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Identifying trust cues: how trust in science is mediated in content about science

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Abstract

Most public audiences in Germany receive scientific information via a variety of (digital) media; in these contexts, media act as intermediaries of trust in science by providing information that present reasons for public audiences to place their trust in science. To describe this process, the study introduces the term "trust cues". To identify such content-related trust cues, an explorative qualitative content analysis has been applied to German journalistic, populist, social, and other (non-journalistic) online media ($n = 158$). In total, $n = 1{,}329$ trust cues were coded. The findings emphasize the diversity of mediated trust, with trust cues being connected to dimensions of trust in science (established: expertise, integrity, benevolence; recently introduced: transparency, dialogue). Through this analysis, the study aims for a better understanding of mediated trust in science. Deriving this finding is crucial since public trust in science is important for individual and collective informed decision-making and crises management.

Keywords

Digital science communication; Representations of science and technology; Science and media

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1 · Introduction

In an era defined by rapid advancements and unprecedented challenges, the role of science has become increasingly central in shaping our future. Science offers valuable insights, supports progress and informed decision-making, and provides responses to crises such as climate change and pandemics [Goldenberg, 2023; Hendriks et al., 2015; Schröder & Guenther, 2024].[1] In this context, *public trust in science* is among the most important variables for public audiences[2] to engage with scientific information [Leiserowitz et al., 2013; Plohl & Musil, 2021; Saffran et al., 2020]. At the same time, however, a decline of public trust in science and its implications have recently been discussed [e.g., Weingart & Guenther, 2016].

For public audiences, *(digital) media* are an important source of scientific information and a contact point with science [European Commission, 2021; National Science Board, 2018; Wissenschaft im Dialog, 2023] — especially in Germany, where nearly the entire population uses the internet [e.g., ARD/ZDF-Forschungskommission, 2023]. In Germany, a variety of media are well established as sources of scientific information, ranging from journalistic media to non-journalistic online media, including right-wing populist media [e.g., Wissenschaft im Dialog, 2023]. Hence, media use is an important variable for trust assessments of public audiences when it comes to scientific issues [e.g., Scheufele & Lewenstein, 2005].

Generally, when public audiences encounter media content, a *trust evaluation process* takes place: people use a variety of *trust heuristics*, i.e., cognitive shortcuts such as (ideological) predispositions, familiarity with a subject, and evaluation of probabilities [e.g., Kahneman & Frederick, 2005; Tversky & Kahneman, 1974] that build the basis of their trust assessments. Following this, audiences evaluate a multitude of indicators provided by media, which can be divided into two different research traditions [e.g., Grünberg, 2014]: on the one hand, research into media credibility examines media as objects of trust and focuses on the use of *credibility markers*, sometimes also called *trustworthiness indicators or cues* [e.g., Metzger & Flanagin, 2013]. This includes a variety of markers that allow public audiences to evaluate the credibility or trustworthiness of a media source and its content. For instance, a media brand, visuals used, the design of a website, or its usability are all part of the media environment and an initial point for the trust evaluation process [Choi & Stvilia, 2015; Einsiedel & Geransar, 2009; Metzger & Flanagin, 2013; Ross Arguedas et al., 2024; Wathen & Burkell, 2002]. For many social media the markers may also include platform affordances such as hyperlinks and interaction metrics [e.g., number of shares or likes; Boothby et al., 2021; Choi & Stvilia, 2015]. On the other hand, media trust research investigates media as intermediaries of trust [e.g., Grünberg, 2014; Reif, 2021] — in the context of trust in science, they mediate trust between science and public audiences by providing a variety of *indicators and cues in their content* that audiences can use to assess whether to trust science or not. Those content-related indicators serve as a secondary point and are, therefore, on a subsequent evaluation level

1. This is true on a general level; however, it should be acknowledged that science does not hold all the answers and science can also be used, for instance, to deny climate change and health risks [see Oreskes & Conway, 2010].
2. To account for a modern public sphere that considers media and communication diversity, we use the terms "publics" and "public audiences" [see also Taddicken & Krämer, 2021; Weingart, 2017]. The modern public sphere is constituted by the connection of traditional journalistic media, their online counterparts, online platforms, and social media. This leads to different publics: "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].

than the credibility markers. In this sense, the specific information provided in content about science is a vital aspect for the trust evaluation process.

As a starting point for the trust evaluation process, this study focuses on media content[3] and thus on indicators and cues in content about science as *trust-evoking cues* — as a shorthand, we introduce the term "*trust cues*". Currently, research on such content-related trust cues is lacking; however, some researchers have provided hints for addressing specific dimensions of trust in science [e.g., Welzenbach-Vogel et al., 2021]. The lack of research is surprising as audience studies show that content-related trust cues can affect audiences' trust in science [Hmielowski et al., 2014; Reif et al., 2020; Rosman et al., 2022]. Therefore, in this study, we exploratively identify trust cues provided by intermediaries of trust in science. Because public audiences "assess who to believe as a heuristic for what to believe" [Goldenberg, 2023, p. 370], research about trust cues is important for understanding how media content shapes mediated trust in science. We address this issue by relying on established literature that considers scientists, scientific organizations, and the science system [Giddens, 1990; Grünberg, 2014; Schäfer, 2016] as *objects of trust* and takes established *dimensions of trust in science* into account, i.e., references to science's expertise, integrity, benevolence, transparency, and dialogue [Reif & Guenther, 2021; Reif et al., 2024; see also Besley et al., 2021; Fiske & Dupree, 2014; Hendriks et al., 2015, 2016; Mayer et al., 1995].

Hence, this study makes use of an explorative approach to examine how trust in science is mediated in content about science, by applying qualitative content analysis. Through this, we want to gain a better understanding of the factors that potentially influence mediated trust in science.

2 ▪ Mediated trust in science

Although there is no agreement in research about how to best *define* trust [e.g., Grünberg, 2014; McKnight & Chervany, 1996], in sociology, psychology, and in communication research, trust is considered to be a relational variable that requires at least two actors: first, a subject of trust (here: publics) and, second, an object of trust [here: science; Giddens, 1990; Luhmann, 2014; Mayer et al., 1995]. A subject of trust decides to trust an object of trust — seeing trust as a relational variable, public audiences decide to trust science. We primarily consider trust from a communication research perspective, that is, strongly influenced by sociological thoughts [e.g., Grünberg, 2014; Reif, 2021] as a mechanism to reduce complexity [e.g., Luhmann, 2014]. Since we focus on public trust in science, the concept of *epistemic trust* is useful, because it refers to trust in science as a producer of valid knowledge; thus, it encompasses both the validity of scientific knowledge per se and science as a secure source of information [Origgi, 2012; Sperber et al., 2010; Wilholt, 2013].

Since public audiences primarily receive scientific information via (digital) media outlets [e.g., European Commission, 2021; National Science Board, 2018], media play a decisive role for establishing public trust in science. Media are not only the objects of trust themselves, but they are also intermediaries of trust, acting between public audiences as subjects and science as objects of trust [e.g., Reif & Guenther, 2021]. Due to this double role, trust intermediaries increase the complexity of the trust relationships [e.g., Kohring, 2004;

3. Consequently, in this paper, there is no focus on (cognitive) trust heuristics of audiences, credibility markers or trustworthiness indicators.

Schäfer, 2016]. In this context, Bentele's [1994] *theory of public trust* suggests that *public trust* has emerged as a new form of trust in the public sector, and considers the media as a significant component in trust relationships [see also Hmielowski et al., 2014]. He states that the formation of trust in systems, organizations, and persons is strongly influenced by mediated information. This includes facts, events, and messages [e.g., Bentele, 1994; Reif, 2021]. Moreover, as the theory of public trust already suggests, objects of trust can be differentiated according to *levels*. A distinction is made between science as a system at the macro level, scientific organizations at the meso level (e.g., universities or research departments of companies), and scientists at the micro level [see also Mayer et al., 1995]. This distinction is decisive because people not only receive information about individuals such as scientists but also about organizations and the system of science [e.g., Luhmann, 2014; Schäfer, 2016]. Consequently, we have a *multilevel* perspective on science; in the following, when we talk about science, we always refer to science at different levels. Journalism remains the most important source when it comes to scientific information, at least in Europe [e.g., European Commission, 2021], and science journalists often try to include a 'human angle' in their science coverage [e.g., Guenther, 2019], therefore, scientists (micro level) are particularly likely to play an important role in content about science.

In digital media environments, journalistic and non-journalistic actors have access to digital public spheres [e.g., Schröder & Guenther, 2024; Taddicken & Krämer, 2021] and are therefore able to publicly communicate about scientific issues [Bucchi, 2013; Weingart & Guenther, 2016]. However, this includes actors with various interests, such as science public relations professionals, governmental actors, politicians, bloggers, or other communicators with a vast online reach (e.g., influencers), as well as publishers of misleading and false information [for example, populist, non-mainstream media or state propaganda; e.g., Weingart, 2017; Zimmermann & Kohring, 2020]. In this sense, in digital media environments, various science communicators not only make use of the various presentation styles and platform affordances available (e.g., images, hyperlinks), which serve as credibility markers when covering science, but also provide information in different ways and, thus, use content-related trust cues differently [see also Boothby et al., 2021; Choi & Stvilia, 2015; Metzger & Flanagin, 2013; Ross Arguedas et al., 2024]. This diversity may also explain why the connection between digital media use and public trust in science is ambivalent, with some studies reporting a positive relationship [for social media, see Huber et al., 2019] and others a negative one [for online sources, see Takahashi & Tandoc, 2016].

3 ▪ Trust cues in content about science

Current research shows various aspects influencing audiences' trust in science. For instance, individuals can use cognitive trust heuristics to evaluate content in general [Kahneman & Frederick, 2005; Tversky & Kahneman, 1974] or markers regarding the environment in which the content is embedded to assess a sources' credibility [e.g., Wathen & Burkell, 2002]. However, there is little research regarding the deeper level of media content about science, specifically the information being conveyed by intermediaries.

Thus, to pay tribute to the importance of media, their messages, and the information they provide [based on the theory of public trust; Bentele, 1994], this study investigates trust cues. The distinction between *trust* and *trustworthiness* sems critical in this context: the perception of science as the object of trust is considered to be trustworthiness; the actual behavior of a subject of trust based on this trustworthiness would be trust [e.g., Mayer et al., 1995]. However, this distinction becomes challenging when focusing neither on the subject nor object of trust, but instead on information provided by intermediaries. Therefore, content-analytical trust research operates in the limbo between trustworthiness and trust. As outlined already, we consider media content (including its messages and information) to evoke or promote trust in science, thus we decided to use the term “trust cues” as a shortcut for “trust-evoking cues”. They present public audiences with reasons to trust science. This consequently means that we do not fully cover the trust heuristics public audiences may use [e.g., Scheufele & Lewenstein, 2005; Tversky & Kahneman, 1974] or further multimodal aspects different media or platforms provide, including visual elements and platform affordances [Boothby et al., 2021; Choi & Stvilia, 2015; Metzger & Flanagin, 2013; Ross Arguedas et al., 2024].

Current research considers such reasons to trust in science to be dimensions of trust in science [e.g., Kohring, 2004]. This way, references to dimensions of trust in science enable public audiences to evaluate whether to trust science as the object of trust through media content. Although there appears to be an overlap in the respective definitions of the dimensions, there is no common understanding in research — especially across different research disciplines [e.g., Grünberg, 2014]. In this paper, we will include the established dimensions in research on epistemic trust: expertise, integrity, and benevolence [e.g., Hendriks et al., 2015, 2016]. Expertise is often referred to as ability and includes skills and competencies in a specific domain; integrity is connected to objectivity, honesty, and adherence to scientific standards; benevolence means the good will in research [e.g., Hendriks et al., 2015; Mayer et al., 1995]. To account for the significance of science communication, the addition of a dimension called *openness* has already been proposed [e.g., Besley et al., 2021]. Moreover, an extension with the additional dimensions *transparency* and *dialogue* was also suggested, to consider the concept of dialogue behind public engagement with science [All European Academies, 2019; Reif & Guenther, 2021; Resnick et al., 2015] in the context of public trust [Bentele, 1994]. We opted for the five-dimensional solution and extended the established dimensions by including two further dimensions of trust: transparency and dialogue. These five dimensions have already been tested for their reliability in surveys [Reif et al., 2024]. Since previous research agrees that these dimensions are essential for judging whether or not to trust science, we assume that trust cues are linked to these five dimensions and potentially refer to them.

Although studies on trust cues using content analysis are lacking, researchers have already started to address this issue — although they usually do not explicitly discuss dimensions of trust in science, insights can be derived from their work. For instance, regarding expertise, some have argued that information about the institutional background of presented research(ers) and publications is often missing in science news [e.g., Hijmans et al., 2003]; this finding provides insight into public trust in science as institutional backgrounds, affiliations, and publications are needed to assess the expertise of science as an object of trust. Similarly, for integrity, funding sources, relevant methodological, research-related criteria, as well as uncertainties are also seldom mentioned in science news [e.g., Cook et al., 2007; Guenther, 2019]. For benevolence, it has been observed that much more is reported about the benefits of science than about potential risks — although this varies across scientific disciplines [e.g., Summ & Volpers, 2016] and media outlets [e.g., Hijmans et al., 2003]. Information discussing the benefits science might provide for society is connected to assessing its benevolence. For transparency, researchers have discussed the inclusion of hyperlinks to external sources in digital media content [Humprecht & Esser, 2018; Phillips, 2010; Reich, 2011; see also Reif, 2021], which could help audiences assess science's transparency.

Nevertheless, research on trust cues from a content-analytical perspective is widely lacking, which results in the need to fill this research gap with an explorative, structured, and systematic identification of content-related trust cues used in intermediaries. Thus, our RQ is: *(a) What trust cues can be identified in content about science mediating trust between science and publics, and (b) how do they link to the established dimensions of trust in science?*

4 ▪ Method

4.1 ▪ *Sample selection and description*

To answer the RQ, a qualitative content analysis was conducted. We collected the most important sources that public audiences in Germany use to inform themselves about science [e.g., European Commission, 2021; Wissenschaft im Dialog, 2023] for three constructed weeks [see also Elmer et al., 2008; Guenther et al., 2019; Hester & Dougall, 2007], starting with a Monday in March 2022 and finishing with a Sunday in August 2022. This helped us achieve a comprehensive and representative sample. The decision on which sources to incorporate was also based on a representative online survey that Reif et al. [2024] conducted in March 2022, which not only asked about frequencies of media use via a list of several sources but also contained an open-ended question about the preferred source(s) respondents used to inform themselves about science.

First, journalistic media, incorporating TV newscasts and special science TV programs, print and online newspapers, weekly news magazines and newspapers, and specialized science magazines were selected. Second, right-wing populist, nonmainstream media sources were considered. Third, several social media platforms[4] (see Table 1 for a detailed overview) were included. Fourth, to incorporate online contexts in more detail, we chose a variety of science blogs and online news aggregators as other (non-journalistic) online media.

Due to the large number of sources included, we had to rely on several databases and other approaches when generating the sample, such as MediathekView and OnlineTVrecorder for most TV newscasts and programs; Factiva for most print and online newspapers and magazines; FAZ Bibliotheksportal for Frankfurter Allgemeine Zeitung/FAZ.net; Google searches and manual savings for most of the populist media, blogs, and news aggregators; 4kdownloader for YouTube; manually saved content for Facebook and Instagram posts; and TweetDownloader for Twitter. The popular science magazines were purchased online. Where possible,[5] the keywords wissenschaft* or studie* or forsch* or universität* or institut* [in English: scien* or stud* or research* or universit* or institut*; see Guenther et al., 2019] were used to retrieve material likely to contain scientific content.

4. We included prominent German accounts for different science communicators such as influencers (e.g., MaiLab, BreakingLab, @diewissenschaftlerin), scientists (e.g., c_drosten), public science funders (e.g., dfg_public), governmental institutions (e.g., BMBF_bund), and research institutes (e.g., helmholtz_de).
5. Search strings were used for print and online newspapers, populist media, blogs, and news aggregators.

Table 1. Sample overview.

Sources of information	Sample considered		Checked sample		Study subsample	
	n	%	*n*	%	*n*	%
Journalistic media						
Public television (ARD Tagesschau, ZDF heute)	42	.8	8	.8	5	1.3
Private television (RTL Aktuell, Sat.1 Nachrichten)	41	.8	2	1.1	2	3.2
Special science programs (Quarks, Gut zu wissen)	5	.1	5	.7	5	3.2
Print newspapers (Frankfurter Allgemeine Zeitung, Süddeutsche Zeitung, Spiegel, Zeit)	1.640	31.4	209	27.5	29	25.3
Online newspapers (FAZ.net, SZ.de, spiegel.de, zeit.de)	2.091	40.1	263	34.6	40	18.4
Print tabloid newspaper (Bild)	61	1.2	13	1.2	6	6.3
Online tabloid newspaper (bild.de)	222	4.3	37	4.3	10	3.8
Popular special science magazines (Geo, P.M. Magazin, Spektrum der Wissenschaft)	45	.9	41	5.4	4	2.5
Right-wing populist, non-mainstream media						
Populist media (Epoch Times, Junge Freiheit, Compact)	169	3.2	34	4.5	14	8.9
Social media						
Facebook (Wissenschaft aktuell, Harald Lesch Ultras, Fortschritt in der Wissenschaft)	110	2.1	15	2	11	7
Instagram (doktorwissenschaft, universumsfakten, don.medicus, diewissenschaftlerin)	54	1	2	.3	1	.6
Twitter (c_drosten, dfg_public, BMBF_bund, helmholtz_de)	172	3.3	15	2	7	4.4
YouTube (MaiLab, Breaking Lab)	7	.1	7	.9	4	2.5
(Non-journalistic) online media						
Blogs (scienceblogs.de, scilogs.de)	29	.6	18	2.4	6	3.8
News aggregators (t-online.de, web.de)	547	10.5	92	12.1	14	8.9
Total	5.262	100	761	100	158	100

In total, $N = 5{,}262$ pieces of information were collected (see first column in Table 1). Since the steps taken did not ensure that all material downloaded was about science, or even included trust cues, a manual check had to be performed. For this, each piece of information (i.e., articles, newscasts, programs, posts) was checked to see if it contained (1) an object of trust connected to science (meaning that scientists, scientific organizations or the science system in general is referred to in the media content) and (2) any information about science that could potentially affect public trust in science (see also coding procedure in Figure 1). Through this step, the initial sample was reduced to $n = 761$ (see second column in Table 1). Because the number of items remaining in the sample was still large for a qualitative assessment, we reduced the number, creating a smaller subsample (see third column in Table 1). For the first two weeks, a representative subsample was created. It contained a large proportion of (online/print) journalism, followed by news aggregators, and (print/online) tabloid media; hence, for these media, theoretical saturation was most likely reached. The subsample contained fewer TV sources, popular science magazines, and right-wing populist media. Furthermore, blogs and social media posts only occasionally qualified for inclusion, although an effort was made to consider them. Since our research goal was to identify trust cues in content about science, we wanted to ensure that each media type used by German

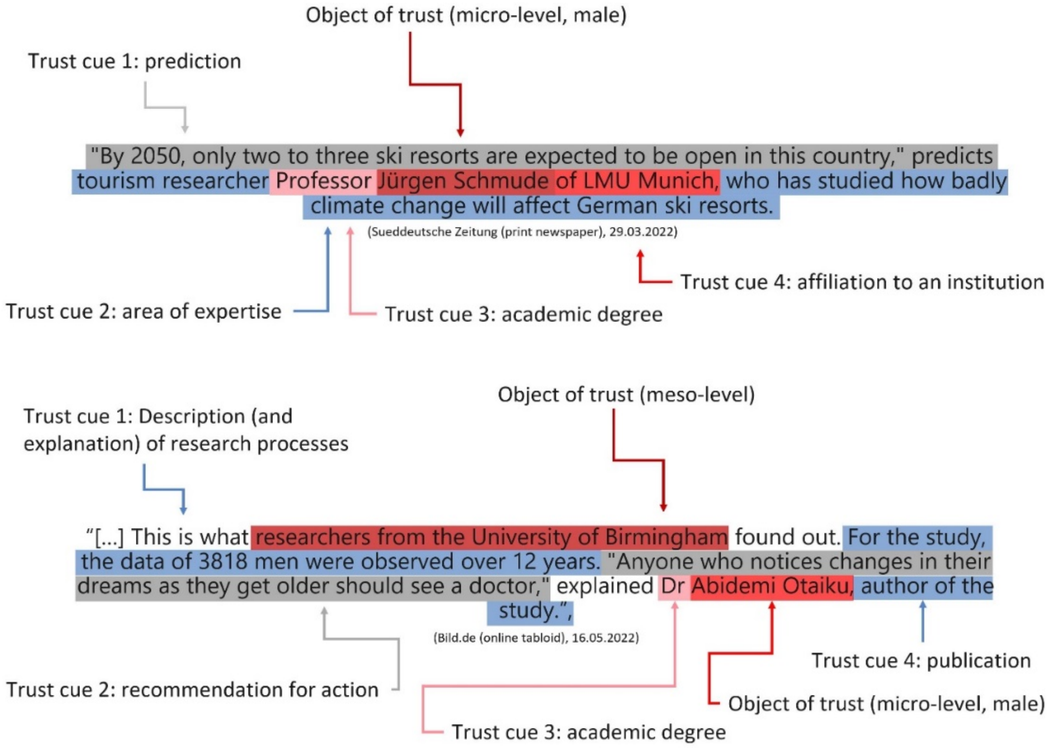

Figure 1. Examples of the qualitative coding with a focus on objects of trust and trust cues.

public audiences to be informed about science was properly represented, to increase our chances of accurately identifying the diversity of trust cues. Thus, in the third artificial week, we focused on these underrepresented media, with the goal of expanding upon the trust cues identified so far. These steps resulted in a subsample of $n = 158$.

4.2 ▪ *Qualitative content analysis*

For the analysis, we decided to use an explorative, qualitative approach with a deductive-inductive design [e.g., Kuckartz, 2014] to examine the media contents. Although we already had a clear idea of the dimensions of trust in science that we wanted to consider based on the extensive literature on the topic, it was unclear what specific cues make up these dimensions (e.g., further categories, cues, their composition). We therefore opted for an open approach, which was also flexible enough to potentially include new dimensions of trust in science, if any of the identified trust cues could not be assigned to an existing dimension.

For our analysis, we transcribed all content that was not yet in text form (e.g., for content received from TV or YouTube). The articles, transcripts, and the texts of social media postings[6] in our subsample served as our units of analysis. We defined a single word as our smallest unit of coding, while our largest unit of coding, i.e., the context unit, was an entire paragraph. Deductively, we assessed formal criteria (e.g., sources of information). For each object of trust mentioned, we identified the level (macro, meso, micro) and determined the specific trust-relevant criteria, i.e., the trust cues, as content-related criteria. Examples are provided in Figure 1.

6. Since we aimed to identify trust cues on a textual level, we did not include images or videos.

In the 158 coded pieces, $n = 1{,}329$ cues were identified. Two independent coders tested and adjusted the coding process over several weeks before the actual coding was performed. They each coded all articles and discussed their codings regularly to increase the validity and reliability of the analysis [e.g., Kuckartz, 2014].

By testing the qualitative coding beforehand, we decided not to collect the dimensions of trust predetermined, but rather to assess information given in the pieces openly, which allowed for later inductive classification. "Openly" here means that coders summarized what they found in their own words, and copy-pasted relevant words or passages to support their findings. Furthermore, the ideas and thoughts of coders were openly collected and considered for the analysis in Excel. In this process, some deductive ideas were included about what trust cues the coders were expected to find. Hence, to generate findings, we (1) openly coded trust-relevant criteria, (2) summarized and condensed them in several iterative steps so that we were able to build superordinate, content-related categories, and (3) linked them to one of the dimensions of trust where appropriate (while being inductively open to creating further dimensions). Some trust cues, however, could not be grouped together and, therefore, do not have a superordinate category. For an overview of all trust cues, the developed categories, and the corresponding dimensions of trust, see Table 2.

Next, the trust cues will be described in detail, and concise examples will be provided for better understanding. Additional typical and relevant examples, which were translated into English by the authors, can be found for each trust cue in Tables S1–5 in the *Supplementary material*. These tables also provide examples of trust cues at different levels to show in what variety trust cues occur.

5 ▪ Results

As described above, trust cues were identified and categorized, and each of the trust cues and superordinate categories could, in turn, be assigned to one of the five dimensions of trust in science. While we inductively assessed each piece of content for trust-relevant criteria and were open to creating new dimensions, all trust cues identified could be allocated to one of the existing dimensions of trust in science. Since each dimension can be referred to by different trust cues, we can more precisely speak of expertise, integrity, benevolence, transparency, and dialogue cues that each focus on a respective dimension [see Table 2 for a detailed overview; Reif & Guenther, 2021; see also Bentele, 1994; Besley et al., 2021; Fiske & Dupree, 2014; Hendriks et al., 2015, 2016; Mayer et al., 1995]. In the following pages, we describe each trust cue and provide examples for each superordinate category, which may include several trust cues using square brackets.[7] For a better overview, only the trust cues for the superordinate category described before are highlighted in the examples using italics; the level of the object of trust is also mentioned in square brackets.

5.1 ▪ *Expertise cues*

Regarding the dimension of *expertise*, the identified trust cues could be grouped into three categories: academic education, professional experience, and qualification. *Academic*

7. Due to our explorative, qualitative approach, this study does not aim for a quantitative comparison of trust cues across media types; rather, a general, initial identification is at the core of the present paper. Nevertheless, Table S6 in the *Supplementary material* provides an overview of the identified categories of trust cues for each type of media.

Table 2. Overview of the dimensions of trust, including categories and trust cues.

Dimensions of trust	*Categories of trust cues*	*Trust cues*	*Frequencies*	
			n	*%*
Expertise			421	31.7
	Academic education		11	.8
	Professional experience		6	.5
	Qualification		404	30.4
		Academic degree	50	3.8
		Reputation	20	1.5
		Professional position	49	3.7
		Affiliation to an organization	140	10.5
		Department or area/discipline of expertise	145	10.9
Integrity			521	39.2
	Independence		34	2.6
		Client	3	.2
		Funding source	15	1.1
		Interests	16	1.2
	Scientific quality assurance		153	11.5
		Correction/Revision	22	1.7
		(Un)Certainties (and Limitations)	98	7.4
		Peer review	/	/
		Continuity/Permanence of research	33	2.5
	Scientific standards and processes		334	25.1
		Legal framework for research	6	.5
		Working conditions in science	10	.8
		Research collaboration	31	2.3
		Publication	93	7
		Description (and explanation) of research processes	194	14.6
Benevolence			332	25.1
	Ethical norms		10	8
	Social responsibility		105	7.9
		Research-related risks	6	.5
		Prediction	48	3.6
		Assessment of public events/current affairs	51	3.8
	Benefits for society		217	16.3
		Social significance of science	29	2.2
		Discoveries and breakthroughs	26	2
		Applicability of results	51	3.8
		(Science-based) recommendations	87	6.5
		Personal reasoning for benevolent behavior	24	1.8
Transparency			18	1.4
	Accessibility of results		3	.2
	Comprehensible language		15	1.1
Dialogue			38	2.9
	Participation at public events		17	1.3
	Public engagement in research		/	/
	Media presence		21	1.6
		Journalistic media presence	14	1.1
		Direct media presence	7	.5
		Further media presence	/	/

education and *professional experience* provide information about the academic education and the professional experience (including work experience in academic and nonacademic fields) of a scientist:

> Benjamin Breitenbach [micro level] *studied biomedical chemistry in Mainz in 2009 including a research stay at the University of Auckland, New Zealand* [academic education]. During his *PhD at Johannes Gutenberg University Mainz* [academic education], he investigated nanodimensional polymer therapeutics in the field of drug delivery" [scilogs.de, 09.06.2022].
>
> Lisa Kainz [micro level] is 33, an agricultural scientist, and *works for the animal rights organization PETA* [professional experience] in Stuttgart [zeit.de, 24.05.2022].

The category *qualification*, in turn, consists of the trust cues academic degree, reputation, professional position, affiliation to an institution, and a department or area or discipline of expertise. All trust cues seem straightforward, with the exception of *reputation*; trust cues for reputation are a little more complex as they include different aspects that reflect the image of a scientist or scientific institution, such as various forms of (symbolic) recognition, prizes and awards, the prominence of an individual, or success in prominent and prestigious positions. Here is an example of a qualification:

> "*Professor* [academic degree] Jürgen Schmude [micro level], *tourism researcher* [department or area/discipline of expertise] at *LMU Munich* [affiliation to an institution], *who has studied how strongly climate change is affecting German ski resorts* [department or area/discipline of expertise]." [SZ, 29.03.2022].

Examples for each expertise cue, as well as the categories, can be found in Table S1 in the *Supplementary material*.

Hence, *expertise cues* illustrate science's capacity to recognize, evaluate, and find solutions to problems via the application of specialized knowledge acquired through education, experience, and qualifications in the respective research domain.

5.2 ▪ *Integrity cues*

Integrity cues are grouped into three categories: independence, scientific quality assurance, and scientific standards and processes. *Independence* can be expressed by three different trust cues: client, funding source, and interests. *Client* and *funding sources* disclose the body commissioning the research (mostly in the case of contract research) or reveal financial ties and resources. Integrity cues with regard to *interests* communicate (in)dependence from economic and social intentions; this also includes forms of forgery and conflicts of interest. For example:

> A current example is the results of a study published in the *New England Journal of Medicine* (NEJM) [meso level] on the safety and efficacy of the third vaccination against COVID-19 with the Pfizer/Biontech vaccine. *As the methods section unmistakably reveals, the responsibility for the study was entirely in the hands of the vaccine manufacturers* [interests]. The two companies did not even have to bother to hide their omnipresence behind a known figure from medicine [FAZ.net, 24.05.2022].

The category *scientific quality assurance* encompasses four trust cues: correction/revision, (un)certainties (and limitations), peer review, and continuity/permanence of research. *Correction/revision* refers to the adjusting and correcting of scientific information and procedures to assure scientific quality. *(Un)certainties (and limitations)* denotes aspects of certainty as well as uncertainty, and limitations of the research. *Peer review* refers to the process of evaluating scientific work before it is published; it is a trust cue based on deductive work and could not yet be confirmed inductively. *Continuity/permanence of research* relates to research being performed constantly or on a long-term basis, including longitudinal studies and regularly repeated studies. For example:

> '*My model is struggling a bit right now. Since we do not yet have sufficient data on the voting behavior of the new Academy, we have not been able to adjust it so far* [(un)certainties (and limitations)]', admits the mathematician [micro level] [FAZ.net, 21.03.2022].

Scientific standards and processes include five different trust cues, such as the legal framework for research, working conditions in science, research collaboration, publication, and description (and explanation) of research processes. A *legal framework* for research refers to the regulatory context that provides guidance through frameworks and laws for science, as well as debates on the legitimacy of scientific research. *Research cooperation* signals the scientific collaboration between two or more researchers working together on a project or study. *Working conditions* in science describes both the environment in which scientists work and overarching judgments of working in science. *Publication* refers to the release of research results such as studies but also to references and source citations. *Description (and explanation) of research processes* denotes the presentation and explanation of research processes that provide further insights; included in this trust cue are descriptions of the research objective and news about scientific discoveries. For example:

> Kolb and Bünemann's team [micro level] *used an algorithm to search for new binding sites in the structures of 113 different GPCR proteins* [description (and explanation) of research processes]. In doing so, they found several 'pockets' that have not been used as drug targets so far [SZ.de, 16.05.2022].

Table S2 in the *Supplementary material* contains examples for each category of trust cues associated with the dimension of integrity.

Consequently, *integrity cues* are indicators of science's objectivity, validity, and reliability, achieved through strict adherence to scientific standards and processes. This includes highlighting science's methodological approach and focus on quality control, as well as emphasizing its independence from external influences.

5.3 ▪ *Benevolence cues*

Three categories of *benevolence cues* were identified: ethical norms, social responsibility, and benefit for society. *Ethical norms* refer to considerations of — as well as discussions and standards about — ethical issues related to science, and more broadly to scientific misconduct, animal testing, and the unethical use of scientific information. For example:

> For the second part of the research — the genetic changes — I operate on laboratory animals. [...] That is sad, of course, but unfortunately, this is part of basic research. Due to my job, I have not yet had any confrontations with opponents of animal testing. However, *I* [micro level] *have attended events organized by Doctors Against Animal Experiments in order to better understand the other side's point of view* [ethical norms] [zeit.de, 03.07.2022].

The category *social responsibility* includes three trust cues: research-related risks, prediction, and assessment of public events/current affairs. Trust cues referring to *research-related risks* communicate risks associated not only with research in general but also with scientific processes or with danger caused by scientific information. *Prediction* refers to the prognosis of possible future events or outcomes based on scientific information or findings. *Assessment of public events/current affairs* includes scientific assessments that evaluate public events and/or current affairs within or outside a scientist's own field of research. For example:

> US researchers [meso level] wanted to test a technology bringing reflective particles of lime dust into the stratosphere. *The fundamental fear in field experiments: Aerosols could behave like rabbits in Australia. Once released, they do damage and defy any attempt at recapture* [research-related risks] [Gut zu wissen, 28.08.2022].

Five different trust cues belong to the category of *benefit for society*: social significance of science, discoveries and breakthroughs, applicability of results, (science-based) recommendations, and personal reasoning for benevolent behavior. *Social significance of science* highlights the importance of science for society in the past, present, and future. *Discoveries and breakthroughs* refer to novel findings in research as well as successes achieved in a particular field of research. *Applicability* denotes the degree and significance to which scientific findings can be used in the everyday life of audiences. (*Science-based) recommendations* are pieces of advice provided based on scientific information; this also includes scientific demands to nonscientific parties, recommendations for action, and scientific advice for politics. Benevolence cues about *personal reasoning for benevolent behavior* communicate scientists' personal motives for helpful behavior toward publics.

These include motivation, selflessness, and emotionality related to research, as well as to a scientist's biography (if it explains their reasons for working in science). For example:

> '*A stimulating fiscal policy that sets investment incentives' could mitigate this* [(science-based) recommendations], judges the DIW [Deutsches Institut für Wirtschaftsforschung; meso level]. *It is important that policymakers prepare the economy for a supply freeze in order to reduce the severity of the potential shock* [(science-based) recommendations] [zeit.de, 29.03.2022].

With regard to the dimension of benevolence, examples for each category are given in Table S3 in the *Supplementary material*.

Concluding, *benevolence cues* signal that science has the goal of improving people's lives and promoting the advancement of societal welfare. This includes referring to the social responsibility of science, and the representation of scientific research as adhering to ethical norms and moral values.

5.4 ▪ *Transparency cues*

The dimension of *transparency* includes two categories: accessibility of results and comprehensible language. *Accessibility of results* means research results are made publicly available in any form, for example: "Here is the *link to the study* [accessibility of results, meso level]." [FAZ.net, 09.06.2022]. *Comprehensible language* refers to the language used to describe research processes and results in a comprehensible — but also sometimes in an incomprehensible — manner, for example:

> The parasite *Plasmodium falciparum* [comprehensible language] absorbs molecules from the blood that are toxic to it & which it therefore transformed into bio-crystals. Researchers @BNITM_de [meso level] want to use this for new medicines [BMBF (Federal Ministry of Education and Research of Germany) via X/Twitter, 04.08.2022].

Again, examples of the categories/trust cues connected to the dimension of transparency are given in Table S4 in the *Supplementary material*.

Transparency cues, therefore, indicate that scientific research and knowledge is accessible to public audiences and comprehensible to all.

5.5 ▪ *Dialogue cues*

For the dimension of *dialogue*, three categories were identified: participation at public events, public engagement in research, and media presence. *Participation in public events* pertains to the attendance of scientific representatives at public events organized by scientific but also by non-scientific individuals or organizations. *Public engagement in research* refers to public audiences engaging in research processes besides being the subjects of studies. The category public engagement in research was built deductively and could not be validated inductively while coding. The two categories of participation at public events and public engagement in research are without further subcategories. *Media presence* concerns the participation of science in the media, such as a mention in an interview, participation in a talk show, or presence in social media. This category can be further subdivided into journalistic, direct (e.g., social media), and further presence (e.g., press releases; this aspect was developed deductively). For example:

> Professor Stefan Rahmstorf of the Potsdam Institute for Climate Impact Research (PIK) [micro level] is one of the best-known climate researchers in Germany, a *popular expert on ARD and ZDF and a regular contributor to Spiegel Online* [media presence] [Junge Freiheit, 22.04.2022].

For dialogue, the examples for each category/trust cue can be found in Table S5 in the *Supplementary material*.

Hence, *dialogue cues* refer to how science actively engages with, and encourages interaction from, the public, with activities such as public lectures or citizen science projects.

6 ▪ Discussion

To analyze media as primary sources for scientific information, we introduced the term "trust cues" — i.e., information provided in media content that present public audiences with reasons to place trust in science by addressing dimensions of trust in science.

We identified such content-related trust cues through an explorative approach using qualitative content analysis for a variety of information sources about science. The trust cues identified are located at the textual level, as our unit of analysis consisted of articles, transcripts, and the texts of social media postings. This study then systematically identified several cues for each of these dimensions in content about science. These can be referred to as expertise, integrity, benevolence, transparency, and dialogue cues. These cues match and extend the definitions of the dimensions of trust in science [Reif & Guenther, 2021; Reif et al., 2024; see also Bentele, 1994; Besley et al., 2021; Fiske & Dupree, 2014; Hendriks et al., 2015, 2016; Mayer et al., 1995]. Although our open, largely inductive approach allowed us to search for further trust cues, we did not find any cues that could not be assigned to those dimensions. Consequently, it can be said that media content does, in fact, address the five dimensions of trust in science and, therefore, that trust cues may be important for earning the trust of public audiences in science. Trust cues can be seen as an operationalization of these dimensions, and their analysis provides insights about *how* reasons to trust science are signaled and *which* reasons to trust science are presented. The theory of public trust [Bentele, 1994] underlines the importance of media and its contents for public trust in science. In this regard, the trust cues identified enable examination of the media content in the context of public trust in science and suggest that media content is indeed not a neutral component in trust relationships but — in line with the theory of public trust — is a critical influencing factor.

To date, most research on the trust evaluation process has focused on cognitive trust heuristics used by audiences [e.g., Kahneman & Frederick, 2005; Tversky & Kahneman, 1974] or on markers that signal media credibility [Metzger & Flanagin, 2013; Ross Arguedas et al., 2024]. However, even though media content is of importance in this process, research focusing on content-related aspects in media is often missing. That is why the applied explorative, structured, and systematic approach to identifying such trust cues fills a research gap in media trust research and enhances our understanding of the trust evaluation process that takes place when public audiences come in contact with science via the media. Nevertheless, it is possible that future research may identify additional, topic-specific trust cues. Furthermore, this study provides the groundwork for further research on the effects trust cues have on public trust in science. With the identification of content-related trust cues, it becomes possible for future research to compare diverse media in terms of how they present reasons to trust in science. So far, because journalism dominates our subsample, the cues identified are trust cues used mainly in journalism. Based on the concept of trust cues, their occurrence can be connected to developments in public trust that takes media use into consideration. This includes finding answers for the ambivalent findings about social and online media and their effect on public trust in science [e.g., Huber et al., 2019; Takahashi & Tandoc, 2016] — the identified trust cues provide explanatory content that allows for a more differentiated view on the effects of media use on public trust in science. Therefore, they also provide the base for a well-founded discussion about a potential decline of public trust in science.

Most people use a variety of diverse media to stay informed; different media could use trust cues differently, and, therefore, could affect various aspects connected to trust in science [e.g., dimensions, categories of trust, and trust cues; Boothby et al., 2021; Metzger & Flanagin, 2013]. The trust cues identified in this study are solely textual cues. They can be embedded in a larger context by considering that there are various indicators other than textual trust cues that can affect trust in science via intermediaries. These include different aspects on which media credibility is based, such as the specific media outlet, the presentation of information, the presence of an image, text sentiment, and the number of likes on social media posts [Boothby et al., 2021; Choi & Stvilia, 2015; Wathen & Burkell, 2002], as well as the context in which the communication takes place, including the communicator and the manner of communication such as the style of language used [e.g., Vaupotič et al., 2021]. For this reason, even though the present content-related, textual analysis is vital to better understand mediated trust in science, it is only one building block in a broader trust relationship or trust evaluation process that should be considered for a complete and comprehensive examination.

The explorative qualitative approach employed by this study limits the significance of the results to some degree. In the present study, a qualitative design was used that does not fully support quantitative derivations, hence, we propose a quantitative content analysis that systematically investigates frequencies and distribution of trust cues across a larger and representative sample of media outlets. Since, in journalistic content, scientists (micro level) may play a more important role compared to scientific organizations and the science system [Guenther, 2019], it might be worth looking at differences between specific objects of trust, such as male and female scientists, who may be represented differently (e.g., regarding gender differences). Additionally, the linkage of trust cues to mis- or distrust is worthy of future research because, for instance, research that is ethically questionable or involves risks can be legitimized (e.g., autonomous weapons), and "alternative" experts that promote mis- or disinformation [see Oreskes & Conway, 2010] can also be described with trust cues.

Moreover, the trust cues identified and the categories developed for each dimension do not inform on their importance for audiences, meaning their effect on public trust in science [for first indications, see Reif et al., 2020; Rosman et al., 2022]. Likewise, they do not explain possible dynamic relations between dimensions, categories, and trust cues. Consequently, audience studies are needed to validate the effect of trust cues on public audiences and reveal potential dynamics or hierarchies between trust cues. However, taken together with trust heuristics and credibility markers, content-related trust cues can enhance our understanding of the overall trust evaluation process when engaging with content about science.

The study presented here has identified trust cues in intermediaries that can, in fact, be connected to the dimensions of expertise, integrity, benevolence, transparency, and dialogue, all of which potentially affect the trust relationship between science and public audiences. This provides motivation for research on the importance of science media content — as well as the role of intermediaries — for public trust in science.

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