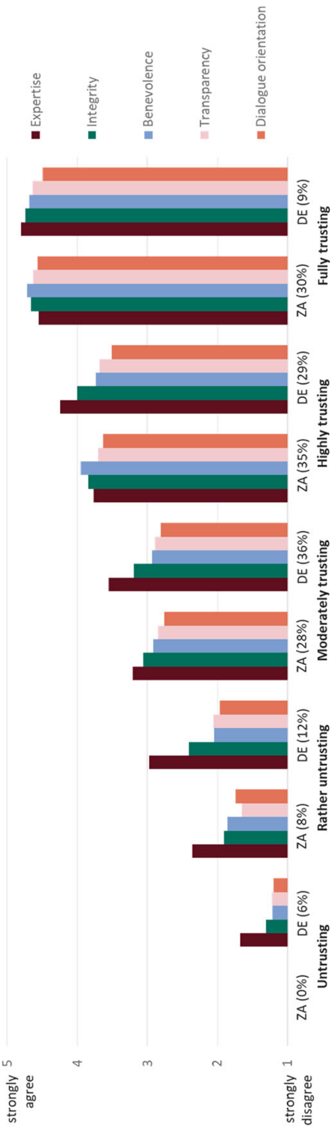

Fig. 20.1 Description of trust dimensions (means) for the groups per country

the same for ZA and DE, indicating that people who trusted more in science had more frequent exposure to it (and vice versa; see Fig. 20.2). In both countries, respondents indicated that they heard about science and scientific information most often by talking to other people. Direct conversations with scientists and different ways of contact were the least frequent. While for ZA, social media was used slightly more frequently than journalistic media, it was the other way around in DE, and the differences were more pronounced.

In general, the differences between the types of contact were greater for the DE sample. In ZA, respondents indicated being in contact with science and scientific information much more regularly than in the DE sample.

As an additional information, right-wing populist media were considered in the DE survey, which is why we could detect the interesting tendency that the *untrusting* group reported the highest frequency of

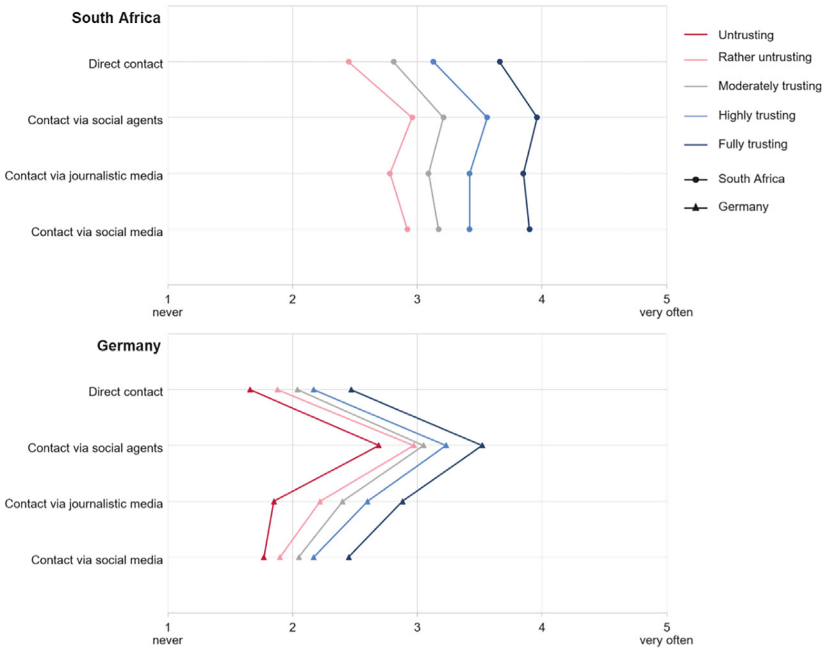

Fig. 20.2 Frequency of contact with science (mean) for the groups per country

interacting with so-called alternative media. For the *untrusting,* it was the second most common way of being in contact with science after conversations with social agents.

Discussion and Conclusion

In this chapter, we compared the results of two LPAs conducted for online samples in ZA and DE to identify different groups of online users in both countries concerning their trust in science. We expanded research by a cross-national comparison using similar measures of the dimensions of how and why people trust scientists and their use of scientific information.

First, we found four similar groups within ZA and DE online users according to their levels of trust in science (from lowest to highest, RQ1): *rather untrusting, moderately trusting, highly trusting* and *fully trusting* groups. In both countries, the *rather untrusting* and *moderately trusting* indicated the highest trust values on expertise. The emphasis on expertise in the DE sample was higher in general. The *fully trusting*, by contrast, gave similar value to all five dimensions as reasons to trust scientists. The differences in the ZA sample were more minor. For the *highly trusting*, the dimensional patterns varied between the countries. In DE, this group revealed the strongest agreement to scientists' expertise; in ZA, benevolence was the most agreed upon. One potential explanation for why less trusting groups exhibit higher values only for expertise might be their overall low level of general trust. It could also suggest that all five dimensions of trust are crucial for public trust in science, as posited theoretically. In contrast, expertise represents a fundamental component of trust in scientists that is less questioned by the public. The varying values observed for benevolence and other non-expertise dimensions across countries may stem from cultural differences. For instance, ZA, being a collectivist country according to cultural dimensions identified by Hofstede (2011), may foster the belief that scientists work for the benefit of the community, whereas DE, characterised as individualistic, may lean towards perceiving scientists as being driven by individual interests. Further comparative research is needed to test this hypothesis. With

DE also scoring high on uncertainty avoidance, the strategy to compensate for uncertainty may be a strong reliance on expertise (Hofstede, 2011).

Interestingly, we only found a group *untrusting* in science in DE. Furthermore, the least trusting groups in both countries were the smallest. While for DE, the *fully trusting* was the second smallest group, in ZA, they were the second largest. In DE, the largest group was the *moderately trusting*; in ZA, the *highly trusting* group was most prevalent. However, the demographic differences of the samples must be kept in mind. The DE sample of online users was similar to the DE population in terms of formal education, and the ZA sample was strongly skewed towards highly educated people, which may have contributed to our empirical differences. Thus, the survey may have received limited or no responses from individuals in the ZA population who trust less in science. However, it is also reasonable to assume differences in cultural dimensions as a possible explanation. The fact that ZA is a country with high values of power distance, whereas DE is low on this cultural dimension and thus more likely to question authority, seems intriguing and may reflect, in general, difference in public trust in science worthy of further research (see Hofstede, 2011).

Lastly, our results suggested that the level of public trust in science may correlate with a higher frequency of exposure to diverse types of science communication (RQ2; Guenther & Weingart, 2018; Schäfer et al., 2018). However, we found more frequent direct contact with science and use of journalistic media and social media for science-related information within the ZA sample. In both countries, social agents such as family and friends were the most frequently used contacts with science. Social media played a more important role in ZA compared to DE which may suggest a beneficial impact on public trust in science as opposed to a decline of public trust in science. The differences between the samples may also be cultural or due to the demographic sample structure. Another possible reason is the time of data collection, which was in the first year of the COVID-19 pandemic in ZA. The general tendency of a possible positive correlation between the frequency of exposure to science and trust in science may indicate the presence and beneficial impact of trust cues in science-related content addressing the five dimensions of trust in science outlined in another study (see Chapter 19). Additionally, it may imply that the measures employed here effectively capture informed trust in science (see Bromme, 2020).

When interpreting these results, several limitations need to be considered. First and foremost, the periods of data collection varied between the countries. Both surveys took place during the COVID-19 pandemic. However, the data collection in ZA was at the beginning of the second wave and before the vaccine had been developed in November 2020. For DE, data was collected during the fifth wave in March/April 2022 and after the vaccine roll-out. The timing may have contributed to the differences between ZA and DE that have been found. We cannot account for possible changes over time within one sample, as we have only presented cross-sectional data. Longitudinal research on how different trust groups are changing over time is needed. Furthermore, using online access panels for data collection and mainly quoting for gender, age and region resulted in a highly educated sample for ZA deviating from the overall population. Another possible variable that may have contributed to the skewed sample regarding formal education is that we only applied the questionnaire in English, neglecting the other ten official languages. For DE, due to the much higher overall online access, the level of formal education is better reflective of the DE population.

Despite these limitations, our findings show comparable but somewhat different groups of trust in science for ZA and DE that also differ regarding their frequency of contact with science. We would like to highlight the necessity for further cross-national comparisons (see also Chapter 22) and targeted science communication. Future research should also explore more deeply how the COVID-19 pandemic has affected public trust in science.

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Research Ethics Statement The survey conducted in ZA received ethical approval from Stellenbosch University (National Health Research Ethics Committee (NHREC) registration number: REC-050411-032, project number: 19084). In Germany, the Technische Universität Braunschweig's ethics committee was consulted, but ethical approval was deemed unnecessary. Utilising online access panels (Ask Afrika, YouGov) ensured that researchers did not have access to respondents' personal information, such as names and contact details. YouGov is certified to ISO 27001.

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21

Personal Epistemologies and Science Information: Exploring the Role of Scientific Evidence and Trust in Four Science-Related Topics

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Introduction

This chapter is based on a consultation on science communication organised in Portugal, in November 2019, in the context of the EU-funded project CONCISE (Communication Role on Perception and Beliefs of EU Citizens about Science). The main goal of the project was to provide qualitative knowledge through citizen consultation on the sources/channels by which EU citizens acquire their science-related

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knowledge and to understand how this knowledge influences their beliefs, opinions, and perceptions.

The public consultation was held in Lisbon and had 102 citizens participating each in four rounds of group discussions, each revolving around a distinct science-related topic: climate change, vaccines, complementary and alternative medicine,[1] and GMOs (genetically modified organisms)[2]. Using vignettes to illustrate individual positions, in this chapter, we examine these discussions through the lens of personal epistemology theories (Hofer, 2008) and epistemic trust (Hendriks et al., 2016), focusing on the positions of selected participants throughout the four rounds of discussions of the Portuguese consultation.

Our research question: how are personal epistemologies of science expressed when participants discuss different science-related topics? More specifically, by analysing the basis upon which participants justify their epistemic trust (or distrust) in science and expert knowledge, when assessing information on these subjects, we aim to reflect on the relationships individuals have with science in general and with specific scientific topics and how trust in scientific expertise is contextually interpreted.

Personal Epistemologies and Trust in Science-Related Topics

Personal epistemologies have been defined as individual conceptions of knowledge and knowing that are central to how we think, interpret, and evaluate science (Hofer, 2008). According to Hofer's (2000) review, the study of personal epistemologies encompasses two interrelated areas: the *nature of knowledge* and the *process of knowing*.

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[1] Complementary and alternative medicine (CAM) is treatment that falls outside of mainstream healthcare. The Portuguese legislation definition is "Non-conventional therapies are considered those that originate from a philosophical basis different from conventional medicine and apply specific diagnostic processes and their own therapeutic methods" as per Law 45/2003 of August 22.

[2] The formal definition of a GMO in Portuguese legislation is "any organism whose genetic material has been altered in a way that does not occur naturally through mating and/or natural recombination" as per Directive 2001/18/EC, Article 2, No. 2.

On the one hand, the *nature of knowledge*, which pertains to individuals' beliefs about the essence of knowledge, encompasses two dimensions: the certainty of knowledge, which addresses whether knowledge is regarded as certain and absolute or as continuously evolving, and the simplicity of knowledge, which concerns whether knowledge is perceived as discrete, concrete, and knowable or as relative, contingent, and contextual.

On the other hand, the *process of knowing*, which considers how individuals come to know, comprises two sub-dimensions: the source of knowledge, which regards whether individuals mostly rely on external authority, or whether one integrates one's own perspective and reasoning. And the justification for knowing, which encompasses how individuals evaluate knowledge claims. This involves either justifying their beliefs through personal observation and first-hand experience or mobilising the rules of inquiry to integrate arguments based on evidence, reason, or expert opinion.

Research has also shown that personal epistemologies can be both domain-specific and domain-general (Muis et al., 2006). Accordingly, this suggests that knowledge in science can be perceived as more certain and scientific expertise can carry more authority in specific domains than in others (Hofer, 2000). Furthermore, it also means that individuals can hold general beliefs about knowledge but may also make distinctions in relation to particular domains of knowledge (Muis et al., 2006).

Personal epistemologies can be expressed and negotiated differently when we discuss issues that mobilise different norms, values, and ways of knowing (Hofer, 2005). These variations may be influenced by our distinct relationships with the topic and levels of expertise in these areas. For instance, differing degrees of academic orientation and structural organisation within various domains can significantly influence how we contextualise and interpret knowledge dimensions (Glaser et al., 1987). Moreover, our expertise within a specific domain can impact our epistemological awareness of that domain, but it may not necessarily influence how we accept authority or seek answers in unrelated domains (Hofer, 2005).

Most studies about personal epistemologies and domain specificity have adopted a quantitative approach, based on measuring a specific set of epistemological dimensions that can be tested in relation to specific scientific disciplines (Muis et al., 2006). In most cases, these studies have relied on studying perceptions between different scientific fields, such as mathematics and social sciences (King et al., 1990), psychology and science more generally (Hofer, 2000), or mathematics, social sciences, and business (Schommer-Aikins et al., 2003). However, this approach tends to focus on quantifiable and decontextualised science knowledge beliefs, limiting the ability to understand how people make sense of science-related topics in their daily lives.

In recent years, there has been a push to expand the scope of personal epistemology studies beyond constrictive notions of scientific domains towards a more integrated model, where "individuals' personal epistemologies can be understood as evolving through a non-linear and recursive path" (Diamond & Stylianides, 2017, p. 334). This shift involved the incorporation of other significant domains of individuals' experiences and worldviews into the development of their personal epistemologies, and considering the wide spectrum of knowledge and epistemic resources that people draw upon when reasoning about specific topics or scientific claims (Davis & Russ, 2012).

Particularly relevant is the exploration of personal epistemologies within the context of individuals' information behaviour (Kelly, 2020). For instance, in the field of science communication, Suldovsky and Taylor-Rodríguez (2021) explored the relationship between personal epistemology and public engagement on a controversial topic affected by declining trust in science among political groups. They analysed citizens' engagement preferences on the topic of climate change for liberals, moderates, and conservatives living in Oregon (USA) and found that liberals prioritise expert knowledge and perceive climate science as certain, while conservatives rely on direct experience and view it as uncertain. Notably, perceived certainty and simplicity of climate knowledge correlated with a preference for the deficit model of science communication.

Schwarzenegger (2020) further developed this notion and introduced the concept of "personal epistemologies of the media" to explore the relationship between personal epistemologies and the decision-making process of whom to trust or challenge as information sources. According to Schwarzenegger (2020), personal epistemologies extend beyond mere epistemic beliefs, as they encompass a broader range of factors, such as prior experiences with topics, worldviews, and political orientations, as well as judgments of personal taste, aesthetics, values, and assumed truths regarding the social and physical world. Within his analysis, he discerned three interrelated dimensions that exert a significant influence on users' navigation of media and news repertoires: selective criticality, pragmatic trust, and competence–confidence.

These studies are relevant because they provide evidence of how personal epistemologies do not have to be necessarily restricted to scientific disciplines or quantifiable notions of belief, truth, and justification. Instead, they are seen as dynamic and contextual, influencing the way individuals make sense of specific issues in their daily lives. Additionally, they highlight the importance of personal epistemologies in studies on trust in science and science communication, by drawing attention to the articulations between people's experiences, their understandings of the nature of science, and their epistemological assumptions about sources of information.

Lastly, this perspective is supported by research on trust that showcases how trust in science varies widely when specific topics are considered. Hendriks et al. (2016) suggest that such variation can be attributed to a difference between a personal position about a topic and personal trust in the science that produces knowledge about that topic, a distinction that is frequently difficult to make. They note, "when a science-related topic is of interest for segments of the public, then these sub-populations develop personal stances related to this topic. These stances thereby modify their 'default' trust in science" (Hendriks et al., 2016, p.151). In other words, epistemic trust in science—understood as trust in knowledge that has been produced or provided by scientists—is contextually defined and evolves in response to the public's perspectives towards specific scientific topics. Personal experiences with topics, controversial debates, political orientations, and epistemic beliefs about science and media, among others, all influence how individuals interpret and evaluate information on science-related topics and decide whom they can trust to provide reliable knowledge within specific domains.

Data and Method

In this article, we conduct an exploratory qualitative analysis based on fieldwork carried out in Portugal as part of the EU-funded (H2020 SwafS) research project CONCISE. The data was collected during a one-day public consultation, where 102 citizens were invited to engage in four rounds of group discussions on science communication, totalling 48 discussions (12 round tables for each topic). Each round of discussion focused on a specific science-related topic: climate change (CC), vaccines (VAX), complementary and alternative medicine (CAM), and genetically modified organisms (GMOs). Each participant participated in four rounds of discussions and debated the four topics.

Each round table included eight to nine participants who remained in the same group for the initial two discussions before switching groups for the subsequent two. At each table, there was a facilitator and an observer who recorded the group's dynamics and the participants' attitudes during the discussions. The discussions were structured into three parts: understanding how citizens perceive science communication, identifying the information sources and channels they rely on and trust, and gathering suggestions for improving science communication.

Participants were recruited through various means, including the press, social media, institutional mailing lists, posters, leaflets, and targeted email campaigns. To achieve our goal of having 100 citizens participate in the consultation, we admitted a substantial number of registrants to the study. The primary exception was science communication professionals, who were requested not to attend due to their close relationship with the topic under discussion. Although participants were not a representative sample of the Portuguese population, it was diverse in terms of age (ranging from 18 to 76), gender, origin, education, and professional backgrounds.

All 48 group discussions were recorded and subsequently transcribed. During the manual transcription process, the data was anonymised, and a unique identifier was assigned to each participant. Following this, we employed Nvivo to automatically create a case node for each participant based on their respective identifiers (Dhakal, 2022). This method facilitated the systematic capture of each participant's contributions throughout the four discussions.

For this chapter, we have decided to base our analysis on individual vignettes (Jacobsen, 2014; Lupton, 2019). Vignettes are short narratives, especially useful when working with rich qualitative material, including interviews and focus groups, since they provide a way to "pull the threads" of an individual's account together and contextually situate the participant's narratives of their experiences (Maslen & Lupton, 2020). In the case of our study, since each participant took part in four separate group discussions, the use of vignettes offers a unique opportunity to analyse the contributions participants made separately on each topic. This approach facilitated the creation of detailed narratives capturing the varied ways individuals expressed their personal epistemologies of knowledge and trust throughout the consultation while underscoring the diversity of their viewpoints across the different scientific domains.

To produce the vignettes, we reviewed the outputs of each case node in Nvivo (i.e., the contributions of each participant), paying particular attention to the participants whose positions during the four discussions were clearly articulated. In this initial analysis, we specifically examined the way participants expressed their positions and the role they attributed to both science and expert knowledge when assessing and trusting information on these subjects. This exploration led us to identify five cases that displayed significant depth and paradigmatic relevance, serving as illustrations of diverse expressions of personal epistemologies of knowledge, the role of scientific evidence, and trust in the scientific process concerning the four topics under discussion. All five cases are university graduates (as well as the majority of the participants in the consultation).

The vignettes were produced and reviewed by the authors of the chapter and were derived from a thorough analysis of the participants' contributions to each discussion. Each vignette is identified by an alias. The use of anonymised data meant that seeking participant approval for these vignettes was not an option. Consequently, these vignettes should not be interpreted as exact representations of the participants' views on the discussed topics. Nevertheless, they provide significant insights into the participants' personal epistemologies about science and trust, as inferred from the perspectives they shared with others in a very specific setting—a group discussion on science communication.

We analyse these individual perspectives to gain a better understanding of how issues related to trust and scientific evidence are approached regarding specific domains. Specifically, we delve into the epistemological foundations they used to make sense of the topics, the knowledge they drew upon to justify their opinions, the consistency of their viewpoints throughout the discussions, and the role they attributed to science and expert knowledge in each topic.

Analysis

A brief note on context. Portugal may not have the most advanced scientific system in Europe but for the past three decades, it has made a substantial effort in bringing science to the public. There is a national agency in charge of promoting scientific culture, all research institutions are required to perform science dissemination to get public funding, and science communication is a thriving profession with its own association and annual conference (Entradas et al., 2020). Mejlgaard et al. (2012), in their cluster analysis of the role and location of science in European countries, classified Portugal as "consolidated" in terms of science communication culture. Survey results have regularly demonstrated that trust in science and in scientists is quite high: the 2018 Wellcome Global Monitor shows that 34% of Portuguese respondents have high trust (the global average is 18%), 54% have medium trust, and 11% low trust in the Trust in Science Index.

The following vignettes are illustrative of how personal epistemologies play a significant role in how citizens interpret and evaluate information and allocate trust on science-related topics.

Vignette 1: André (male, land planning, late thirties)

> *CC*: André learned about the consultation on Facebook through a pro-science association, an organisation devoted to promoting science-based scepticism and resisting the spread of pseudoscience. He mentions that climate change it is not a topic he actively seeks out but

rather something he encounters passively in online newspapers and on social media. He often relies on sources shared by the sceptic community group, which he describes as an 'absolutely robust scrutinising machine.' During what he calls the 'last years of the post-truth era,' he developed a method to access information that involves: seeking credible sources, verifying the origins of information (including scientific studies), and always looking for counterarguments to better position and defend his views. He believes that information on this topic is relatively unambiguous and easier to connect with various positions influenced by political ideologies.

VAX: This is a topic he has not actively sought out much information on and he mostly relies on medical professionals for guidance. He has engaged in discussions with a friend who harbours doubts about vaccines and finds it enlightening to understand the reasons behind their hesitancy. He also recognizes the potential risks of avoiding critical discussions, as it may create voids that allow for other forms of questioning. He emphasises the importance of trusting the scientific process and underscores that one individual case is not statistically significant.

CAM: His current stance towards science was mainly sparked by his curiosity about CAM. His girlfriend is a CAM advocate and works in the field, which prompted him to delve deeper to understand why people choose alternative therapies over conventional medicine. This exploration has made him increasingly sceptical about CAM. He views CAM as a fascinating subject for examining what drives belief in alternative therapies, describing it as having an inclusive nature that aims for our well-being. He acknowledges that the complexity and elusiveness of science make it challenging for people to trust. Nevertheless, he emphasises the importance of regulation and trust in scientific experts in these matters.

GMOs: He considers them a positive scientific development, but notes that there is often an ideological, non-scientific component to people's perceptions of GMOs. He describes it as a topic that blends various factors, making it difficult to separate them. André highlights the distinction between the scientific aspects and the role of large corporations in the GMOs discussion. He believes that CAM advocacy, vaccine hesitancy, and criticism of GMOs all tend to stem from a lack of trust in science and large private corporations. He believes that science has not effectively informed the public about this issue, and the lack of clarity around the term 'biological' further complicates the matter. However, he personally expresses trust and appreciation for living under EU regulation, which alleviates his concerns about GMOs.

Vignette 2: Sofia (female, lab technician, late twenties)

*CC***:** She is particularly attuned to the issue of climate change and has curated her social media feed to access information tailored to her interests. She follows the IPCC and UN closely, giving precedence to scientific sources. She is cautious in relation to NGOs and scrutinises their funding sources. She observes a significant gap between scientific understanding and public awareness on this matter. She mentions an incident involving an academic journal publishing a false article, highlighting a systemic issue within the scientific community. She also notes the connection between climate change and significant economic interests. She contends that discussions on secondary issues like recycling divert attention from more critical matters. She stresses the need for accessible resources to help people comprehend complex issues and locate reliable scientific information, expressing concern about the prevailing tendency to view everything through the lens of personal opinion.
*VAX***:** She has observed numerous discussions surrounding vaccines in her social networks, which pique her interest in the subject. She actively gathers information to stay informed and be prepared for discussions with friends who seek insights from individuals with scientific backgrounds like her, but she refrains from sharing information online, fearing that it may inadvertently empower anti-vaccine movements. Her information-seeking habits involve consulting reputable sources such as health clinic websites, the World Health Organization (WHO), and scientific articles, but she also refers to her doctor as her primary source of information. She has a much more critical stance toward private laboratories that sell vaccines.

CAM: Sofia has developed a keen interest in osteopathy, prompted by a friend's recommendation. She is currently exploring this field, particularly Chinese medicine, on a part-time basis. However, she seeks sources that are credible and certified, distinct from what she calls "old-fashioned practices resembling witchcraft". She emphasises India and China as vital repositories of knowledge in this realm, stressing that modern science has evolved from traditional wisdom over millennia. She advocates for greater availability of information on these traditions and critiques the scepticism that exists towards CAM within the scientific community. She highlights the value of CAM in underexplored aspects of conventional medicine, such as the placebo effect or holistic bodily health.
GMOs: She has extensive knowledge of GMOs due to her field of work. She values their importance but acknowledges the need for preventing them from reproducing due to the potential risks of disrupting ecosystems. She views GMOs as a considerably more intricate topic than vaccines, with numerous factors to consider and consequences that are often challenging to test. She points out the complexity of distinguishing between fundamentalist views, hidden interests, and ethical arguments within the GMOs discourse making it difficult to discern reliable sources. She acknowledges the difficulty in reaching definitive conclusions, recognizing that individual values and priorities play a pivotal role in shaping perspectives on this complex issue.

Vignette 3: Nuno (male, physician, early forties)

CC: Nuno believes there is an abundance of information on climate change. He primarily relies on social media and online newspapers as his sources of information. When searching for information, he considers it essential to validate the claims by evaluating the scientific evidence that has accumulated in a certain direction. Not all studies are equal, and individuals must possess scientific literacy and critical thinking skills to evaluate it. However, he notes that science is not entirely neutral, and there is a need for impartial evaluations, meta-analyses, and systematic reviews. Sometimes the conclusion is that there is no absolute truth. Nevertheless, for the general public, some aspects can be intricate and science must find ways to make information accessible to them. Public entities should bear responsibilities in this regard.

VAX: Nuno works in the field and acknowledges that his opinion is biased. He possesses substantial knowledge about the scientific and public policies related to vaccines. He believes there is a deficit of information in the general population on this topic and that many misconceptions exist not only regarding the side effects of vaccines but also concerning public policies and available information. He strongly criticises the anti-vax movement because he believes it endangers others and considers vaccination a social responsibility that everyone should uphold. While he does not advocate for mandatory vaccination, he emphasises the importance of informed choice.

CAM: Nuno believes that CAM is a pseudo-science and that the political validation it receives in Portugal is counterproductive. He thinks that some CAM practices may have placebo effects but lack scientific validity, leading to widespread misunderstandings on the topic. In conventional medicine, there are rigorous studies, evidence, and research, whereas CAM often lacks sufficient evidence. Therefore, he contends that homoeopathic products should not be labelled as medicine since they are not subject to the same regulations as conventional medicines. In conventional medicine, treatments that prove ineffective are discontinued, reflecting an ongoing process of refinement. Nuno believes that the scientific method should be applied uniformly, and CAM practices must be held to the same standards. He understands that people turn to CAM when they do not find answers in conventional medicine, but he is critical of those who sell ineffective products, emphasising that individual cases should not be generalised.

GMOs: Nuno has limited knowledge on this topic and does not hold a strong opinion about it. He recognizes that various factors come into play concerning the environment and public health, but he has not formed a definitive position towards it.

Vignette 4: António (male, retired designer, early seventies)

CC: He considers climate change a very important issue and worries about the future of the planet. He believes that there is an excessive amount of information on the subject, but much of it is not directly related to people's everyday lives, which can desensitise public opinion on the issue. He values the role NGOs and artists have in raising awareness on the issue. Although he appreciates the scientific information available on the subject, he believes that a purely scientific discussion around climate change—based on notions of absolute truth and the sanctity of science—is pointless. He also points out that there are scientists who argue against the existence of climate change. He thinks there should be more information on how citizens can take action, not just science information. He highlights the importance of decisive political and economic action to address it.
VAX: He is highly sceptical of vaccine benefits and worries about their health impacts. He thinks that vaccination in Portugal is an accomplished fact, a consensual topic that people consider beyond debate, and that, because of that, there is no good information on the issue. He believes that people cannot make objective decisions because there is no information on the adverse effects. He considers that there is no scientific consensus on this matter, and the information is not clear on the subject. He is aware of many cases of side effects, including his own. He believes that science is a specific belief system with a high degree of uncertainty, and citizens need to cross-reference scientific information with information from everyday life to reduce the degree of uncertainty when making choices. He refers to the fact that there is no such thing as complete neutrality in research and that universities are often funded by pharmaceutical companies.
CAM: He is a CAM advocate and studied the topic in India. He considers there is a lot of quackery around CAM in Portugal and that it is important to turn to the best sources, such as Ayurvedic universities, the School of Traditional Chinese Medicine, or homoeopathy centres. He thinks there is scientific ethnocentrism in how traditional medicines are seen. He considers them legitimate forms of medicine with theories, scientists, and medical practice. He blames the pharmaceutical and medical lobby for creating barriers and misconceptions and for the lack of information on the topic.

GMOs: He is against GMOs and thinks they are an invention of the agribusiness. He considers that there is no good information on the issue and that they pose a risk to biodiversity and health. He worries about research in biogenetics. He thinks it is a topic where consumers have more to say because they can stop consuming GMO products. He considers the EU could have a more important role in regulating it by creating positive discrimination towards non-GMO agriculture in Europe.

Vignette 5: Júlia (female, biology teacher, mid-fifties)

CC: She subscribes to several scientific journals, follows several scientists and the IPCC, and she often shares information with her students. She believes people may not understand the urgency of the topic because many impacts are projected as long-term. She thinks that individual choices and policymaking should be based on the positive and negative impacts already mapped by science and believes that too much information on the topic can be counterproductive if people do not have the knowledge and scientific reasoning to assess the information. People do not have access to evidence and experience.
VAX: She reads a lot of scientific information about the topic, namely from journals and websites like *Science*, *Nature*, and *Science Daily*. She is not against vaccines but questions the existence of a universal vaccine, and the way some vaccines operate and are administered. She believes that in order to reflect on these issues and be able to identify what is fake or what comes from pharmaceutical lobbies, it is important to inform herself. She had some hesitations and only vaccinated her son when he was one year old, with the agreement of her paediatrician. She thinks that science is dynamic and contextual; it is important to provide people with the basis to read and interpret scientific information because it changes every day.
CAM: She is a CAM advocate. She believes there are tensions between traditional and alternative medicines, as well as too much misinformation and resistance from those in traditional medicine. She thinks both medicines are complementary and supports alternative medicines as part of the healing process. She is surprised when she perceives that

scepticism towards CAM is much higher than towards VAX. She questions why it is easier for us to take something we do not know what is inside (vaccines) and so difficult to take something that is natural (CAM). She thinks that this is due to cultural factors and believes there are cultural prejudices towards CAM. She defends that there are scientific articles supporting areas like Reiki or meditation.

GMOs: It is a subject she informed herself about to be able to teach her students. She thinks it is a complex topic with contradictory information and believes it is important to seek scientific knowledge not to criticise, but to question. She thinks that there are not enough studies about GMOs' impacts, so she tries to stay informed to see what studies there are for and against. She uses NGO websites as sources of information. She thinks that the reason there is not much attention given to the topic is that there are no long-term studies that can help us measure impacts. She thinks we cannot be blind to science; this type of intervention can have unforeseen consequences, like the ones we are seeing with the climate. She is scared by the fact that people are so uninformed on the subject, leaving decisions to politicians only.

Discussion

These vignettes illustrate how the five selected participants expressed their epistemic assumptions about authority, media, and the role of science during the group discussions and how these are profoundly intertwined with the way they access information and sources but also the difference in attitudes towards different science-related topics. The vignettes also reveal how they relate to science in different ways when specific topics are considered expressing different degrees of epistemic trust in scientists and scientific expertise (Muis et al., 2006). Educational background, occupational activities, and personal experiences all colour the way the selected participants envision scientific topics and trust the scientific establishment and its professionals (Hendriks et al., 2016).

Some of the participants shared similar viewpoints, albeit with individual nuances. Nuno and André, for example, share similar positions regarding the role of science and scientific knowledge in all topics. They both emphasise the importance of scientific evidence and express trust in the scientific process. They express high confidence in scientists in specific topics (vaccines for Nuno and CAM for André) and rely on a more pragmatic trust in external sources of authority on topics about which they are less knowledgeable. However, their paths to these understandings are distinct. Nuno is heavily influenced by his academic background and professional experience, leading him to adopt a more assured standpoint in relation to the authoritative value of science. André's interest in these topics seems to be primarily driven by personal curiosity and exploration. The two men also highlight different aspects related to science production and communication. Nuno expresses an epistemic trust in the scientific process (and is mostly concerned with the difficulty of making scientific information accessible to the public). André, on the other hand, is more interested in the inherent complexity of these issues and understands that some topics are more "open to interpretation", which explains the difficulty scientific knowledge has in establishing itself as the main criteria for evaluation in specific fields.

In contrast, Sofia and Júlia showed less consistent positions towards the role of science in all the discussed topics. Both value the importance of scientific knowledge and actively seek information from what they consider to be credible sources regarding the four topics. They are both interested in the topic of vaccines and emphasise the need to stay informed on the topic, even though they rely on their physicians for reference. They show a selective critical approach to sources of information often highlighting the need to discern hidden biases, such as those of NGOs and pharmaceutical companies. This selectivity becomes more evident in the case of CAM. They are both advocates of CAM and believe that cultural prejudices exist towards these practices. They see this as a result of the clash between conventional and alternative medicines, leading them to manifest an epistemic distrust in the scientific community's stance on the topic. They draw on their own positive personal experiences with CAM but also highlight the existence of credible alternative knowledge on the topic, whether from certified sources or scientific literature, to justify their interest and position. They both refer to the importance of science information to be able to question assumptions and help people make informed decisions.

António, on the other hand, stands out and demonstrates much lower levels of trust in science in all the topics in discussion, often criticising the scientific process, functioning, and implementation. For him, science is "just another system of beliefs" and as such, it is susceptible to be criticised as any other. He criticises science's detachment from everyday life and considers that purely scientific discussions are often pointless. He was one of the consultation participants who expressed more concern about vaccines.

Scientific knowledge was considered less certain and straightforward in CAM and GMOs, where the inherent complexity of the topic was acknowledged by several participants. However, domain specificity (Muis et al., 2006) was much more evident in the case of CAM. Although some participants were critical about these kinds of practices, highlighting the lack of scientific evidence and regulatory mandates as conventional medicine, others found space to question the certainty of current scientific knowledge on the topic and to defend the validity of alternative sources of knowledge. Scientific expertise carried greater authority in domains like vaccines and climate change, even if the inherent uncertainties of the scientific process were acknowledged, particularly by participants with lower levels of trust in science and heightened selectivity regarding information sources (Schwarzenegger, 2020).

Even among participants with seemingly similar epistemic orientations towards science, subtle differences and nuances emerged in how they valued and assessed scientific knowledge, particularly in terms of its certainty or simplicity (Hofer, 2005). These differences are often obscured in larger quantitative studies, albeit they reflect diverse conceptions of the normative role that science plays or should play in various aspects of society. They also underscore the intricate ways in which scientific knowledge is contextually interpreted and negotiated.

Furthermore, the cases presented also illustrated how personal epistemologies articulate specific orientations towards science communication (Suldovsky & Taylor-Rodríguez, 2021). Participants who emphasised the complexity and uncertainty of the scientific knowledge associated with the topics under discussion often stressed the importance of citizens' critical questioning and active engagement. This inclination was particularly conspicuous in the context of more controversial topics such as CAM or GMOs but was also visible in the discourse of participants who expressed criticism or hesitation regarding vaccines.

Conclusion

The use of rich individual vignettes to describe participants' position in the four group discussions offers us an opportunity to better understand how their professional and academic background, personal experiences, and relations, all shaped, in different ways, the specific way they think, interpret, and evaluate different science-related topics. The analysis illustrates how citizens' personal epistemologies towards different science-related issues tend to reflect general beliefs about knowledge but are also shaped by domain specificity. While some participants expressed more consistent epistemic positions towards the role of science in all the discussions, others showed more contextual understandings. Differences between domains reflected not so much a lack of information on the topic, but a specific understanding of the role of scientific evidence within that domain.

Nevertheless, we must acknowledge the exploratory nature of this study, as well as its limitations. The cases presented were selected by the authors because of their paradigmatic relevance and capacity to illustrate diverse expressions of personal epistemologies. This might signify a bias towards science-oriented participants who were more comfortable expressing their views within a large group discussion. Future studies on personal epistemologies of science should strive for a more diverse and representative sample and explore alternative methodologies of data collection that would allow delving deeper into the contextual interpretation of trust in science in everyday life and a more comprehensive understanding of how individuals' diverse backgrounds and perspectives shape their relationships with science.

In conclusion, this research underscores the dynamic and topic-dependent nature of personal epistemologies and trust in scientific expertise and their profound influence on the way individuals engage with and evaluate science-related topics. It emphasises the need for tailored approaches to science communication that account for the nuanced epistemological positions held by different individuals across various domains of scientific knowledge.

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Research Ethics Statement The project CONCISE had an Ethics advisor and written guidance on the technical and organisational measures implemented to safeguard the rights and freedoms of the data subjects/research (Deliverable 6.2) and an analysis of the potential risk the proposed research raises in regard to the vulnerable populations, and the measures to protect them and minimise the risk of their stigmatisation (Deliverable 6.5), as well as instructions on obtaining informed consent (Deliverable 6.4).

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22

How Citizens Explain Trust in Vaccines: Insights from Armenia, Brazil, Denmark, and Italy

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Introduction

The rapid development and approval of new vaccines for emerging infectious diseases over the last decades like H1N1 (swine flu), HPV (Human Papilloma Virus), and COVID-19 have received significant media coverage and brought vaccines to the forefront of public discourse.

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In the wake of the COVID-19 pandemic, public perceptions of the importance of vaccines for children have dropped dramatically worldwide (Eagan et al., 2023; UNICEF, 2023)—presumably due to misinformation and general mistrust in government, healthcare institutions, or pharmaceutical companies that tend to spill over into vaccine mistrust—thus impacting longstanding confidence in childhood vaccination programmes. As an amplifying mechanism of this type of mistrust, scholars point to the rapid spread of false claims about vaccine safety and efficacy through the internet and social media (Agergaard et al., 2023; Dredze et al., 2016; Dubé et al., 2015; Jones et al., 2012; Phadke et al., 2016).

Public trust in vaccines is a complex issue influenced by many factors. Prior studies find that vaccine attitudes diverge on two main themes: causal mechanisms (e.g., whether vaccines prevent or cause illnesses) and trusted authorities (i.e., which social and institutional entities are regarded as authoritative) (Gierth & Bromme, 2020; Hendriks et al., 2016). It is important to note that vaccine trust is not static and can change over time in response to evolving information and events (ch. 16), and the reasons for trust or mistrust can vary by region and context. Studying parents' grounds for trusting vaccines *to a certain degree* offers important insights into broader trust in science—helping us understand how vaccination decisions are critical and often emotionally charged for parents, involving considerations of risk, benefit, and trust. Qualitative comparative studies are especially valuable here because they let us compare different contexts and situations and recognise diverse and country-specific ways of articulating trust (Azarian, 2011; Bucchi & Trench, 2015; Eagan et al., 2023; Rowland et al., 2022; chap. 20 in this book), which again are important beacons for custom-tailoring science communication both locally and globally.

This chapter aims to shed light onto citizens' trust in childhood vaccines, a science-based technology, and hereby indirectly onto these citizens' trust in science.

We focus on parents' attitudes towards childhood vaccination in Armenia, Brazil, Denmark, and Italy (chosen for their very different socio-historical backgrounds) by analysing material from a pilot survey conducted in each of these four countries during the COVID-19 pandemic. The main aim of the survey was to recruit interviewees for a cross-linguistic interview study about their experience and motivation to vaccinate their children. After examining the recruitment questionnaire results, we realised that respondents' free-text explanations for their score on a 10-point scale on trust in vaccines contained information of how people weigh causal mechanisms and justify their position by constructing, substantiating, and expressing different arguments of trust in vaccines.

In our analysis of these free-text explanations, we addressed the following research questions:

RQ1: which rhetorical-linguistic strategies do parents apply to argue for their trust (or lack thereof) in childhood vaccines?
RQ2: to what degree are these rhetorical-linguistic patterns related to the supplied trust scores, also across countries?
RQ3: to what degree do our data mirror the single countries' trust level in vaccines as well as in health and political authorities as mapped by extant sociological studies and statistics?

When looking at those sociological data on trust for our four countries of comparison, it becomes clear that they differ highly. In Armenia, factors such as fragile governance structures, ongoing border disputes, and pervasive corruption significantly contribute to a heightened sense of distrust in national authorities (Saari, 2011; Sauer, 2023). A survey conducted in 2020 in Yerevan showed that nearly half of the respondents were dissatisfied with Armenia's healthcare system, largely due to a lack of trust in the government (Harutyunyan & Hayrumyan, 2020). Gallup data indicates that Armenia is among the countries with a high level of scepticism regarding vaccine safety, efficacy, and necessity, resulting in low vaccine uptake among children (Gallup, 2019; for an example, see Torosyan, 2020). Vaccine acceptance in Brazil is generally high and the country is renowned for its immunisation programmes with high uptake rates (Bernardeau-Serra et al., 2021). In recent years, however, Brazil has seen a decline in vaccination rates due to political instability, COVID-19 challenges, and the spread of vaccine-related misinformation. Despite this, there is a shift in societal attitudes towards

COVID-19 vaccines, with the population increasingly trusting in science and perceiving these vaccines as essential (Andrade, 2021; Ferreira, 2022; IOC/Fiocruz, 2022). Finally, Denmark and Italy exhibit varying levels of trust. The most pronounced disparities lie in public administration trust, with Denmark showing high trust (between two-thirds to three-quarters of the population) and Italy displaying lower trust (ranging from one-quarter to one-third) in government institutions. However, both Denmark and Italy display relatively high trust in healthcare institutions and personnel (European Commission, 2019). Data from the WHO/UNICEF estimates of national immunisation coverage show that DTP3 coverage (i.e., the third dose of the diphtheria, tetanus, and pertussis vaccine, administered to children) declined in all countries, except in Denmark, from 2010 to 2019 and continued to decline after COVID-19 (Eagan et al., 2023).

In what follows, we will supply our theoretical background on trust in science, science communication, and vaccines respectively and then go on to describe the settings and the study, including our data collection and analytical coding procedures. In the results section, we present examples for typical rhetorical-linguistic patterns in our data, also in relation to trust scores and country-specific distribution. In the discussion, we relate our findings to existing research on trust in science and science communication before summarising our findings in the conclusion.

Theoretical Framework of Trust

'Trust', as reported by Hendriks et al. (2016), can be defined as a willingness to depend on other agents (with reference to Blöbaum 2016) and is connected to being vulnerable, being out of control as well as running risks (with reference to Mayer et al., 1995). When it comes to trust in "knowledge", as in the case of science-related information, the risk lies in its possible falseness or invalidity.

We emphasise that trust in knowledge is directly connected to the notion of "believing" and "faith" (both in the religious and secular sense). In the encyclopaedia *Treccani,* the Italian expression for "faith", *fede*, is defined as "[…] adhesion to affirmations or doctrines not rationally evident, but believed based on well-founded or authoritative testimonies […]" (our translation; Treccani, s.a.). This implies a so-called leap of faith, for which a linguistic-cognitive definition is given further below. This is also the definition that we work with on our data analysis.

Literature on science and trust has focused on different empirical aspects, e.g., on mapping lay people's general dispositions but also concrete grounds for trusting scientists (Hendriks et al., 2016), on inventorying lay people's grounds for and degrees of trust in various science-mediating sources (Rowland et al., 2022), and on shedding light on lay people's trust in science-based technologies in the form of vaccines by analysing their verbalisations on the topic (Kratschmer & Braga Mattos, 2024; as well as the present chapter). In the following, we will present these studies, point to differences and overlaps, and state which of their theoretical concepts will be relevant for this chapter.

Hendriks et al. (2016) describe trust in scientists by lay citizens, dubbed as "epistemic trust", as building on the factors of perceived *expertise, integrity*, and *benevolence* of the experts. The authors define e*xpertise* as knowledge and skills in the relevant professional domain. An expert is further trustworthy when perceived as being both willing and able to follow their profession's acknowledged knowledge-generation procedures, i.e., as having *integrity*. Finally, *benevolence* is demonstrated by the scientist when striving for the good of other people. By shifting the point of view from the trustee (the scientist) to the trustor (lay people), Hendriks et al. (2016), with reference to Origgi (2004), furthermore point out that epistemic trust, as granted by lay people, entails *default trust*, a general predisposition in humans for cooperation and communication, and *vigilant trust*, where sources are critically evaluated before trust is granted.

Rowland et al. (2022) shed light on the trustworthiness of sources of science information. The authors convincingly show in their interview study with Polish and Portuguese informants regarding the topics of climate change and vaccination that trust in science cannot be reduced to the question, "How much does a public trust in science (and why)?". This question must be split up into a series of potential recipients of trust, as well as a fan of factors that heighten or inhibit trust and which are often directly linked to the type of recipient. As Rowland et al., (2022, p. 1418) point out, factors nurturing trust are: expertise, independency in the light of external pressure, a motivation for striving for the common good, and finally commitment—high engagement in a cause, consistency over years and a clear position. Factors weakening trust are economic and private interests, instrumental polarisation, extremism, and inconsistencies (seen as symptoms of hidden agendas). The authors distilled four basic patterns and at the same time degrees of trust from their data (p. 1420f.). *Unquestioned confidence*—a "confident, positive expectation"—builds on the a priori credibility of the trust receivers due to their perceived role, expertise, and independence (following Origgi (2004), we believe that this is made possible due to the human *default trust* disposition). *Justified trust* arises from an assessment of the receivers' motives, level of engagement and consistency, and a subsequent positive expectation about integrity and benevolence; however, this kind of trust must be earned (we believe *justified trust* echoes Origgi's (2004) *vigilant trust*). *Reflexive trust* is applied to actors whose trustworthiness is not questioned in its entirety, but where single characteristics (independence, commitment) of the actors are assessed as defective and thus making the public question the actors' objectivity, resulting in lower levels of trust in the information mediated by these actors (which, we believe, could equally be subsumed under *vigilant trust*). *Active distrust* is shown towards individuals (politicians) and institutions assessed as having an agenda of self-interest and showing irresponsibility, inconsistency, politicisation of scientific matters, opportunism, and striving for financial gain.

We found these trust construct components highly illuminating for the analysis and interpretation of our results. However, we must emphasise that Rowland et al. (2022) and our study differ on crucial points: data collection method (interviews vs. questionnaire) as well as RQ (trust in science information sources vs. trust in a concrete science-based technology). This means, in particular, that the category of *reflective trust* (referring to concrete, single actors) might not apply to our data, even if our informants often refer, but more broadly, to sources of information. For the other three categories, "trust (in vaccines)" must be measured by the criteria of vaccines' efficacy and safety as perceived by the informants, and only indirectly in relation to information sources.

Kratschmer and Braga Mattos (2024) have focused on concrete linguistic structures of lay citizens explaining different degrees of trust (on a scale of 1/*no trust at all* to 10/*total trust*) in vaccines. The authors analysed the Italian sample of our data set and developed a data-driven coding scheme for the linguistic-rhetorical analysis of these data. The coding scheme mapped three parameters: argument structure, source of arguments, and utterance-related attitude (in the following overview, fabricated text examples are given in parentheses).

i. *Argument structure*, i.e., the presence of pro or contra arguments towards vaccines and their relative weight inside one given free-text sample:

   PRO (*vaccines prevent diseases*)
   PRO > CON (V*accines are important because they prevent diseases, even if there can be slight side effects*)
   PRO = CON (*Vaccines prevent diseases, but have side effects*)
   CON > PRO (*Vaccines might prevent some diseases, but they have devastating side effects*)
   CON (*Vaccines have side effects)*
   Ø, no argument given while explaining one's degree of trust (*I trust vaccines; I believe in science*)

ii. *Source of arguments*

   Authority (I trust vaccines because I believe in science/my paediatrician)
   Personal experience (*I don't trust vaccines because I have suffered heavy side effects*)
   Personal expertise (*I know that vaccines work because I am a biologist*)
   Accepted and acquired information ("AAI"); *vaccines don't work and have heavy side effects*).

Kratschmer and Braga Mattos (2024) underscore the importance of this last manifestation of the parameter. It describes—in a neutral way—the fact that the citizen uses one or more arguments for which they do not explicitly indicate the source, while, at the same time, the epistemic status of the content is outside the evaluation framework of the non-expert citizen; it means that the citizen has acquired and accepted the information as valid, but they do not mention from where. The authors emphasise that this is a neutral description as it does not distinguish between the possible types of sources and hence the latters' authority or trustworthiness as measured from an opinioned perspective.

iii. *Utterance-related attitude*, i.e., a linguistic marker (or absence of such) as to how a speaker engages with the information unit expressed in the utterance[1]:

   Opinion, i.e., based on personal evaluation of information received from others (*I am convinced that vaccines prevent diseases*)
   Faith, i.e., based on a leap of faith, or active decision to adhere to a piece of information given by an authoritative source without being able to assess it oneself (*I believe/trust that vaccines prevent diseases;* and its opposite: *Neg-Faith*: *I don't believe/trust in vaccines*).
   Assertion, i.e., absence of engagement marker (*vaccines prevent diseases*).

As Rowland et al. (2022) and Chapter 20 show, trust in different science-related aspects is context-dependent, with different societies and cultures interpreting it in distinct ways. Therefore, we applied the coding schema developed by Kratschmer and Braga Mattos (2024) for the Italian data set to the Armenian, Brazilian, and Danish data. As mentioned, these four countries vary in relation to social, political, economic, and historical characteristics and hence can support a mapping of country-related differences as well as cross-country similarities.

[1] In Kratschmer and Braga Mattos (2024) the utterance-related attitude is more precisely defined as a combination of the linguistic descriptive categories epistemic modality, evidentiality and a novel category ("mode of engagement"), which denotes the socio-cognitive path of adhering to a piece of information. (For the highly theoretical linguistic details, see that publication.).

Data and Method

In this chapter, we analyse empirical data from a multilingual pilot survey aimed at understanding parental attitudes towards childhood vaccination. We adapted questionnaires from prior Danish and international studies on vaccination attitudes, creating parallel versions in Danish, Armenian, Brazilian Portuguese, Italian, and English (as a cross-linguistic template). The survey was conducted online between August and December 2020, using the SurveyXact platform (https://ramboll xact.com/), disseminated by ads from the Aarhus University Facebook site and subsequent snowball system. Data collection coincided with the first year of the COVID-19 pandemic, but under preparation from the year before. Respondents were asked to rate their general trust in vaccines on a scale of 1 to 10 (1/*no trust at all* to 10/*total trust*) and provide reasons for their rating in a free-text window.

A total of 277 respondents completed the questionnaire, with 38% excluded for not providing an explanation of their trust score. Our final dataset had 51 Danish, 43 Armenian, 42 Brazilian, and 37 Italian free-text explanations.

We coded the Armenian, Brazilian, and Danish data sample following the coding scheme from Kratschmer and Braga Mattos (2024) for the Italian data set.

In order to minimise subjectivity, coding followed a strictly mechanical linguistic method based on mapping concrete linguistic material, rather than interpreting inferences or indirect speech acts. Thus, the code OPINION was attributed to expressions such as “I (don't) think”, “I (don't) believe that” “I am (not) convinced that”. The code FAITH attributed to expressions such as “I have faith”, “I trust”, “(my) trust”, “trustful”, “trustworthy”, “confident”, “I believe in”. The code NEG-FAITH was applied to expressions of the antithesis of a leap of faith, i.e., explicitly expressing a rejection of something by having e.g., “no faith”, “no trust in”, etc.). Note that the expression “I believe that” (~ “I think that”) was coded as OPINION, whereas “I believe in” was coded as FAITH. For more details on the linguistic rationale behind our coding, please see Kratschmer and Braga Mattos (2024).

It needs to be emphasised, however, that respondents' cognitive and argumentative processes regarding opinion formation vs. deciding to perform a leap of faith may not always be distinct, making their stance less clear-cut.

Since our free-text responses from the questionnaire need to be viewed as meta-textual comments to the trust scores, they need to be viewed in the context of these comments. For example, a statement like "Vaccines don't deliver on their promises" paired with a score of "1" reflects the respondent's lack of faith in vaccines, while the comment "there are side effects" matched with a score of "9" explains why the respondent chose not to give a perfect score of "10".

In the following section, we report our findings in relation to Rowland et al.'s (2022) trust construct components, illustrating among other things how these constructs can be mapped upon different constellations of our analytical parameters as well as providing illustrative quotes with coding highlighted in capitals and specifying country (AR, BR, DK, IT) and trust score (1–10) of each subject.

Results

In the following, we highlight free-text examples and discuss how the coding maps onto Rowland et al.'s (2022) trust construct components. By this, it will become clear how our mechanical linguistic-rhetorical analysis could help typify public trust in vaccines with some caveats attached.

Unquestioned Confidence

Unquestioned confidence is defined by Rowland et al. (2022, 1420) as a "confident, positive expectation" that builds on the a priori credibility of the trust receivers, due to their perceived role, expertise and independence. This is visible in high scores (9–10), and it is typically (but with some exceptions) associated with a very low degree of rhetorical elaboration, which can be expressed by different combinations of lack of PRO/

CON arguments, lack of reference to authority, pure assertions, or pure expressions of faith.

> Ex. 1. *I trust [FAITH] evidence-based medicine [AUTHORITY]* (AR, score 9).

Example 1 does not rely on arguments, which are obviously not judged as necessary by the informant.

> Ex. 2. *I believe [FAITH] it helps to prevent disease [PRO]* (BR, score 9).

In example 2, we find an argument and the expression of faith towards vaccination, but no reference to a source.

> Ex. 3. *I believe [FAITH] in science [AUTHORITY] and trust [FAITH] that doctors and the Health Authority [AUTHORITY] tell the truth* (DK, score 10).

In example 3, we have a double declaration of trust to three different types of authority (science, practitioners as well as the national health authority).

> Ex. 4. *I have almost total faith [FAITH] in vaccines [no argument(s), no source(s)]* (IT, score 10).

In example 4, we find a declaration of faith which goes directly to vaccines, i.e., no source is needed to mediate that trust. Moreover, the trust is described as "almost total" (while the grade "10" given represents "total trust"), but the respondent does not explain why her trust would not be total. High scores and their mostly associated short free texts are in the absolute majority in our dataset (Danish: 76%, Brazilian: 69%, Italian: 57%), with the exception of the Armenian subset (7%). The texts tied to high score emphasise trust in vaccines, in science and in health and civic authorities.

Justified Trust

Justified trust, according to Rowland and colleagues' definition, must be earned. A person or institution's motives, level of engagement, and consistency are evaluated, and if the evaluation is positive, it engenders an expectation about integrity and benevolence (Rowland et al., 2022, p. 1421). In the case of vaccines, however, it is not only the motives and level of engagement of the mediating authorities that is at stake: it is also the consistency over years as to the vaccines' efficacy and safety. And it is here, where several informants make a distinction between proven childhood vaccination and newer vaccines like the one against HPV, see e.g., example 5 below, or the future COVID-19 vaccine at the time of example 5.

Justified trust is prototypically found with scores still over middle and typically shows a level of high elaboration, where PRO and CON arguments related to vaccines are weighed against each other, but still with the overweight PRO > CON. Informants refer to authorities, but very often leave no reference to a source, meaning that they have acquired and accepted the information (AAI) potentially from many different available sources. In these contexts, we find both OPINION statements and FAITH declarations, but, for the latter, fewer than for the *unquestioned confidence* construct. Often, they are found side by side in one text. Pure assertions are also frequent.

> Ex. 5. *There should be more differentiation between individual vaccines. I have good confidence [FAITH] in, for example, the MMR vaccine, even though I believe [OPINION] it is associated with cases of aluminium allergy [CON]. On the other hand, I have less faith [NEG-FAITH] in, for example, the HPV vaccine, where a number of serious side effects have been reported [CON, AAI]. I think research should be done to develop better vaccines with fewer negative side effects [CON). On a very personal level, I find it difficult to make a decision on behalf of my children* (DK, score 6).

The informant that provided example 5 reported a medium trust score ("6") and declared confidence in the established MMR vaccine. However, in her opinion, it is associated with aluminium allergies, and negative side effects are mentioned twice later in the text in the form of assertions with no sources (that is, she provides acquired and accepted information).

> Ex. 6. *I believe [FAITH] that they do work [PRO], but I don't know [OPINION] if the promoted immunization is efficient [PRO=CON] and I believe that [OPINION] for some individuals susceptible to allergies they can be quite dangerous [CON, AAI]* (BR, score 8).

The informant of example 6, having given the relatively high score "8", both declares her faith in vaccines being efficient, but also states that she is not able to hold a clear epistemic stance towards the efficacy of vaccines (PRO = CON, i.e., undecided). She concludes that, in her opinion, severe con-arguments exist. No source for the information is given (i.e., reference to acquired and accepted information).

> Ex. 7. *I can only have personal experience. I have gotten all vaccines and I'm glad I got them [PERSONAL EXPERIENCE]. Obviously, I have no children depending on me and if it were so, I would have dug deeper to understand more. I think [OPINION] there are always pros and cons [PRO=CON]. But I often prefer to support medicine [AUTHORITY], even if it is sometimes wrong, as with certain vaccines [CON], or that certain pharmaceutical companies have made mistakes [CON, AAI] and of this I'm sure [OPINION]. Vaccines are used to protect [PRO, AAI] and if done properly, they have to be administered [PRO > CONS, AAI]* (IT, score 5).

In example 7, we see a combination of personal experience, authority, and acquired or accepted information, the argument balance is PRO > CON, and some information is given without a source.

The percentage of this type of free text is more levelled out among all subsets (Italian: 41%, Armenian: 33%, Brazilian: 26%, Danish: 18%).

Reflexive Trust

Reflexive trust is applied to actors whose independence or commitment, and hence objectivity, is assessed as less than ideal, which results in lower levels of trust in the information mediated by these actors (Rowland et al., 2022, p. 1421). In our vaccine-related data, we expected this to translate to lower trust scores (while still above 1), while trust first and foremost assessed regarding the efficacy and safety of vaccines. However, the linguistic and rhetorical structure of the few examples in our dataset with scores between two and four, are not really, for the most part, distinguishable from active distrust, which we will discuss immediately below.

Active Distrust

Active distrust is directed towards actors assessed as having an agenda of financial or political self-interest, as well as having a track record of showing irresponsibility or inconsistency (Rowland et al., 2022, p. 1421). In our case of vaccines, many criticisms amount to pointing at the self-interested motives of vaccine proponents, be it politicians or manufacturers. However, mistrust held directly towards vaccines' efficacy or safety, or the methodology applied in their development or manufacturing, is equally important.

We have mapped our examples for scores with "1" ("no trust at all") onto this construct.

There are none in the Brazilian dataset and only one in the Danish and the Italian dataset, respectively.

We start with the only Italian example, example 8, which is also the only Italian example with a score below "5":

> Ex. 8. *I work with a doctor and have studied the leaflets [EXPERTISE]. They are drugs that do not do what they promise [CON, ASSERTION]* (IT, score 1).

This is also the only example in our whole dataset where a respondent pointed to their own expertise without declaring high trust in vaccines. There is equally only one contribution in the Danish dataset with score 1, example 9:

Ex. 9. *Too many scandals [CON, AAI] for one to trust vaccines [NEG-FAITH]. There is a need for an INDEPENDENT body to report vaccine damages to and investigate the cases UNBIASED (which excludes the health authority)* (DK, score 1).

In contrast to these three datasets, the Armenian dataset contains 18 datapoints with the score 1. Most of the contributions are very short (with some exceptions), like examples 10, 11, 12, and 13.

Ex. 10. *There is no scientific proof about the safety and efficacy of vaccines. [CON, AAI, ASSERTION] (AR, score 1).*
Ex. 11. *It's just a business [CON, AAI, ASSERTION]* (AR, s*cor*e 1).
Ex. 12. *There is no supervisory body I could trust [CON, AAI, NEG-FAITH].* (AR, score 1)
Ex. 13. *Because of vaccines my son got autism [CON, PERSONAL EXPERIENCE]* (AR, score 1)

The distribution of trust scores from 1 to 4 is upside down compared to the distribution of the highest scores: Danish (6%), Brazilian (5%), Italian (3%), and Armenian with a striking 51%.

Very typical for most of these Armenian contributions is that they report personal experience with side effects portrayed as severe (in the broader sense, both encompassing the respondent's own experience but also that of people in their closer network; example 13 above), while some express deep distrust and negative faith in the national authorities (example 12 above) and pharmaceutical companies (implied in example 11 above). To conclude, when disregarding trust scores, those contributions in our data that could not be mapped unto either "unquestioned confidence" or "justified trust" all fit the category "active distrust".

Discussion

While the individual countries' data displayed expected variations in the distribution of trust scores and types of arguments provided, our linguistic-rhetorical analysis revealed that many explanations reflected a comprehensive consideration of various arguments by citizens.

Moreover, we were able to demonstrate that our data, in their typical manifestations, could be meaningfully aligned with Rowland et al.'s (2022) trust construct components—*unquestioned confidence* (characterised by low rhetorical elaboration), *justified trust* (with high elaboration), and *active distrust* (involving low elaboration). However, there are somewhat more exceptions to the typical low elaboration associated with active distrust, especially within the Armenian dataset. What piques our interest is that, in our data, there appear to be rhetorical preferences (expressed through elaboration depth) for invoking these constructs, which, to some extent, might even have predictive value. We propose exploring whether our insights into the rhetorical and linguistic characteristics of different trust construct components could be leveraged for automated detection of these patterns in large text collections, potentially predicting trust levels. It is worth noting, though, that our data assess not primarily institutions and individuals as information sources but the vaccines themselves. This implies that the definitions for trust construct components need slight adjustments, at least for non-extreme scores, which, following Rowland et al. (2022), relate to trust in single-actor science information sources. Consistency over time in the context of vaccines must therefore be defined as "consistency in terms of efficacy and the absence of significant and frequent side effects". In fact, we could not convincingly align any segments of our dataset with the concept of *reflexive trust*. This may be linked to the fact that this construct primarily concerns individual persons (isolated by Rowland et al. for the climate debate), which is of much less relevance in the context of vaccines. Our data reveal a clear divide between those who trust vaccines, either automatically or after careful deliberation, and those who do not trust them at all, even though the trust scores exhibit a more diverse distribution.

Our data show similar high trust in vaccine technology in Brazil, Denmark, and Italy and very low trust in both vaccine technology and national authorities in Armenia. Hereby it becomes clear that, depending on the country, pro-vaccine science communication needs to address additional aspects such as health and civic politics (see similar results in chapter 20 for Germany and South Africa). Trust in vaccines must be earned on different societal levels. However, for future studies, it is important to use larger and potentially less skewed datasets than ours. It would be relevant to investigate whether *reflexive trust* emerges as a robust general trust construct component or if it was unique to Rowland et al.'s (2022) Polish and Portuguese subjects, the focus on trust in sources of science information, the treatment of two science-related topics side by side, and/or the method of focus group interviews.

The content of the PRO and CON vaccine arguments that we found in our free texts can be referred to Hendrik et al.'s (2016) aspects of *epistemic trust*, and we can again see differences between our four countries. *Expertise* and *integrity* are frequently positively evoked in our Danish, Brazilian, and Italian dataset, but only rarely in our Armenian subset, which emphasises lack of *benevolence* in both authorities and health related personnel and institutions. Critical Brazilian voices rather refer to lack of *expertise* or lack of *integrity*.

Consequently, our findings provide further support for claims made by Hendriks et al. (2016) and Rowland et al. (2022) that characterising citizens' stances on science-related issues as simply for or against is an oversimplification of their engagement with these matters. Furthermore, the complexity observed in our data appears to be a positive aspect regarding important points made in Chapter 16 seeing trust and lack thereof intertwined with warranting an operational society and democracy that flexibly assesses novel conditions (the perspectives of chapter 16 were mirrored by our data regarding attitudes towards proven childhood vaccines versus the newer HPV and COVID-19 vaccines). This also means that science communication must take these varieties of citizens' trust into account (Chapter 16). From a governance point of view, the right balance is important though: too much scepticism regarding vaccines can be a challenge for health authorities striving to achieve herd immunity (Lindholt et al., 2021).

To sum up, our findings suggest that science communication neither needs to nor should shy away from (e.g., by leaving negative issues unaddressed) strategies involving a certain level of argumentative complexity.

Conclusions

We performed a qualitative linguistic-rhetorical analysis on free-text input from an online questionnaire in which parents from Armenia, Brazil, Denmark, and Italy were asked to explain their given trust score in childhood vaccines (from 1/*no trust at all* to 10/*total trust*). Our analysis showed that parents from all countries used similar rhetorical-linguistic patterns when giving arguments for their scores, relating to sources for these arguments as well as regarding their utterance-related engagement with the arguments given (holding an opinion vs. believing/ trusting vs. merely asserting the content; RQ1). We equally found that these patterns varied according to the trust scores: typically, simple elaboration for both ends of the scale as opposed to more extensive elaboration for middle scores, a pattern equally shared by the data from all countries (RQ2). Furthermore, we also could show that our data patterns could successfully be mapped onto Rowland et al.'s (2022) trust construct components—*unquestioned confidence*, *justified trust*, and *active distrust*—even if that study differed as to data collection methods (interviews) and also investigated trust in relation to science information sources and not to a science-based technology. Despite the limitations of our data sample, we found that it mirrored the single countries' general tendencies as to trust in authorities as well as in vaccine technology as mapped in national statistics and scholarly investigations (RQ3): high trust in vaccine technology in Denmark and Italy, relatively high trust in vaccine technology, but low trust in national authorities in Brazil, very low trust in both vaccine technology and national authorities in Armenia, situations which demand adaptable strategies in science communication. Finally, the highly elaborated free texts typically tied to the medium trust scores also showed that non-expert citizens actively engage with complex information, weighing pros and cons and drawing their own conclusions. We interpret this as an indication that science communication should rather fear oversimplification (e.g., leaving negative issues unaddressed) than complexity.

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Research Ethics Statement The respondents of the questionnaire, by ticking a box at the end of the questionnaire, gave informed consent to the anonymous use of the data supplied. The questionnaire could not be submitted without the ticking of this box. All collected data is stored on Aarhus University's and SurveyXact's encrypted drives. A data processing declaration is stored at Aarhus University.

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23

Spelling Errors and "Shouting" Capitalisation Implicitly Cause Linearly Additive Penalties to Trustworthiness Judgements of Online Health Information: Online Randomised Experiments with Laypersons

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Introduction

How people assess trustworthiness of scientific information remains an important and controversial topic for medical and public health information, as trust failure in large or small subsets of populations may undermine the cooperation and coordination that is essential for the success of public programmes including vaccination (Vergara et al., 2021), environmental regulations (Hamilton et al., 2015), and research funding (Gauchat, 2012). Traditionally, trust is defined as an individual's

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willingness to render themselves vulnerable to the actions of another person (Hendriks et al., 2016; Mayer et al., 1995), but trust is not a homogeneous construct, and individual differences in assessment of trustworthiness are striking (Frazier et al., 2013). For some, personal judgements are more influenced by the personal experiences of others than by facts or expert knowledge (d'Agincourt-Cannning, 2005).

Popular assessment of trustworthiness in scientific information presents a paradox. The Enlightenment ideal of science asks us to replace faith in assertions put forward by authorities with making rational conclusions based on personal observations (Hendriks et al., 2016; Sperber et al., 2010), as summarised by the motto of the Royal Society, *Nullius in verba* ("Take nobody's word for it"). However, believing nothing except phenomena you have seen with your own eyes would make scientific publication meaningless and make modern science impossible. All people, including scientists, employ shortcuts to trust that are sometimes called *swift trust* (Robert et al., 2009), which encompasses heuristics as varied as role-based trust, rule-based trust, third-party recommendation-based trust, dispositional-based trust (the innate tendency to be more or less trusting), and category-based trust (trust based on membership in certain social or organisational groups) (Kramer, 1999; Meyerson et al., 1996; Xu et al., 2007). In these heuristics, one aspect of the speaker or within the relationship dominates the decision of the audience to trust.

In online scientific communication, perceived trustworthiness is contingent on many factors (Sun et al., 2019), and research about

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contributing factors can broadly be divided into two camps: (1) piecemeal models in which many different contributing factors to perceived trustworthiness are listed and sometimes loosely grouped into categories (Lederman et al., 2014; Sun et al., 2019); and (2) integrative models (the ability/benevolence/integrity model of source credibility, see below) in which the many potential contributing factors to perceived trustworthiness are subcategorised into a handful of core contributing factors (Hendriks et al., 2016; Mayer et al., 1995). The theoretical basis that we use suggests that contributing factors to perceived trustworthiness have been categorised into source (i.e., authors), medium (e.g., textbook, internet article), and content (the actual text; what is said) (Rieh & Danielson, 2007). Much recent research into perceived trustworthiness focuses on source trust, spurred by the influence of political populism on reception of public health information (McCluan, 2022; Perlis et al., 2023; Samuels & Kelly, 2020).

This chapter summarises our empirical research programme over three years and six experiments (Witchel et al., 2020, 2022), which seeks to objectively interrogate the effects on trustworthiness judgements when multiple factors of distrust are introduced in computer-mediated text (Gigerenzer, 2008). We call decreases in perceived trustworthiness caused by textual errors and violations of presentation conventions *penalties to trustworthiness* (Albuja et al., 2018); they occur when contributing factors about the source interact with the medium.

When multiple factors that influence trustworthiness are perceived concurrently, there are two broad options for how the audience’s judgements are cognitively reached: (a) a cost–benefit model, in which a rational weighing of multiple influences occurs (Sun et al., 2019); and (b) a heuristic model, in which a cognitive shortcut is used to make judgements based on either one, or a minimal subset of those influences (Gigerenzer, 2008). To further understand the mechanism for weighing the psychological assessment of trustworthiness, we include violations of presentation convention in the broader error category (Bieswanger, 2013; Carr & Stefaniak, 2012).

The terminology of trust is broad (Rieh & Danielson, 2007), and different researchers discuss the related concepts of trustworthiness (Sbaffi & Rowley, 2017), credibility (Fogg et al., 2003), and information quality (Diviani et al., 2015). Our team focuses on *trustworthiness judgements* as instinctively perceived text credibility, and this book chapter presents the results from our experiments culminating with how spelling errors and violations of presentation conventions additively influence perceived trustworthiness of medical information, presented in short paragraphs on computer screens in our various experiments.

The Ability-Benevolence-Integrity (ABI) Model

In Mayer et al.'s integrative ABI model, trustworthiness is assessed on the basis of source credibility, meaning the credibility or perceived trustworthiness that flows from the source of the information. The ABI model uses three broad categories of assessment criteria: ability/expertise, benevolence/loyalty, and integrity (Hendriks et al., 2022; Mayer et al., 1995; Robert et al., 2009). Expertise/ability is the perceived expertise of the author or source in relation to the topic and message being communicated (Lederman et al., 2014; Tseng & Fogg, 1999). Sometimes, expertise is less important to the audience than the ability to communicate effectively, which shifts focus to the perception of accuracy or truthfulness (Thon & Jucks, 2017).

Such perceptions are contingent on assumed benevolence, that is, "the extent to which a trustee is believed to want to do good *to the trustor*" (italics in original) (Mayer et al., 1995). In some parts of the literature the attachment element between the trustor and the trustee (i.e., the italicised "to the trustor") is over-simplified, such as in this summary definition, "kind, caring, empathic" (Levine et al., 2018). As the attachment or bond between speaker and audience is not necessarily one-dimensional, our team refers to this element as *loyalty*. For example, a speaker may be regarded as benevolent by one group and malevolent by others (Sperber et al., 2010), such as Donald Trump's statements on Covid-19, which were considered benevolent by his loyal base, and malevolent by his political opponents ('the libs') and the scientific establishment (e.g., Dr. Anthony Fauci). In information design, perceived benevolence should therefore be considered in relation to in- and out-group associations.

Integrity is the perception that the trustee consistently acts in coherence with a set of rules or principles that are acceptable to the trustor. With scientific information, integrity is the trustee's commitment to provide acceptable and reliable information, especially when under pressure to provide information at variance with the trustee's self-interest. The relationship in this type of trust is mutual, such that the trustee also makes themselves vulnerable to the trustor. Some researchers combine benevolence and integrity into a composite factor called trustworthiness, but our team starts from the idea that perceived trustworthiness may be contributed to by all three assessment criteria of the ABI model (ability, benevolence, and integrity), and perhaps by other unmeasured or unmeasurable factors.

Research into the effects of grammatical errors on trustworthiness judgements confirm the trustworthiness penalty at sufficient levels of spelling and grammatical errors but, although it shows that various subgroups weigh the importance of conventionality differently (Appelman & Schmierbach, 2018), does not always clarify that divergence from conventions can serve as positive in- and out-group markers. The ABI model used by our team accommodates such affiliative preferences, as it centres the relationship between the trustor, or audience, and the trustee or source (and the source's intelligence, care or diligence (Carr & Stefaniak, 2012)), and its "halo" effect (Martin-Lacroux & Lacroux, 2017) on the assessment of the trustworthiness of the content.

Research Questions

The main research questions for this programme of research can be divided into two complementary problem spaces: the first establishing how trustworthiness is judged by a combination of multiple factors; and secondly, how objective metrics may be used to assess how these factors combine.

Our trustworthiness judgement questions are:

RQ1: Do judgements of multiple penalties to trustworthiness involve additive cost–benefit analyses, or are they heuristic-based?

RQ2: Are the penalties to trustworthiness of spelling errors similar (on average) in magnitude to alterations in content?
RQ3: Are the penalties to trustworthiness of "shouting text" (emphasising certain words using unconventional capitalisation of the entire word) of a similar magnitude to the penalties of spelling errors?

The methodological questions concerning the application of objective metrics to the interrogation of how trustworthiness is assessed are:

RQ4: Can these online implicit experiments measure subjective trustworthiness, allowing future use of these text excerpts as examples of medical information, presented with a variety of spelling errors and violations of presentation format?
RQ5: Will implicit measures of trustworthiness give us insights that previous explicit measures would not detect?

Methods

Participants and Ethical Approval

The research described here is based on a series of six similar online experiments performed between 2016 and 2021 (some unpublished, others published in Witchel et al., 2020, 2022). The studies included from 30 to 301 nominally healthy participants (i.e., not multiple sclerosis patients because we did not want them to have any in-depth knowledge of treatment options), who were recruited online or via our university and later remunerated in different ways (e.g., lotteries for Amazon vouchers), although the final sets of participants were recruited via the Prolific micropayment platform, which allows for indirect payment of the participants and the specification of their health status. Upon landing on the experimental website, participants were shown ethical information equivalent to a patient information sheet and were asked to press an "I agree" button to grant the researchers informed consent, as prescribed by the Declaration of Helsinki (WMA, 2013). All experiments were approved by the local research governance and ethics committee (BSMS

RGEC) and received the following approval numbers: 16–044-WIT and ER/BSMS1645/5.

Stimuli: Paragraphs

In previous experiments by others, the effects of textual errors or formatting changes were sometimes highlighted to the experimental participants by explicit questions, by side-by-side comparison, or by having online elements (e.g., a URL) announce the goal of the experiment (Shaikh, 2007). In our research, we avoided these tip-offs and simply instructed participants to judge the credibility of the text; this meant that any effects of spelling or writing unconventionalities could only affect their judgements *implicitly* (i.e., if their disapproval was internal, automatically accessible, and ongoing).

The experiments involved participants reading short paragraphs (70–100 words) in the style of a post to an unmoderated online health forum about multiple sclerosis (MS). The topic was chosen because it is obviously important (a life-or-death matter); most people have heard of it, yet factual details about available treatments are not widely known by the general public or by the broader medical community. There were nine experimental paragraphs plus two practice paragraphs; the practice paragraphs were always presented first, they were not labelled as practice (they were presented no differently from the other paragraphs), and they were never included in the experimental analysis (except briefly in our limitations, see below). The purpose of including practice paragraphs was to familiarise the participants with the process and the type and range of readings, to minimise data artefacts resulting from lack of familiarity with the experimental methods. Each participant read each experimental paragraph once (with a randomised unconventionality condition). The main experiment represents a 9×4 incomplete block design, such that we used linear mixed effects (LME) models (see below). Excerpts/paragraphs were randomised for a given participant as follows: each of the nine paragraphs was always shown once (randomised without replacement), and for each paragraph, the intervention (no unconventionalities, spelling errors, capitalisation, combinations) was randomised with replacement. An image explaining this randomisation appears in Fig. 1 in (Witchel et al., 2020). After the experimental stimuli were completed, a screen was shown for debrief, with either instructions or web-forwarding for remuneration. Supplementary methods with the full-length paragraphs, as well as raw data, is available online at: https://github.com/harry-witchel/CapitalizationMisspelling and at https://github.com/harry-witchel/Typographic.

We chose to present paragraphs about MS to healthy participants because we hoped that participants would (a) understand that the content of the paragraphs was important to the intended readers, and (b) not actually know the detailed truth about the information, so the participants would be in a similar knowledge position to newcomers to the forum. In early experiments we asked participants for information about whether they were healthcare professionals, but they made up only a tiny minority of participants, and in later studies this issue was ignored. Here is one of the stimuli (entitled "Exercises"), which contains five spelling errors and five capitalisations:

> Does multiple sclerosis decrease intelligence/IQ?
> *DO NOT despear. Many people with MS exprience cognitive symptoms like short term memory, ability to quickly process information and so on. Something to THINK ABOUT is doing brain exercises. EVERY DAY. There are plenty of wwebsites for brain exercises out there. These sites usually offer some of the exrcises FREE, but charge if you want to track your progress or USE other brain enhancing exercises. The websites offer exercises and/or games in thinking flexibility, information processing, meemory, math, logic, and so on. Good Luck.*

Text Interventions: Writing Unconventionalities

The goal was to determine whether occasional written unconventionalities would implicitly lead to decreased ratings of the trustworthiness of the written content. The written unconventionalities were of two types: typographic spelling errors and shouting text (a single word or word-pair written in all capital letters as a form of emphasis). Spelling errors were selected and designed on the following basis:

1. be quite noticeable.
2. remain clear to the reader even when misspelled (e.g., "yu" plainly means "you").
3. obviously be a misspelling.
4. not be a homonym.
5. be a plausible misspelling that could actually happen on the web.

To make sure that these criteria were met, we focused on changes in the first syllable or at the end of a word, and we searched the internet and verified that each typographic error selected has actually occurred in an online health forum somewhere on the web. The design of the spelling errors often used one of the following strategies:

1. swap one letter for another letter that is next to it on a qwerty keyboard ("pisitive").
2. leave out a final silent e ("cognitiv").
3. double a consonant ("esstimate").
4. double a vowel, or add an extra vowel ("theere").
5. leave out a vowel ("expsure").

To determine whether different types of writing unconventionalities had additive effects on trustworthiness penalties, a larger experiment (301 participants) with four interventions was ultimately tested: no unconventionalities, five spelling errors, five words in shouting text (all capital letters), and the combination of five spelling errors plus five words in all capitals (where the capitalised words were never the words that were misspelled).

Delivery and Presentation of Online Studies

Originally these experiments were presented as an online questionnaire via Qualtrics, and later versions of the experiment were redesigned to PsychoPy (Python) and then automatically translated into an online version in PsychoJS (Javascript) for presentation on Pavlovia. Recruitment of participants and experimental conditions were consistent across the different experiments. Advertising stated that a short experiment was looking to measure a response to text online (it never mentioned misspelling or text format), and on landing on the web page, participants encountered ethical information and consent, brief demographics questions (gender, age, industry/professional background), instructions, then two practice paragraphs (described above; always in the same order), followed by nine experimental paragraphs (order randomised). Each experimental paragraph was preceded by a question to frame the subsequent text, and underneath the paragraph was an unnumbered horizontal slider that had anchors "completely untrustworthy" (left) and "completely trustworthy" (right); the sliders provided the experimenters with data as numbers from zero (untrustworthy) to 100 (trustworthy); the numbers were not visible to participants.

Study Design, Analysis, and Statistics

All the studies were of an incomplete block, repeated measures design in which individual participants made multiple ratings, and thus needed to be corrected during analysis using robust standard errors (Williams, 2000) and linear mixed effects (LME) models that included the participant identification number (instead of their name, as the data was completely anonymised) as a random effect. Trustworthiness rating was the outcome variable, and the unconventionality condition was the fixed predictor variable. LME models were calculated either in **Stata 15** using the **mixed** command, or in **Matlab** using the **fitlme** command. Power calculations were made in later studies using standard deviations observed in earlier studies, although some upper limits for sample size were made based on cost. Reporting standards were according to the TREND checklist (Des Jarlais et al., 2004).

Results

Spelling Errors Only

The participants' ratings using the unnumbered slider resulted in data that varied as expected, such that some paragraphs were on average rated as much less trustworthy when presented without any errors (e.g., paragraph 7 from a patient-written emotional support website called dailystrength.org had a median rating equal to 38 points on a scale of 0–100) while others were rated as more trustworthy (paragraph 8 from a science-based university website ms.pitt.edu had a median rating equal to 64 points). It is worth noting that the dispersion of this kind of rating data from a scale without numbers is quite high, such that the data for individual paragraphs often appeared to be almost uniformly distributed rather than normally distributed.

Because of this wide and uniform dispersion, we used cumulative probability graphs to compare the effects of error conditions (Witchel et al., 2022). This allowed us to illustrate the near-linear additive effect of spelling errors.

To quantify this trustworthiness penalty of increasing spelling errors, we derived an LME model in which the outcome variable was trustworthiness rating, the two categorical fixed effects predictor variables were (a) number of misspellings and (b) the excerpt, and the participant was the random effect. In this model the reference predictor values were zero errors and paragraph 5 (an excerpt with a middle value for trustworthiness rating). Compared to zero errors, two misspelling errors led to a decrease in trustworthiness rating (on the 0–100 scale) of 5.906 points (95% confidence interval 2.583 to 9.229 points, z value = 3.48, $p < 0.001$) and five misspelling errors led to a decrease in trustworthiness rating of 13.547 points (95% confidence interval 8.708 to 18.385 points, z value = 5.49, $p < 0.001$). Given that 5 errors is 2.5-times more errors than 2 errors, the ratio of the corresponding trustworthiness penalties ($13.547 \div 5.906$) is 2.294 (nearly 2.5), which implies a near-linear response. In a follow-up experiment with 30 participants, we asked "Please explain how you graded the content you read. Were there any issues that influenced you in how you determined any of the ratings you made?" All but one participant filled in that open text box (with 1 to 3 separate reasons), and 14 participants explicitly mentioned either spelling or grammar, whereas only 8 mentioned scientific evidence and sources, and only 6 mentioned scientific language or tone. Thus, although the ratings that seem to be affected by spelling errors were implicit (i.e., the experiment gave no indication that it was about spelling errors), nearly half of those participants doing the follow-up experiment mentioned such errors, meaning that the role of the typographic errors on ratings may have been implicit, but it was not subconscious.

Combining Spelling Errors and Unconventional Capitalisation ('Shouting')

To quantify the trustworthiness penalties elicited by the combination of spelling errors and "shouting" capitalisation, based on data from a different online cohort we made an LME model in which the outcome variable was trustworthiness rating, the two categorical fixed effects predictor variables were unconventionality condition and the excerpt, and the participant was the random effect. Again, the reference condition was no writing unconventionalities. Table 23.1 shows part of the results for that LME model (for clarity, it does not show the effects of the different paragraphs, which were included in the model). In this cohort, the five misspellings had a similar-sized negative effect to the five capitalised words on trustworthiness rating (−8.860 versus −6.411), and the combination of unconventionalities condition showed that the two writing mechanics unconventionalities together had an almost additive effect on the trustworthiness penalty (−14.330). As shown in the table, the zero unconventionalities condition was statistically significantly different from all of the other conditions ($p < 0.001$ for all), and in a series of related LME models (not shown here), the combination of unconventionalities condition was statistically significantly different from all of the other conditions ($p < 0.001$ for all).

We did not previously publish the data on the training paragraphs, which appeared at the beginning of the experiments and were meant

Table 23.1 LME model for textual error type and text content (latter not shown)

Mixed Effects Regression for Trustworthiness Rating (outcome variable)				Number of Observations		2,709
Group Variable: Participant				Number of Groups		301
				Wald chi2 (11)		494.92
				Prob > Chi2		0.000
Log pseudolikelihood =		−12,282.888 (Std. Err. adjusted for 301 clusters in participants)				
Categorical Predictor Variable Values	Coeff	Robust Std. Err	z	P > |z|	95% Conf Interval (lower)	(higher)
Alteration						
Caps Only	−6.411	1.299	−4.93	0.000	−8.958	−3.864
Misspelled	−8.860	1.404	−6.31	0.000	−11.611	−6.109
Both Errors	−14.330	1.419	−10.10	0.000	−17.111	−11.550

to teach participants the range of trustworthiness ratings in our paragraphs (and how to use the rating sliders) and were explicitly planned to be outside of our analyses. However, the training paragraphs give some insight into the wild dispersion of data when getting data from the general public. The first training paragraph was meant to be judged as more trustworthy (mean ± St Dev trustworthiness rating was 54.33 ± 23.39, N = 301) and the second training paragraph was meant to elicit a much lower trustworthiness rating (mean ± St Dev trustworthiness rating was 40.20 ± 25.80), and the 14 point difference in ratings between them strongly supports our design plan (Cohen's $d = 0.59$, Wilcoxon Rank Sum $P = 2.23 \times 10^{-12}$); this is a solid medium size effect where the first training paragraph is significantly more perceptually trustworthy. However, 30.6% of participants rated the "less trustworthy" second training paragraph as more trustworthy than they rated the first one, and 16.0% of participants rated the less trustworthy paragraph at least 20 points more trustworthy than they rated what we thought was the more trustworthy paragraph. So, when using this unnumbered slider, one in six people rated the stimuli in completely the opposite order of our design for assessment of the trustworthiness of those paragraphs.

Discussion

The goal of this programme of experiments on short computer-mediated text excerpts describing a medical topic was to learn how judgements of trustworthiness "add up": how does a person who concurrently sees two meaningful indicators appraise them together in his/her final judgement?

RQ1: We have shown that increasing the presence of textual unconventionalities implicitly leads to linearly additive penalties to mean trustworthiness ratings. Plainly there may be a floor below which the number of misspellings may have no effect, and there must be a ceiling above which the number of misspellings can have no further penalty to trustworthiness, so somewhere in the edges of the range the results must be nonlinear (e.g., Appelman & Schmierbach, 2018), but our experiments were inside the range where the penalties were still additive.

Although a range of studies have previously shown that spelling errors (Figueredo & Varnhagen, 2005; Kreiner et al., 2002; Singletary et al., 1977) and shouting text (Lederman et al., 2014; Schindler & Bickart, 2012) undermine trustworthiness judgements, in our studies we have shown that these effects are quantifiable, additive, and implicitly understood as values. The novel contribution of quantifying and demonstrating the linearly additive nature of the textual flaws is that this evidence undermines theories that psychological trust judgements are based on a simplified trust heuristics (e.g., the take-the-best heuristic (Bröder, 2000; Gigerenzer, 2008)), and it supports psychological theories of lay people using a rough cost–benefit analysis as suggested by Sun et al. (2019).

The following results are also indicated by our data:

RQ2: The penalties to trustworthiness of a modest but noticeable number of spelling errors (5–10% of words) is much smaller (perhaps only 1/5 to 1/3 the size) than the maximum effects caused by changes in content.

RQ3: Shouting text leads to penalties to mean trustworthiness ratings that are similar in magnitude to spelling errors.

RQ4: The paragraphs that we have chosen provide a workable experimental system for testing trustworthiness judgements and audience reception of computer-mediated scientific text communication. Based on six experiments, we gather repeatable results from ratings of text stimuli that demonstrate implicit, linearly additive effects on penalties to trustworthiness.

Limitations

A key issue (RQ5) is whether this research approach using implicit experiments (as opposed to explicitly asking people about their lay understanding of their own trust judgement process) reveals information that would be otherwise undetectable. This programme of experiments is both a success and a cautionary warning about simplifying research questions on trust to reductionist experiments. Our goal was to eliminate the influence of lay psychology on our results, and we certainly found that our experimental system was much less sensitive to formatting changes than experiments that explicitly asked about such changes. A great deal of effort and money was spent to design, perfect and run these experiments; our resulting conclusions (trust decisions are additive like a cost–benefit analysis and not simple heuristics) are encouraging but not iron-clad.

First, although the experiments were designed to detect subconscious effects (i.e., "under the radar") of text formatting that were demonstrated to affect judgements (at a conscious level) as early as the 1920s (Henderson et al., 2004; Poffenberger & Franken, 1923; Schiller, 1935; Shaikh, 2007), the under-the-radar effects of typefaces/fonts on trust that we originally sought were almost impossible to detect using this method (data from our lab not shown here). We hypothesise that these implicit effects of typefaces are too subtle to detect without literally tens of thousands of data points as done in Morris (2012a, 2012b, August 8; 2012, August 9).

The magnitude of the effects of spelling errors (rather than of typefaces) was chosen because (a) the effects of spelling errors on trust are very clear when explicit, and (b) spelling errors are conspicuous, so their effects on trust would be expected to be larger and experimentally detectable. Although these effects may have been implicit (i.e., we did not tip-off the participants that our experiments were about spelling errors), they were definitely not subconscious; when we asked participants in free text to identify their judgement criteria, nearly half of them mentioned spelling and grammar errors.

Another issue was that the ratings for each individual paragraph were nearly uniformly distributed (which is why our analysis used cumulative distribution functions) and were not at all normally distributed. This suggests that the ratings did not arise from a composite error function but were instead a single decision with upper and lower limits to that decision. This would not affect our conclusions if it was explained by the use of an unnumbered slider (making the participants' ratings inconsistent and partly "random"), but we suspect that it would affect the value of our experiments if we concluded that the breadth of ratings for a single condition may reflect genuine differences between raters. For example, in one study job applicants' resumes with spelling errors were less downgraded if the professional recruiter doing the rating had weak spelling skills (Martin-Lacroux & Lacroux, 2017). This variability was seen in our own data, as shown by the results for the training paragraphs.

Conclusions

Rapid trust assessments of short computer-mediated text excerpts, as judged objectively by using a slider, are complex and heterogeneous decisions. The ABI model of source trustworthiness may be relevant to this process, especially with regard to ability/expertise. To objectively understand the detailed mechanism of these assessments of text trustworthiness, future research might perform sub-analyses based on the participant's sensitivity to spelling errors and flaws in writing mechanics, taking care that these sensitivities might not be homogeneous in any given person. Our data suggests that a trustworthiness judgement may be an intuitive (but additive) cost–benefit calculation with multiple influences rather than a quick heuristic based on only one (spelling), two (shouting text), or three (content) issues, but more detailed experiments (including qualitative and mixed methods studies) may be needed to establish this result conclusively.

Statement of Original Publication This chapter has never been published before. It represents an overview of our team's work over a seven-year period, with a mixture of some data that has been published in various journal papers as well as some data that has never been published before. The overview is completely original.

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Conclusion

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Introduction

Amid ongoing global challenges such as health pandemics, climate change and environmental degradation, a nuanced discussion of the relational and contextual dynamics of trust has arguably never been more critical. Global challenges exemplify the urgency and complexity of issues where, despite scientific consensus, policy responses may be considered contentious, underscoring the roles of communicators, the public and media in shaping perceptions and actions. In such circumstances, there is an acute need to understand trust in science communication, as trust is a prerequisite for effective dialogue. Throughout this volume, trust

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emerges not merely as foundational to successful science communication but as a complex, dynamic construct shaped by diverse influences including the communicator's ethos, transparency of communication processes, and public engagement. The discussion moves beyond simple dichotomies of trust and mistrust, presenting a spectrum that includes ambivalence and critical engagement. It encourages a rethinking of trust as something that must be continually earned and sustained through credible, ethical and responsive communication practices.

In this volume, chapters explore topics, settings and forms of science communication where public trust is at play. The volume highlights the transformative potential of science communication in shaping public perception and trust. It underlines the importance of adapting communication strategies to diverse audiences and contexts, particularly during crises. Participatory approaches and third-order thinking in science communication are discussed as ways of enhancing trust by fostering inclusivity and dialogue.

In this concluding chapter, we unpack the above in more detail, taking a retrospective and synthesising look at the output of the book with respect to the following aspects:

- What are the main findings and implications of the chapters in Sections A, B and C in relation to public trust in science communication?
- What notions of trust and science communication emerge in the three sections?
- What are the main strengths and weaknesses of the volume?
- What are possible areas for further research?

Main Findings and Implications of the Chapters in Sections A, B and C

In this section, we identify the main findings and implications for trust in science communication emerging from Sections A, B and C, respectively.

Section A—Trustworthy Science Communicators

The chapters in Section A focus on science communicators in different communicative contexts and on how they may employ strategies to create and maintain public trust in science. There is particular emphasis on the roles of science communicators, relational aspects of public trust, and rhetorical qualities of science communication.

In general, high levels of public trust in scientists are found. As such, promoting or safeguarding scientists' communicative roles is highlighted as an important way of strengthening trust relations between scientists and publics. Scientists' increasingly diverse communicative roles in online contexts may, for example, extend to "journalists' roles" and "scientist activist roles". If well-known or celebrity scientists engage with publics in ways that personalise and humanise science, they may contribute to maintaining trust in science.

Scientists can use various strategies to strengthen their role as communicators. For example, they can cultivate deeper understanding of their rhetorical contexts and roles commensurate with the relevant communication possibilities to ensure trustworthy, ethical and effective communication. Increasingly, scientists are visible in online public arenas, which are often characterised as having high levels of affective public engagement. Since relations between scientists and publics are crucial for public trust, it is also important to know how emotions circulate and influence online epistemic conflicts and how they may affect relations between scientists and publics. Indeed, trustworthy celebrity scientists may help reduce public anxiety during a crisis. Public-facing scientists can also include narrative elements in pro-scientific communication. In sum, various roles and strategies in evolving communicative landscapes allow scientists to embody trustworthiness and present trustworthy knowledge, potentially enhancing public trust.

Section B—Trust and the Contexts of Science Communication

The chapters in Section B centre on the importance of context and representation for trust in science communication. The chapters clustered around three main expressions of these overarching concerns.

First, context matters for the type of trust members of the public can place in science communication. For example, public trust in science communication can take the form of "radical trust" (implicit or unreflexive trust), but it can also be "semi-trust", where one trusts consciously on the basis of some awareness (or form of knowledge) that scientists are trustworthy. Crucially, socioeconomic context matters for people's ability to adopt the reflexive position of semi-trust.

Second, context comes with practical consequences for practitioners and researchers and thus requires a reflexive approach to the praxis of science communication. For example, the academic disciplinary contexts of science communication are associated with different trust levels, implying the need for a reflexive and more critical approach to trust in "science", understood broadly. Similarly, the complex epistemic contexts of communication with publics necessitate reflexive practices on the part of communicators. Respectful cross-cultural participatory approaches may be one way of engaging with publics and securing their trust. While the rather unregulated online contexts for communication may have negative implications for trust in science communication, dialogic practices in this context too may help overcome potential challenges to trust. Also, the choice of national language used in science communication inevitably reflects culture and political histories with implications for public trust, and thus needs due consideration.

Third, representations in various science communication settings and media can impact public trust in science communication positively and negatively. For example, science journalists can select forms of representation that help ensure that audiences are informed and engaged. It may be beneficial for risk communicators to draw on narratives when communicating with the public, due to the cognitive predilections of their audiences. On the other hand, the trope in science-fiction films of science corporations as the stereotypical "bad guy" is problematised as such cultural representations may negatively impact public trust in science.

Section C—Trust in Science Communication

In Section C, the chapters explore the nuances of trust and mistrust. This section challenges the binary view that trust and mistrust are at opposite ends of a spectrum, proposing instead that they often coexist. The chapters argue that both trust and mistrust are essential components of a healthy democratic society, facilitating a more reflective and critical public discourse. This nuanced understanding encourages readers to see trust not as a static or singular state but as a dynamic relationship that evolves with ongoing interactions between science and society.

Further enriching this discussion, the section highlights the significant influence of context and personal epistemologies on trust in science. It delves into how individual beliefs and personal knowledge frameworks shape one's reception and interpretation of scientific information. The chapters provide insights into how personal experiences, background and education influence the degree of trust or scepticism individuals hold towards scientific authority and claims. This personal dimension of trust underscores the importance of considering diverse perspectives and epistemological approaches in science communication strategies, pointing to the need for a more tailored and context-sensitive approach when engaging different publics. The personal lenses through which science is viewed reinforce the importance of addressing and understanding varied epistemic communities within the broader discourse on science communication.

Finally, the role of social and ethical factors, along with the impact of media representation and gender bias, are scrutinised for their effects on public trust in science. The media's portrayal of scientists and scientific issues often perpetuates stereotypes or biases, such as the gendered representation of scientists, which can influence public perceptions and trust. Gender bias in media coverage, for instance, can lead to differing trust levels in male versus female scientists, affecting the credibility assigned to their communication. Moreover, the ethical conduct of scientists and how they are portrayed in the media significantly impact public trust. Ethical controversies or perceived conflicts of interest can swiftly erode trust, highlighting the need for transparency and integrity in scientific processes. Additionally, cultural and contextual variations play a critical role, illustrating that trust in science is not universal but is shaped by local, regional and national contexts. These variations prompt a reevaluation of global communication strategies, suggesting that effective science communication must be adaptable to fit the cultural and social fabric of each audience.

Forms of Trust and Science Communication Evident in the Volume

Forms of Trust

This sub-section on forms of trust begins by briefly recapping a number of challenges relating to the investigation of trust in academic research. It then presents the forms of trust that emerge from the three sections of the volume, before comparing these with our findings from a systematic meta-narrative review on conceptualisations of trust in academic literature on climate change (Fage-Butler et al., 2022), noting similarities and deviations.

Despite trust's societal significance, it has often been described as an elusive research object (Kramer, 1999; Luhmann, 1979). Literature reviews reveal that "trust" is often used without clarification or definition (Fage-Butler et al., 2022; Larson et al., 2018), which is problematic for such a "broad-spectrum concept" (Baghramian, 2019, p. 1). Besides being semantically broad, the notion of trust is also complex: as Castelfranchi and Falcone (2010) state: trust is "a layered notion, used to refer to several different (although interrelated) meanings" (p. 10). Methods used to investigate trust are often associated with a particular ontological view on trust (Fage-Butler, 2024; Fage-Butler et al., 2022). Trust's many societal roles have been captured in seemingly contrasting metaphors, as trust has been described as functioning both as "oil" that eases policy processes (Van der Meer & Zmerli, 2017, p. 1) and as "glue" that provides social cohesion (Castelfranchi & Falcone, 2010, p. 265).

In the context of science communication, trust is perhaps best seen as a lubricant that allows things to get things done—and thus is closer to the metaphor of oil than glue. This is reflected in Hardin's (2002) definition of trust in terms of "encapsulated interest" (p. 3), where the truster trusts the trustee on the assumption that the trustee has strong reasons to act in the truster's interests. Thus, the tripartite definition of trust that Hardin (2002) draws on—"A trusts B to do X" (p. 9)—which emphasises relations and actions, can be glossed as follows: "A trusts B to do X because doing X is in B's own interest or because doing X will positively impact both B and A". While emphasis in this volume has been on public trust in science communication, Offe (1999) states that trust relations can also exist from institutions towards citizens. For example, in the case of vaccines, public health authorities (A) trust members of the public (B) to be vaccinated (X), securing benefits for A and B—see Fage-Butler (2024) for further elaboration of bilateral institutional-public trust.

The chapters in Section A have largely to do with the trustworthiness of scientists and scientific experts and how they may build and maintain trustworthy relations with publics. Trust is conceptualised as significantly influenced by scientists' ability to adapt their communication to the public's needs, highlighting the importance of communicative context, ethos and engagement. Public trust is represented as to some extent malleable: scientists can use rhetorical and communicative strategies to build and maintain trust.

Many of the chapters in Section B consider the conditions or factors that influence public trust in science, highlighting contextual aspects of public trust in science communication. Variants occur as well in the form of bilateral trust and mutual understanding between publics and authorities, as well as in the disciplinary specifics of trust. This section demonstrates how trust can be strategically built and sustained through thoughtful communication practices that consider the complexities of contemporary media landscapes and public sentiment.

Section C broadens the focus to encompass societal and cultural dimensions of trust in scientific institutions and knowledge systems. It critically examines the dichotomy between trust and mistrust, proposing a more nuanced understanding that accommodates ambivalence and critical engagement as part of a healthy democratic society. The chapters in Section C advocate a reassessment of trust-building mechanisms, underscoring the importance of transparency, integrity and ethical considerations. These elements are crucial for fostering trust both within the scientific community and with the broader public. Such a focus highlights the need for clear communication and moral conduct as foundational to establishing and maintaining trust in scientific discourse and practices.

In sum, we would encapsulate the overarching findings on conceptualisations of trust in the volume in two words: trust in science communication is both *relational* and *contextual*.

In a recent systematic meta-narrative literature review (Fage-Butler et al., 2022), the editors of this volume explored meta-narratives of trust that were evident in academic literature relating to climate change, where meta-narratives are conceptualisations that frame a research object (Greenhalgh et al., 2005; Wong et al., 2013) such as "trust in science communication". In our literature review, we identified six meta-narratives of trust in academic literature on trust in climate science: affective (where trust relates to emotions), contextual (where trust relates to social, cultural or political contexts), contingent (where trust mediates and/or is mediated by other factors), attitudinal (where trust is a disposition, often measured by surveys), cognitive (where trust is derived from engagement with the scientific evidence) and communicated (where trust is communicated, often linked to the perceived trustworthiness of the sender or the medium). Each of these six meta-narratives was present in the chapters of this book, suggesting the usefulness of these categorisations more broadly. However, we did identify one more conceptualisation in the chapters of this book: trust as a co-construction, a common achievement, to be attained through participation and as reflecting concern about carefully navigating power differentials.

Science Communication

Regarding the forms and locations of science communication, there is much diversity in the volume, showing a field where a lively "social conversation" (Bucchi & Trench, 2021) is being had around science in different media, settings and constellations.

The chapters in Section A emphasise the pivotal role of science communicators as trustworthy conveyors of scientific knowledge, who embody the ethos necessary to bridge the gap between the scientific community and the public. Several chapters present science communication in online public arenas and showcase a range of strategies used in science communication. Together, the chapters emphasise a diversity of methods, theories and analytical strategies, which altogether offer novel insights into scientists' engagements in science communication. Through various case studies, it is demonstrated that the credibility of scientists and science communicators can significantly influence public engagement, highlighting the importance of their perceived integrity and expertise in fostering a receptive and informed audience. The cases effectively show that science communication involves discourses around perceived integrity and expertise, especially when addressing contentious issues like climate change or public health crises, where societal stakes and emotions may run high.

The chapters in Section B present science communication as taking place in a wide range of forms and contexts. These include science communication with local communities, also those experiencing socioeconomic disadvantage, as well as mediated forms of communication, for example in online settings (social media and national online newspapers) and science-fiction films. Narratives are also in focus in the form of risk communication to publics, as the way in which scientific risks are conveyed can significantly impact public understanding and response. Moreover, the chapters discuss the significant role of language in science communication, noting that the national language in which science communication is expressed can affect its accessibility, effectiveness and trustworthiness. The uneven landscape across scientific disciplines for trust is also recognised, where media representations can reinforce or challenge existing biases concerning epistemic authority in science communication.

Section C enhances our understanding of the role of science communication within society, particularly examining how internal scientific interactions and public dissemination intersect. It explores how the scientific commitment to openness affects the relationship between science and society, notably in the biosciences, and discusses the impact of public trust valuation on perceptions of science as a collaborative endeavour. The significant role of legacy media is emphasised as a crucial link between the scientific community and the public, providing essential cues about scientists' credibility, influenced by factors such as gender. Concurrently, social media is analysed for its role in democratising access to scientific discussions and enabling direct public-scientist interactions, with attention to how geographical and linguistic variations affect the perceived trustworthiness of information. Public consultations are also highlighted as key platforms for expressing personal epistemologies, shaping public engagement with science. Detailed analysis highlights the complexity and diverse aspects of science communication, emphasising their role in shaping scientists' interactions within the field and enhancing public understanding and trust.

Strengths and Weaknesses of the Volume

We believe that this book has several strengths. Our commitment to an inclusive approach is reflected in the range of scholarly engagement in trust in science communication in the volume. Trust in science has often been discussed in the media in recent times, with concerns often expressed about a potential decrease in public trust in science—and even its potential demise. As such, the many disciplinary fields represented in this volume could also be seen as an expression of the third mission of universities (Compagnucci & Spigarelli, 2020), where university researchers are expected to engage with what are considered grand challenges or wicked problems (Lazarus, 2009; Rittel & Webber, 1973).

The disciplinary heterogeneity of the contributors to this volume is reflected in the volume's breadth of theories and perspectives that enrich the investigation of science communication and trust. It also means that different methods are on display that may be advantageous for further academic endeavours in this area. Another strength of the volume is that it presents the perspectives of academics situated in different contexts around the world. Although academic focus on trust in science communication may be international, the importance of national and even local cases is evident in the volume as a good number of the chapters focused on national or local arenas with their own cultural concerns. Such specificity is valuable and even necessary: sociologists and anthropologists remind us that trust and mistrust take different forms in local conditions and contexts (Carey, 2017; Sztompka, 1999).

Although we have defined the volume's inclusive approach to scholarship as a strength, it could be seen as a weakness. Are we (editors) at risk of scattering the focus so that only glimpses of our object—trust in science communication—are possible? Or expressed differently: instead of reducing the complexity of this topic, are we simply contributing to more of the same? As we deliberately did not conduct a deep dive into a specific aspect of trust in science communication, the perhaps slightly mosaic-like qualities of the volume are inevitable. We might rejoinder that trust's contextual and relational qualities meant that this complexity was inevitable and that showcasing examples of research engagement is in keeping with the genre of the edited volume. Indeed, our intention with this concluding chapter is to "bring things together", identifying commonalities across the chapters—seeing the picture emerging from the "mosaic" from afar, as it were.

More concretely, we consider that one of the book's main weaknesses is its tendency to focus on theoretical exploration at the expense of practical application. The insights gained, while valuable, often remain at a conceptual level, which may limit their utility for practitioners in the field. Additionally, the scope of the research is primarily centred on Western experiences, and thus may not fully capture the global nuances of trust and science communication. These gaps suggest potential topics for future research, as we go on to specify below.

Suggestions for Further Research

Surveys show that trust in science has so far proven to be relatively durable (Cologna et al., 2025; National Science Foundation, 2024), even increasing during the pandemic (Wellcome Global Monitor, 2020). However, many of the challenges currently facing societies, such as those relating to health or the environment, have been documented scientifically, which suggests the ongoing need for trust in science communication. Moreover, new socio-scientific (Bromme & Goldman, 2014) challenges will continue to expose and test public trust in science communication. We therefore expect public trust in science communication to be an important focus for the future, particularly in relation to contextual and relational aspects.

With this in mind we now highlight a number of potential areas for future research that build on the insights gained from the chapters in this volume and can help to address the aforementioned gaps:

1. Epistemic trust in science rests on knowledge, but there is a need for further recognition and probing of the role of values in public trust in science communication, in line with a contextual and relational approach to trust. Axiomatic or values-related aspects of trust can be seen as independent of but also as overlapping with epistemic trust (Branch, 2022).
2. Trust is needed where there is "an implicit imbalance of power due to a high level of information asymmetry" (Larson et al., 2018, p. 1599), so greater focus on the power dimensions of this asymmetry, addressing questions of equity and justice, is warranted. Methodologically, participatory processes could be used to support the co-construction of knowledge, as participation provides insights into the public's "value-knowledge" (Gabriel et al., 2022, p. 25) and can at the same time indicate communicators' trust in publics, supporting bilateral trust. Participatory processes are, moreover, likely to be valuable for empowerment and reflexivity. Participation also aligns with the conceptualisation of science communication that we have found valuable for this volume: science communication as the "social conversation around science" (Bucchi & Trench, 2021), i.e.

communication that is multiway (rather than one-way) and that often involves flatter hierarchies.

3. The volume illustrates that it is essential to go beyond monolithic approaches to “the public” and acknowledge the complexity of the social contexts of trusting. We believe it would be advantageous to explore relational and contextual aspects of communities of trust or mini-publics, particularly with the rise in social media for communication about science (Taddicken & Krämer, 2021).
4. Investigating the impact of digital technologies and social media on trust dynamics is another critical area that could be further developed, particularly for understanding how these platforms can both erode and enhance public trust through the spread of information and misinformation. Also, the implications of new developments such as generative AI for public trust in science communication need further attention.
5. Another area for further research is how to build judicious public trust. Learning about the “how” of scientific knowledge development is likely to support reflexive trust in publics. We suggest that it could be advantageous to put greater emphasis on developing citizens’ awareness of epistemic features of scientific practice, and the limits on judicious trust.
6. More generally, we encourage empirical studies that test the applicability of the theoretical frameworks presented in this volume. There is, moreover, a significant opportunity to expand the scope of the research presented in the chapters to non-Western contexts, exploring how cultural, social and political factors influence trust in science communication.
7. In continuance of the practices of this volume, further interdisciplinary exploration, combining insights from fields such as science communication, Science and Technology Studies (STS), psychology, sociology, media studies, ethnography and ethics could enrich understandings of how public trust in science communication may be built, maintained and lost. Such studies could help develop more effective communication strategies that are sensitive to the complexities of current information environments.

Concluding Words

"Trust in science" has often been discursified as monolithic and context-free, as evident in statements such as: "Trust the science" or "If only people would trust the science". Yet, the environmental and health-related crises facing humanity and the planet—which are often well-documented scientifically—require a more nuanced approach. There is a need for greater specificity with respect to communicative practices of trusting. As this volume shows, monolithic approaches to trust in science communication are giving way to more complex and reflexive engagements, reflecting the ineluctability of contextual and relational qualities of trust.

Besides the existing well-documented global challenges, emerging developments, such as in the field of generative artificial intelligence and other technological advances, will continue to expose and test public trust in science communication, which often lies dormant and implicit. There is a need for ongoing theoretical and empirical investigation of this rather elusive but highly significant societal lubricant (Luhmann, 1979) in contexts in which it is salient but often only subtly present. We hope with this volume to have contributed to that effort.

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