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Decisionmakers' Assessment of Science Communication and Scientific Media Coverage. A Qualitative Study Focussing on Materials Science

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Abstract

Science communication and media coverage of scientific topics have been extensively researched over the past few decades, yet gaps remain in terms of focus areas and study design. Here I examine the case of materials science based on data from 22 semi-standardised interviews with experts from the political-administrative field as well as from science and industry. Materials science plays a key role in the development towards a sustainable future and its public perception today might impact science policy. Therefore, I analyse how German decisionmakers position themselves towards science communication and what their views are on the media portrayal of materials science. Their main argument for enhancing communication practices is the maintenance of democracy and support for scientific work, which implies empowering the lay public to enter into a dialogue with scientists in the field, as postulated by the dialogue model. Most respondents are critical of the media coverage of science topics, though they acknowledge its role in shaping public opinion and, to some extent, influencing policymakers' agendas. However, the impact arises from the interplay of various factors, and direct media influence on decision-making processes is perceived only in particular situations.

Keywords: expert interviews, science communication, media coverage, materials science, decision-making process

1. Introduction

In recent years actors at different levels of society have re-positioned the topic of science communication to make it a matter of public concern and ensure its relevance in public statements (Siggener Impulse, 2013-2020), policy papers (BMBF, 2019) and parliamentarian motions (German National Parliament, 2019, 2020 a and b). Moreover, the occurrence of the Covid-19 pandemic has brought the topic to the public attention, generating extensive debates about the role of scientists as communicators to politicians, journalists and citizens.

The communication of science topic unfolds many aspects regarding the production, transmission and reception of scientific messages, which have been made the object of numerous scholarly research projects in the fields of communication and social sciences (Metag, 2020; Guenther and Joubert, 2017; Petersen, 2010; Dunwoody et al., 2009). Schäfer's meta-analyses (2011 and 2012) as well as many of the studies consulted for this paper indicate that scholars directed their attention particularly to the representation of science in the mass media. Due to the high fragmentation of science (Weingart, 2002) numerous fields and disciplines are likely to become the object of media coverage. However, scholars in science communication focused on specific fields. Among the studies analysed in the first decade of the 2000s, 81% relate to disciplines such as biology, medicine and climate research (Schäfer, 2012: 655) covering topics like genomes (Rödder, 2009), stem cells (Peters et al., 2008), climate change (Boykoff and Boykoff, 2007) among others.

This study proposes to cover a discipline that has not been researched by media studies experts as a single subject of investigation, namely materials science.

Although mostly unnoticed, materials are embedded in our lives and have shaped our world (Miodownik, 2014) from the very beginning of history. They were central drivers in processes that have bettered humans' lives (Flemmings and Cahn, 2000: 371) across sectors such as environment, communication, health or mobility. While materials can be traced back to the origins of civilisation, the scientific field of materials science is rather a new one. It emerged in the 1960s from the fields of metallurgy, solid state physics and physical chemistry and evolved alongside the development of new technologies and instrumentation used by the professionals and scientists in these disciplines.

The developments in the mid-20th century played a crucial role in the establishment of this discipline, particularly in the United States, where it first crystalised. In the context of the Cold War and the technological gap laid blatantly open with the Sputnik launch (Groenewegen and Peters, 2002), materials research was fostered by the American science policy prevailing at that time, since materials were considered a priority for the national security interest (Bensaude-Vincent, 2010). The definition of materials as "substances having properties which make them useful in machines, structures, devices and products" (Bensaude-Vincent, 2001: 223) stresses the utilitarian purpose of this field and its applications to meet social and industrial challenges. Multidisciplinarity and interdisciplinarity are the core features of this field, rooted in its origins and in the convergence of elements from physics, chemistry, engineering, mathematics and mechanics, conglomerating different methodological approaches (Martin, 2015). Even though materials science has established itself as a distinct discipline (Hentschel, 2011), its inherently multidisciplinary nature may still have an influence on how it is perceived, especially by the non-expert public.

In Germany the discipline evolved a few years later than in the US (for an overview, see Hentschel, 2011; Bensaude-Vincent and Hessenbruch, 2004), and today it is firmly established in science and technology institutions and also in companies. According to a report of the German Federal Ministry of Education and Research (2015: 22), discoveries in materials research account for about 70% of new technologies. Hence, the initial strategic role bestowed on this field still prevails today, though with a stronger focus on sustainability. In the context of climate change, the scarcity of resources and the substitution of old by more sustainable technologies have become high-profile topics on the political and public agendas. Materials science has adapted its design research to meet these societal needs and, with the scientific approach of "data-driven materials design" now plays a key role in the endeavours to green our world by accelerating a faster discovery of novel materials for e.g. energy system transformation.

Although essential for advancement, new technologies and products often generate uncertainties or scepticism among consumers and the public. It is essential therefore to use different communication channels to disseminate research results and inform broad audiences, especially as communication in the early phases of technology development is essential for the societal acceptance (Petersen et al., 2009).

Against this backdrop the study aims firstly to map the relevance of materials research dissemination to the general public. Therefore, expert interviews were conducted with decisionmakers of three social fields: political and administrative, science and industry. Second, the study focuses on a single channel of communication, namely the mass media. What is of interest here are the views of decisionmakers with regard to the media coverage of materials research activities and results as well as whether such coverage has consequences for the decisions related to research policy. To this end, the study is structured around three research questions:

RQ1: What are the main functions of science communication in the opinion of respondents?

RQ2: How do the respondents perceive and evaluate the media coverage of materials research?

RQ3: How do the respondents deal with the information received from the media in their decision-making processes?

2. Conceptual Framework

The role of science communication is to enhance people's knowledge about scientific matters, methods and their impact on society (Burns et al., 2003). The relationship between science and society has changed over the years and is described in different models. The prominent deficit model assumes that the public lacks knowledge and that it is up to the scientists to close this gap (Nisbet and Scheufele, 2009), since a well-informed public on scientific matters is considered to be linked to a widespread acceptance and support for research. However, empirical research shows only a weak correlation between the scientific literacy of people and their positive attitudes towards science (Bauer et al., 2007: 84). The deficit model is criticised also because it promotes a top-down relationship between the scientist as a communicator and the public as recipients of science-related information.

This unidirectional communication from science to the public at large is reversed by a new model which advocates a dialogue between scientists and lay audiences. Gibbons (1999) calls this action "speaking back" to science, that is to say adding a reverse flow to the previous flow of information from science to the public. The involvement of citizens in decisions with a societal impact corresponds to the beliefs of a democratic society (Scheufele, 2014: 13587) which expects the production of knowledge to be transparent with the taxpayers being given the option to take part in the debate about the production and the uncertainties of research. Furthermore, the relationship between scientists and the public has been theorised in the participatory model, which postulates a shift of power from the scientists to the laypeople (Metcalfe, 2019). Here, the public is not merely a dialogue partner as in the previous model, but it can produce new knowledge, take decisions and shape the agenda of science (Trench, 2008). The aim is to democratise science through public participation and to increase the engagement of citizens in critical issues like GM food or climate change (Bucchi and Neresini, 2008). Although policymakers in scientific and political organisations widely speak out in favour of dialogue and public participation in science, scholars warn against the early adoption of these models, a fact that seems to indicate that science communication is still fraught with deficits. Hence, the deficit model coexists with the dialogue and participatory models (Simis et al., 2016).

Starting with the aims of these communication concepts Weingart and Joubert (2019) distinguish between two types of motives for science communication with the first being directed to informing general audiences in order to augment their scientific knowledge; this can therefore be called a public-centred model. The second type is largely self-centred, which means the communication measures are developed with the objective of promoting and enhancing the benefits for scientific organisations or individual scientists as initiators of such measures.

The first part of the interviews (RQ1) explores the different functions of science communication proposed by Weingart and Joubert (2019) for the specific field of materials science. Thus, decisionmakers were asked what they think about science communication to lay audiences and whether they expect a willingness of scientists across all disciplines or career stages to engage in such activities.

The research undertaken by scientists and its results may be communicated to the non-expert public via a wide range of channels. There are many different formats for the so-called external self-mediated communication (Dogruel and Beck, 2017), such as science festivals, science slams, science cafés, popular science lectures, which are selected according to the initiators' motivations and the resources available. This study is above all concerned with the external communication transmitted by the mass media, the channel which is considered to be responsible for a wide dissemination of scientific knowledge outside the scholarly community (Schäfer et al., 2015; Weingart, 2005). This is justified by the increase of scientific reports in the last few decades, particularly in the print media (Schäfer, 2012; Bauer, 2011; Elmer et al., 2008; Bauer, 1994). Peters (1995: 32) puts this increase down to a new type of scientific coverage that complements the existing popularisation formats. According to his diagnosis, scientific issues are more and more intertwined with current problems or conflicts in a given society and presented either as a trigger of, or as possible solutions to such conflicts.

In this sense, most citizens obtain information about the latest results of scientific research via traditional media channels such as television and newspapers, either online or in print (Van Aelst et al., 2021; European Comission, 2021; Wissenschaft im Dialog, 2018-2022; Caulfield et al., 2014; Scheufele, 2014). Thus, it may be asserted that the image many people have about science is shaped by the media acting as "translators" (Weingart, 1998) between science and lay audiences. In this constellation, scholars direct their interests to the dynamics operating between the media and science and, with their research, contribute to a better understanding of this relationship, e.g. the representation of scientific expertise in the mass media and its perception by different stakeholders.

These studies are of relevance for this inquiry as they assess that the suitability of a particular topic for communication differs across different disciplines (Scheufele, 2014) and that some, such as medical or health issues, attract public attention much more easily than others (Summ and Volpers, 2016; Schäfer, 2007; Bucchi and Mazzolini, 2003). Scholars explain this by the use of selection criteria by science journalists. It is not only the news factors such as controversy or the impact on people (Badenschier and Wormer, 2012) that contribute to the decision of whether or not to report on a particular science issue. Guenther and Ruhrmann (2013) additionally point to criteria related to the individual level, such as the personal interest of journalists in a topic, and communication practices in the editorial office. Other studies underline the use of frames in the scientific coverage (Kohring and Matthes, 2002) which are often interrelated with media effects such as shaping the readers' perceptions of specific scientific subject matters (Scheufele, 2013).

For a comprehensive understanding of the case of materials science, the second major point of this research (RQ2) aims to obtain information from interview respondents, hence actors in leading positions, as to how they perceive and evaluate the coverage of materials research in the German mass media. This point in the interviews refers particularly to legacy media – daily newspapers, weekly news magazines, with their print and online versions, broadcast media and covers both genres of reports on science as differentiated by Schäfer (2011) according to the characteristics of coverage, namely the popularisation and mediatisation mode. As for the popularisation mode, research findings are presented in a simplified manner, and they are usually published in the science section of the media outlet. The articles published in the mediatisation mode are related to science, but set in a broader context with political, economic and ethical implications, often published in non-science sections (Schäfer, 2011: 405).

Today's media landscape is dynamic and comprises various forms of production, transmission and reception of messages. Apart from traditional mass media, it is important to mention the digital media (websites, blogs, online media) and specifically social networking and micro-blogging sites, which introduced the many-to-many communication model and have reached billions of users today. Such channels were also adopted by scientists, providing them with alternative ways to communicate their messages to a broad audience without relying on the mediation of professional journalists (Hunter, 2020). Beyond serving as sources of news and entertainment, social media platforms allow users to interact, exchange perspectives and express support or criticism for the presented content (Collins et al., 2016). Communication scholars see the digital media both a chance for the democratisation of the public debate and also a danger for spreading misinformation or disinformation (Schäfer and North, 2019), due to the absence of the journalists' gatekeeping role and the resulting lack of control over information dissemination.

While today's new media environment has transformed the access to information through a wide range of channels and formats, legacy media are still important sources of scientific news (Weitkamp et al., 2021; Pearce et al., 2019) and among the information channels serviced on a regular basis by expert stakeholders in political organisations (Langer and Gruber, 2021; Fawzi, 2018; Blöbaum et al., 2013). Although such stakeholders usually dispose of direct expertise in scientific affairs (Petersen, 2010), due to the standard activities of journalists, i.e. informing, orienting and evaluating (Kohring, 2005), the legacy media represent a practical instrument in the working routine of political decisionmakers. Particularly for those without any knowledge of the subject matter at hand, the press gives an overview of current scientific issues and public opinion.

Apart from delivering scientific knowledge to and informing the general public about ongoing research, the media can play an important role in drawing the attention of stakeholders to particular topics (Langer and Gruber, 2021). Thus, perceptions of medialised expertise may also translate into putting certain themes on the political agenda and setting up research projects in these fields. The climate change debate is a case in point, an example considered by Weingart (1998: 876) to have been established as a highly-ranked issue in the public sphere especially due to the contribution of the media which enhanced its prominence by extensive and repeated coverage.

Given this background, scholars extended their views regarding the possible effects of medialised science on research policy (Peters, 2013: 311). The results of different quantitative and qualitative studies (Scheu, 2019; Blöbaum et al., 2013; Petersen et al., 2010; Peters et al., 2008) suggest that scientific mass-mediated expertise has an impact on stakeholders within the political and science-policy constellations, but the degree is difficult to assess, especially so because actors in key positions base their decisions on various informational and advisory sources. Based on these assumptions, the third area of the interviews (RQ3) aims to find out how the respondents of this study deal with the information received from the media in their work routine and decision-making processes on research policy, e.g. funding allocation, collaborations.

3. Materials and Methods

The qualitative method of semi-structured expert interviews was used to address the questions of the present research. This type of interview is suitable for our study, firstly due to its flexibility with regard to the questions and discussions and secondly, due to the access to the knowledge a potential respondent is assumed to possess in the researched field (Gläser and Laudel, 2009: 42).

Scholars in the field of qualitative research define the term "expert" in a variety of ways (Meuser and Nagel, 2009; Blöbaum et al., 2016; Brinkmann and Kvale, 2015). However, there is general agreement that a person is considered an expert on the basis of the knowledge acquired through work experience combined with a leading position within an organisation. Due to the acquired experience and knowledge in an institutional context an expert should be able to deliver information and help to reconstruct specific processes or situations (Gläser and Laudel, 2009), e.g. the logics of acting and decision-making (Blöbaum et al., 2016).

Following the typology of the expert interview by Bogner et al. (2014) the study at hand is based on an exploratory type of interview, aiming to gather information about a field that has not yet been analysed in depth, i.e. communication of materials research. However, the interest is not primarily directed towards the acquisition of technical knowledge. It is the interviewees' experience within their professional field which generates information on routines, but also beliefs, interpretations, expectations, thus the interpretative knowledge related to researched object (Bogner and Menz, 2002: 43f).

3.1 Sample

In materials science as well as in other disciplines, decisions on research are taken by different stakeholders at different levels. Scientists, actors in political committees and research foundations and representatives of the relevant industry are involved in decision-making processes about the set-up of research programmes, cooperations or funding and, as a result, wield considerable influence on the development of research.

For this reason, interview participants were sampled from various groups and were identified by means of public profiles, mostly available on the internet. The experts were firstly selected according to their profession and affiliation to the respective organisation, such as research institution, ministry or technology company, which qualifies them as experts (Collins and Evans, 2002). Second, their selection was based on their position in the organisational hierarchy of an institution, their membership in associations and decision-making forums, their research experience and their authority to influence other actors. The persons interviewed were involved in decision-making processes at different stages and degrees in their organisations. These selection criteria stress the status of the respondents in their respective fields of activity, namely that they were attributed the role of expert by social and institutional reality (Bogner and Menz, 2009: 50), hence that they have the capacity to offer insight into the specific fields of research.

Given the focus of this study, the interviewees were sampled from areas linked with materials science. In the case of political and administrative actors these criteria could not be met by all respondents. An invitation email providing information about the study was sent to several actors individually. From 41 invitations, 22 participants gave informed consent to these interviews and the subsequent publication of anonymised results. The sample of interviewees was made up as follows:

- nine actors from the political-administrative field: German Parliament (Committee of Education, Research and Technology Assessment), Federal Ministry of Education and Research, Ministry of Culture and Science of the State of North Rhine-Westphalia and two research foundations. [PA]
- eight scientists (universities, non-academic research organisations, both basic and applied research). [SC]
- five representatives of technology companies headquartered in Germany with operations in the field of materials, with their own R&D activities and with over 5.000 employees. [IN]

This composition of the panel of experts is partially homogeneous, with the exception of the industry sector, where the acceptance rate was lower than in the other two groups. One reason is the selection criteria focusing on large companies that have their own R&D departments and also collaborate with research organizations. Besides, in the corporate sector the willingness of experts to participate in interviews is rather low due to their more highly prioritised professional duties (Littig, 2009: 104).

3.2 Sample Size Determination

The non-probability purposive sampling method was used for this study. The number of respondents was not established in advance. However, scholars postulate that a minimum of 15 interviews is needed to ensure the validity (Moser and Korstjens, 2018: 11; Guest et al., 2006: 61). Our sample size was determined by the concept of theme or code saturation as markers for data adequacy (Morse, 1995); and this is achieved when further interviews do not generate new information, hence there are no further thematic categories (Guest et al., 2006). This dataset proves its comprehensiveness, as most of the new categories in this analysis were identified during the first half of the interviews. Additional interviews could have provided more data, since qualitative research offers limitless perspectives (O'Relly and Parker, 2012). However, due to the methodological design involving a single researcher and a lower participation rate from industry representatives, the number of interviews was restricted to 22 to avoid an unequal ratio among the three groups interviewed.

3.3 Interview Situation

Standardised surveys and qualitative studies about similar topics were consulted for the development of the questions (Scheu, 2019; Allgaier et al., 2013; Tsfati et al., 2011; Royal Society et al., 2006; Heinrichs and Petersen, 2009). The interviews were semi-structured based on a guideline with questions relating to four topics of interest for the research questions, i.e. science communication, sources of information, materials science in the press, media impact on decision-making processes (see supplemental file 1).

The interviews were conducted in German, via video calls, with two conducted by telephone and lasted 30 minutes on average (M 34.82, SD 11.97). Given the data collection period (November 2020–January 2022), some variations in responses may have occurred. Nonetheless, as the interviews focused on science communication, a widely debated topic during that time, participants demonstrated their up-to-date understanding by referencing the latest developments on the subject.

The audio-recordings of the interviews were transcribed clean verbatim and anonymised (see supplemental file 2). Citations in this paper have been translated by the author.

3.4 Data Analysis

The text data obtained from the transcriptions of the interviews were analysed using the research method of qualitative content; analysis and the interpretation followed the pattern of the content structuring approach by Kuckartz (2018). Some of the categories were developed beforehand, starting from the interview guide and implicitly based on the existing literature, so concept-driven, and they were supplemented during the analysis of the transcripts, that is to say data-driven (Kuckartz, 2019). The transcripts were analysed in MAXQDA 20, a computer-assisted qualitative data analysis software. The single transcripts are identical with the analysis units.

To organise the data systematically, the text was divided into meaningful units and each unit was labelled with a thematic category that reflects its relevant content (Brinkmann and Kvale, 2015: 227). The main categories derived beforehand from the interview guidelines were science communication, information sources, media use, scientific reports in the media and decision-making processes. During the repeated readings of the transcripts, new themes emerged, thus complementing the initial list of categories.

A second round of reviews of the whole material followed this process. In this step, the categories were refined and subcategories were developed and added. A cobebook was elaborated with short definitions of the categories generated from the transcribed interviews, along with some examples.

3.5 Intercoder Reliability Process

To assess the accuracy of measurements and the reliability of the conclusions drawn from the analysed content, an intercoder reliability study was conducted (O'Connor and Joffe, 2020).

The coding scheme was discussed with a second coder who was familiarized with the research topic and the thematic categories. The second coder applied the coding frame to a subset of the sample which included one interview from each of the three areas: science, political-administrative and industry. This selection ensured that a diversified spectrum of data could be obtained. For this process, the thematic categories retrieved by the first coder were removed from the files, while at the same time the corresponding marked units were retained.

The intercoder agreement of the subsample was calculated according to Brennan and Prediger's coefficient Kappa (1981). The Kappa level might range between "no agreement" (-1.00) and "perfect agreement" (+1.00) (Rädiker and Kuckartz, 2019) and the interpretation rely on Cohen's Kappa values as stated by Landis and Koch (1977). The coefficient generated by the three interviews was of 0.80, which represents a substantial value. However, some discrepancies were adjusted and the codebook refined.

The final Kappa value for the whole data set was calculated at an average of 0.78 and of a percentage agreement of 78,72: this indicates a satisfacatory reliability level. The intercoder agreement on the 22 categories and subcategories ranged from 62,50% to 100% (see supplemental file 3).

4. Findings

The results of the interviews are organised in accordance with the three research questions of this study.

4.1 Functions of Science Communication

The data collection occurred during the Covid-19 pandemic when science communication with a non-expert audience was a major issue in the public debate. The role of scientists as experts and communicators became more visible, especially when the scientific guidance was implemented in the policymaking processes which in some cases had an immediate societal impact. This situation may have played a role in the respondents' assessment of the role of science communication. Without exception the interviewees underlined the importance of science communication with a non-expert audience via different channels. (RQ1)

Most respondents were of the opinion that the main goal of the communication measures is to ensure that society is well-informed about science in general and materials science in particular. This perspective can be understood both normatively and practically.

From the normative point of view, informing broad audiences on research findings goes a long way towards justifying research work and its funding in the eyes of society at large. The taxpayer can expect the funding of research to be made fully transparent. It is particularly the interviewed actors in the political and administrative field who stress this point and see science communication as a prerequisite for maintaining democracy and justifying the scientific work. The necessity of legitimization is rooted in the interdependence among different systems that should be enabled to function within right parameters:

> *"Wherever money flows within a system, that system must justify itself more rigorously [...] we currently have access to a greater amount of research funding from the GDP, which was not the case before. So, scientists engaged in scientific research should be willing to and must provide justifications for their work" [PA2].*

It is therefore an obligation falling on scientists to inform the public about their scientific work. By doing so *"trust in science is secured"*, as a representative of the executive power comments [PA4]. The regular flow of information on current scientific work contributes then to strengthening the resilience of society to any kind of mis- or disinformation. This enables individuals to make decisions on the basis of sound information, while at the same time being sure to have the support of actors in the political environment, especially when decisions with a political impact require a more general level of public acceptance.

Respondents from the fields of science and industry name various practical aspects, which go hand in hand with a broader degree of communication. In their experience people often show a certain degree of aversion towards science and technology, although some of the preconceptions about technological issues *"are 10 years old and already cleared up by scientists"* [SC4]. A society that is well-informed about and has a sound knowledge of scientific issues is therefore much more amenable to questions of research and its applications. This goes especially for materials science in its endeavour to contribute with solutions to the current challenges such as climate change which require support for new scientific developments and technologies. An industry decisionmaker points out, for instance, that for the technological change

> *"we need to test different technologies. And these technologies are often doomed to failure and not accepted, because many people are not adequately informed"* [IN2].

In this sense a higher degree of willingness on the part of researchers to *"leave the ivory tower"* [SC8] would be beneficial for society as a whole.

Furthermore, a higher degree of visibility of materials science in the public sphere may attract young aspiring academics to study or work in this field. By means of this form of *"self-promotion"* [SC7], as one scientist calls it, a particular university and the respective region would obtain an advantage over other competitors which may translate into more funding becoming available. Thus, science communication may serve as a *"lobby for one's own interests"* and become part of a marketing strategy, as a member of the legislative power observes [PA2].

While all the respondents suggest agreement on the importance of science communication and the enhancement of the awareness for this issue among scholars, they are by no means unanimous as to whether communication should become a duty for every single scientist. The majority agree that this task cannot be fulfilled by everyone and bring forward two arguments. First, the personal skills required for such activities and second, the suitability of a particular topic for dissemination to a greater public. However, the excuse that scientists have no time to devote to science outreach is considered *"outdated in our day and age"* [PA5] by a member of the executive power. It might be a feasible solution to designate qualified representatives within a research group, maybe *"excellent researchers, who pursue a career in academia"* [SC5]. But this sensible way of proceeding is not in line with the expectations of some political representatives who are looking for a readiness of each and every scientist to get involved in communication activities, irrespective of their research field or career stage, so that *"the communication about their own research, will become an integral part of scientific practice"* [PA4].

4.2 Assessment of Science Coverage in the Media

As to the area of interest (RQ2), data were gathered on the respondents' information sources for general issues and materials science as well as on their media use. The five respondents without a materials science background reported on information sources on general science.

The interviewees' answers show that for scientific novelties they rely on sources such as scientific journals, conferences, advisors or scientific commissions. Apart from these sources, different news media as well as the internet are frequently used to get information on scientific and general matters.

The respondents from materials science do not perceive media reports as an effective source of information about novel insights from their field. Such reports represent rather a validation of information that is already available from specialised scientific sources such as scientific journals, conferences or personal networks.

The overall social media use is low and ranges from never to occasionally with specific channels like LinkedIn or X (formerly Twitter). The social networking site LinkedIn is frequently mentioned by science and industry actors when it comes to obtaining cutting-edge information on the research undertaken by peers. They stress LinkedIn's advantage of up-to-datedness over scientific journals and call the input available on this site *"spotlights among the daily news and events"* [IN3].

In spite of the different approaches to and the use of media, all respondents are aware of the contents of the press, a fact that represented a premise for the further interview questions exploring their perceptions of reports on materials research in mass media.

In terms of quantity, there is widespread agreement that materials-related topics are underrepresented in the general media. They state this firstly in comparison with the coverage of other disciplines and, secondly, in relation to the relevance of this research field for our world at the present time. A science representative puts it in a nutshell:

> *"When one thinks of the significance of materials for our daily lives from morning to night and the attention it gets in the daily press, that is rather small to put it mildly"* [SC7].

Some interviewees are aware of the media logic, such as the production routines of journalists or the selection criteria by which the press releases are filtered. A foundation representative observes for instance that the level of media coverage is attributed to the nature of the topics:

> *"I would say, a lot depends on how sexy a topic is […]. It may be scientifically very exciting, but if there is no direct societal effect or if there is nothing problematical as for example in the case of carbon nanotubes which may or may not cause cancer. And if it is interesting only from a scientific point of view, then it is simply unattractive for communication"* [PA3].

As to the quality of materials science coverage, the perceptions are split. Several respondents mention examples of accurate journalistic reporting about highly relevant subjects from fields such as batteries and electric mobility. However, these positive statements mainly refer to quality newspapers for example *FAZ, SZ* or the weekly *Die Zeit*. The pervading perception among the interviewees is dissatisfaction; and here two main problem areas can be identified, the first being related to content and the second to the approach of journalists.

As for content, half of the respondents claim to have witnessed incomplete or faulty information on materials research issues as disseminated in the media. Communication of inaccurate information is seen as

> *"the worst that can happen in our democracy, namely that decisions are suddenly taken on the basis of incomplete information, of a fragmented picture, with people thinking they have a well-grounded opinion"* [IN2].

Such biases are also the result of journalistic framing. A respondent from academia makes a keen observation about the use of journalistic frames in reports, noting that they often reinforce negative statements about scientific developments or reduce narratives to a dichotomy of good vs. bad. Such shortcomings are explained with the media logic of the necessity to sell and create audiences whatever it costs.

The specific approach to the field of materials science pursued by some journalists is also outlined by different respondents. They notice a discrepancy between the topicality of the research results and the relevant news items in the media. An industry representative remarks that

> *"at the beginning we looked at every such article with very great interest, but at some point we realised, ok, every two weeks they reveal the great breakthrough, and somehow the research is slow-going, step by step. Nevertheless, in the newspapers and internet articles, the ground-breaking super battery is announced every two weeks, something that obviously never materialised"* [IN4].

This tendency of journalists to constantly announce breakthroughs in research is also emphasised by a science representative who links this problem to practices within the scientific community itself. Driven by the desire to increase their visibility some researchers produce a press release for each scientific publication, *"and there cannot be 50 breakthroughs at a university per month"* [SC8].

Such phenomena contribute to another perception of the field of materials science in the mass media, namely science hypes. Respondents are aware of the double-edged effect of hyped topics. A scientist quotes the case of nanotechnology, which has received much attention from political actors and the general public and acknowledges that

> *"such mega topics generate research projects. And research projects mean money for science. Nevertheless, one must distinguish between what is hype and what has really content"* [SC3],

in the sense of being achievable, because hyping a topic may become disruptive for science, especially when the promises are not fulfilled and people are disappointed.

In spite of these drawbacks, the reports serve as teasers to several respondents and stimulate them to seek further information, if the topic has raised their interest. The monitoring function of the media is also perceived, as one respondent notes, *"the media tell me which topics are trendy at the moment, so I think one can find out where exactly the money is going"* [IN2].

4.3 Decision-making Processes

The third part of the study (RQ3) is concerned with the way expert stakeholders handle the information obtained from the media and their perceptions regarding decision-making processes. This points covers decisions such as elaborating a research policy, grant funding schemes, the set-up of research programmes or cooperations.

There is general agreement among all respondent groups that the scientific quality is the central factor in the decisions on science policy. However, the media are deemed to have a latent and indirect role, but only in specific situations. An industry representative mentions an example where the media might serve as a source of new topics or indication of potential partners for cooperation:

> *"It happens that our boss reads an article or watches a report on ARD about a company, institute, that does something great, and this lands on my desk for evaluation afterwards to see if they are a suitable candidate for a cooperation with us"* [IN4].

Even if the media provide the initial spark, the follow-up process is driven by internal practices and the final decisions are based on the competences of the respective institution. On the other hand, visibility in the press may also have opposite effects, as a science representative observes, namely, that media coverage of researchers or institutes may negatively influence the decisionmakers of the scientific committees,

> *"who share the opinion that scientists should not give interviews about scientific research and should only do their research and remain thoroughly neutral"* [SC4].

Some scientists hold the view that scientific expertise in the media may have a bigger impact on political actors, because they often rely more on media information and may consider such reports in their decisions:

> *"I imagine, people in the BMBF (Federal Ministry of Education and Research) or BMWI (Federal Ministry for Economic Affairs and Energy) are influenced by publications in dailies and magazines when they write out a call for research projects"* [SC6].

The function of the media as contributors to opinion-making is confirmed by the respondents of the political group, particularly when topics receive extensive and repeated coverage, so that "*the relevance [of a topic] in the public discourse, is something that is reflected in the relevance of media coverage and has repercussions in politics"* [PA2]. Such prominent topics gain a certain weight in the perception of decisionmakers and may be considered for debate; nevertheless, in further discussions and in the decision-making process it is direct expertise that plays the major role.

5. Discussion

Based on interviews with experts from different groups this article analyses the respondents' attitudes towards science communication and their perceptions of scientific coverage in the mass media, focusing on materials science, a discipline hitherto neglected by media scholars. The data obtained from the semi-structured interviews revealed three main findings, which are briefly explored below.

5.1 Raising Awareness of Science

Arguments for enhancing the communication of science show variations across the three categories investigated here. Political actors advocate the information of members of society on scientific progress, emphasising the media as a channel for justifying the role of science in democratic societies (Franzen et al., 2012: 5). They relate the communication of research to the public trust in science, since political decisions, particularly those involving the allocation of taxpayers' funds for research, require legitimation and general acceptance.

Representatives of science and industry argue with more practical objectives, e.g. the promotion of their respective organizations and the creation of attention as well as the attraction of further benefits. These results yield support to the classification of Weingart and Joubert (2019). The political group has the public interest in mind, while the scientists and industry representatives are largely driven by self-interest.

While the interviewees agree on the need to strengthen the scientific literacy of the general public via science communication, the majority of respondents, i.e. those involved in research and holding leading positions, see the objective of science communication practiced by everybody as being rather difficult to achieve.

Nevertheless, research institutions should increase their efforts to implement science communication programmes, to identify suitable candidates and to provide them with ongoing support. Apart from the traditional mass media which this study focuses on, further channels and formats of communication might be employed.

Although the interviewees themselves did not indicate any frequent use of social media platforms, these channels might become an alternative to the traditional media and contribute to a broader dissemination of materials research. The number of scientists involved in public communication via the social media has increased; and there are quite a few reasons for this deveelopment (Collins et al., 2016). Using these platforms enables communicators to share their scientific results more easily. The same goes for obtaining information on funding opportunities, for connecting with other researchers and, in general, for enhancing their visibility (Côté and Darling, 2018). Apart from these academic benefits, they can directly reach non-scientific audiences alternativley to the other formats of self-mediated external communication (see 2 above Conceptual Framework). Such encounters are aimed at reinforcing the involvement of broad audiences in discussions about science, thus alowing for a dialogue between researchers and non-experts, as postulated by the dialogue model.

Another way of reaching out to the public is through formats of the participatory model such as the citizen science programmes. These approaches enable non-professional participants to become part of scientific projects and contribute to research mainly by collecting data on various subject matters (Fraisl et al., 2022). The field of materials might face challenges in adopting such initiatives, partly due to its inherent complexity and specialised work practices. Nevertheless, science organizations in this area should avail themselves of this oportunity and initiate outreach projects that allow for the involvement of members of the general public in knowledge production and, in this way, strengthen the collaboration between science and society.

5.2 Omnipresent but Unseen

Depending on their affiliation, the decisionmakers interviewed for this study use different sources of information. Among the sources mentioned, online or print newspapers serve to contextualise information (Kohring, 2005) or to validate knowledge already available and acquired through other channels.

Experts with a materials science affiliation agree that there is a paradoxical situation in the media coverage of this discipline. Although materials are indispensable for our life and valued as keys for growth and the development of a nation (Flemings and Cahn, 2000: 371), even more so in today's ecological crisis, this field receives little media attention,

attention that is disproportional to the assumed relevance to society. These actors assess the complexity of the field and the challenges of breaking it down in a clear and straightforward way for a general audience. Materials science often integrates multidisciplinary and interdisciplinary elements drawing on physics, engineering and chemistry and necessitates a differentiated approach. This multifacetness may contribute to the limited coverage of research results in this field, as the public often seeks simple and concise explanations, and journalists tend to prioritise topics that tie up with the public's existing knowledge base (Besley et al., 2013).

The claim of limited presence in the media landscape is based on the respondents' experience with different media, mainly the traditional ones. A content analysis of such media outlets could verify this assumption and provide another perspective on this matter.

To date, no analysis of media reporting on materials science is known to the author. However, when considering the coverage of related disciplines analysed by Summ and Volpers (2016), physics and engineering topics seem to receive significantly less attention in the German press compared to those of social sciences or medicine. Further insights come from nanotechnology, a field classified as an extension of materials science (Schummer, 2011). A compartive study shows that over a six-year period this topic received five times less coverage than nuclear energy (Cacciatore et al., 2012). Although the results do not refer directly to materials science, they appear to corroborate the perception of low media coverage noted by our interviewees.

Another phenomenon discussed in the interviews is the hype around certain scientific matters. The exaggeration of scientific results with the aim of enhancing political and social support for specific research topics may also have a negative effect, by dismissing risks and uncertainties (Roberson, 2020). Hype in the media is perceived by several respondents as ambivalent and therefore consistent with previous theoretical assumptions (Roberson, 2020). While the emphasis on the benefits of particular research in materials science might contribute to increasing the visibility and to financial resources becoming available, previous experience of hyped scientific topics, such as nanotechnology, shows that hyping may have a detrimental effect. People's faith in science is undermined since their expectations are not fulfilled.

Overall, the results suggest that the individuals interviewed for this study are critical with regard to media reporting on materials research. Journalists and media outlets are seen as being interested above all in creating audiences much to the detriment of a balanced and objective coverage. In this sense, the prominence that the media seek to give researchers or the scientific results of their work is not in line with the scientific culture and the commitment to objectivity, autonomy and detail (Franzen et al., 2012; Hartz and Chappell, 1997), a fact which is disapproved of by a majority of the respondents.

5.3 Media Exposure Might Be Beneficial but not Decisive

The role that media play for the respondents varies across the three categories of interviewees. Political actors perceive the media reports as a reflection of relevant societal issues and therefore tend to pay attention to them, especially when a topic gains media prominence. While the policymakers may attribute more salience to a scientific issue, this does not necessarily lead to decisions that align with the media's perspective or demands.

As indicated by the interview results, these actors have access to a wide range of information sources, like thematic seminars, reports on specific topics from academies of sciences or unions, think tanks and direct exchanges with scientists. These enable them to develop a comprehensive understanding of scientific issues, thus building the foundation for their decisions in the political sphere.

The science and industry representatives do not depend on mass media as a primary source of scientific news or expertise. Nor does media coverage exert an undue influence in the decisions they take on funding, collaborations or other activities. Scientific quality is the main criterion and media visibility is regarded as relevant only in exceptional cases, when reports draw attention to certain topics or research groups and emphasise science trends in society.

Some respondents assume that media coverage of science matters may have an impact or stronger impact even on other actors than on themselves. Political actors with their perceived lack of adequate expertise in scientific fields are expected to make more use of the media's contextualising function with regard to scientific issues, and this may consequently have an impact on their science-related decisions. This empirical evidence is in line with the "third person effect" (Davison, 1983) confirmed in earlier studies on media perceptions (Scheu et al., 2014).

In the context of decision-making routines, respondents underline the interdependence of the media with other factors like science, politics and society as a whole. Nanotechnology and hydrogen research are two topics related to materials science that are illustrative in this regard. Literature indicates that media coverage of new technologies can shape public perception (Scheufele and Lewenstein, 2005), amplifying the visibility of technological issues and shaping priorities. The narratives chosen by journalists, whether optimistic or alarmist, have an effect on how the public perceives the risks and benefits of such emerging technologies, impacting on their acceptance and the direction of their development (Scherer, 2023; Dudo et al., 2011). Over time, stakeholders have increasingly prioritised these topics, integrating them into research and political agendas. Recently the German government has developed a national hydrogen strategy as part of a broader energy transition plan, for instance, coupled with increased funding for hydrogen research and development. Nevertheless, such decisions cannot only be attributed to intense media coverage. Decision-making at leadership level is ultimately basen on a complex interplay of factors, with media acting as one contributing force within a larger network of influences.

Authors of other studies on perceived media logic with decisionmakers from academia and politics reached similar conclusions. Scheu et al. (2014) found that these actors recongnise the role of mass media in reaching public attention and putting topics on the political agenda. They acknowledge the supremacy of research quality over media publicity, when it comes to decision-making however. These insights stress that our findings are not standalone and could be generalised to similar samples.

6. Final Remarks and Limitations

Although the experts interviewed generally share many of conceptions on the three research questions, it can be concluded that their affiliations and roles in their respective organisations are the catalysts for the perceived divergences in opinions. The findings suggest that political and administrative actors, as representatives of the general public, be they elected or appointed officials, are more committed to justifying their decisions towards the people. These actors accord an important role to the press, as the media are seen to reflect public opinion and relevant issues that are of interest to society as a whole. On the other hand, science and industry representatives are concerned with the objective promulgation of knowledge and technological developments which do not require the direct involvement of the non-scientific community, at least not in the early stages of the process.

The method of qualitative interviews proved its suitability and offered information on specific situations in the professional context of the experts. With regard to the explorative aim of the interviews, these provide first insights into the views of decisionmakers about the communication of research; they show their perceptions and evaluations of media coverage on materials research and the impact media visibility has in science-related decisions. Additionally, the findings lead us to reflect on the reasons for research dissemination to a broad audience at a time when actors from different communities intensify their calls for more engagement of scientists with the public.

There clearly is a need for tailored communication strategies that address both the complex nature of materials research and the varied backgrounds of the target audiences. While media is seen as deficient in fulfilling this obligation to the satisfaction of the respondents, the scientists may take this task in their hands and reach out to the lay audiences by self-mediated communication. Independently of the channels used for public engagement, the stakeholders involved are responsible for providing the necessary framework and support this process. Since time is a determinant in the scientists' willingness to public engagement (Besley et al., 2018), employing organizations can step in to handle the organizational tasks related to the communication process and reduce this way the time burden on researchers. Futhermore, they should be guided during this outreach process, until a certain confidence in these activities is achieved. On the other hand, scientific institutions should be motivated to create institutional policies for science communication and integrate this component into their routine activities.

Apart from these results and implications, this study also presents certain limitations.

First, individuals with specific characteristics were selected for this study; and, as for the qualitative approach, the study covers only a small number of respondents. Holding leading positions and having decision-making authority in their professional field were the prerequisites for approaching potential respondents. While such criteria were necessary to allow an in-depth analysis of the experiences and perspectives of experts, they also limited the sample size. For further research, this problem can be addressed by using a standardised survey, which would require less time to complete and could be distributed more easily among a larger target population. Although this method limits the depth of the data, it increases the quantity of responses, thus allowing for an improved level of generalisation of the conclusions.

Second, the findings reflect a snapshot taken at a time when science communication was a major issue in the public discourse, namely during the Covid-19 pandemic. The respondents provided several examples from ongoing debates on the role of expert opinions in political decision-making, on the impact of the media on these decisions and the public trust in science, particularly issues that gained prominence during the pandemic. This can be seen as a unique record of reactions and perceptions in an extraordinary situation, but it may also alter the views on science coverage and enhance the intensity of the perceptions, particularly regarding the impact of research dissemination. It would therefore be useful to validate and expand these thought patterns by means of additional research methods and at a later date.

Another aspect that deserves further examination is the media coverage of materials science. Respondents of this study claim that this discipline is underrepresented compared to other scientific fields. While their perspective is informed, a content analysis of media coverage is necessary to validate the interview findings and give an accurate picture of how materials science is portrayed in the media.

Despite the acknowledged need for further research, this study provides first insights into the nuanced perceptions of decisionmakers regarding the communication of research and the role of media in shaping public opinions on materials science. Understanding these perspectives is useful for the materials science community, as they stress the responsibility of its members to step forward and ensure that accurate and reliable scientific expertise is made accessible to a broader audience.

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