The Impact of Communicating Advocacy and Scientific Uncertainty on a Scientist's Trustworthiness

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Abstract A central aspect of scientific knowledge is scientific uncertainty. When scientists touch upon political issues, there are two contrary expectations: One is that scientists communicate in a straightforward manner and give a direct, concrete suggestion. The other is that they communicate in a way that carefully considers the pros and cons as well as the current state of (non-) knowledge. This 2x2 experimental study investigated how disclosing scientific uncertainty affects the perceived trustworthiness of a scientist when they express either their motive to inform or their motive to advocate. All participants ($N = 503$) read an interview with a scientist about the usefulness of further vaccinations against COVID-19. In the interview, uncertainty was explicitly addressed (vs. not). Furthermore, the scientist either disclosed their motive to advocate or their motive to merely inform about research results. Results showed that the scientist was perceived as more trustworthy (i. e., having more expertise, integrity, and benevolence) when they communicated uncertainty than when they did not. However, contrary to our expectations, the effect of the scientist's expressed motive to advocate (vs. to inform) on trustworthiness did not depend on whether uncertainty was explicitly addressed or not.

Keywords advocacy communication, COVID-19 pandemic (vaccination), political/politicized issues, science communication, scientific uncertainty, trustworthiness

1 Introduction

Scientific knowledge is culturally acknowledged to serve as an epistemic authority, providing the currently best available knowledge for personal and public decision-making (Douglas 2009). During the COVID-19 pandemic, this high expectation on science was thrust into the public spotlight (Abdool Karim 2022). Scientific findings were of immediate relevance and often fed directly into policymaking. Scientific experts were not only consulted to provide formal advice to governments, but they were also frequently asked to informally present their views on current pandemic developments and policies to the media (Leidecker-Sandmann et al. 2022). At the same time, however, it became apparent that scientific uncertainty – in the simplest terms a lack of knowledge or a disagreement over knowledge (Friedman/Dunwoody/Rogers 1999) – is a core characteristic of scientific knowledge (Kampourakis/McCain 2020). Particularly in the beginning of the pandemic in 2020, a mere lack of knowledge about the novel Sars-Cov-2 virus was present. Yet, even as the pandemic progressed and important gaps in knowledge were closed, new questions continuously occurred, and uncertainties remained. For example, although effective vaccines against COVID-19 were developed, it was an open

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question how they have to be adapted in the future and how often and at what time intervals people should get vaccinated in the time ahead.

While disclosing scientific uncertainty is a common norm in the inner-scientific communication and characterizes a scientific discourse style (Zehr 1999), it is equally imperative outside of scientific circles (Friedman/Dunwoody/Rogers 1999). This is because communicating scientific uncertainty is necessary to provide a basis for adequate decision-making in liberal democracies (Nielsen/Sørensen 2017, Blastland et al. 2020), while concealing scientific uncertainty may lead to ill-decision-making (Fischhoff 2012). Furthermore, the disclosure of scientific uncertainty may also be assessed as an indicator of a communicator's trustworthiness. Namely, the public disclosure of scientific uncertainty may strengthen a scientist's perceived trustworthiness as it signals honest as well as objective intentions and hints to an awareness about the limits of experts' knowledge (Steijaert/Schaap/Riet 2020).

Notably, previous research has mostly scrutinized the effects of communicating scientific uncertainty when scientists are merely aiming to inform about scientific findings – that is, when they do not take a stance regarding any policy option, and therefore expose informative and not persuasive intentions. However, this neglects the circumstance that scientists are also often asked to advocate more with regard to climate- or COVID-19-related questions (Cologna et al. 2021, Wissenschaft im Dialog/Kantar 2021) – that is, to show an "active, covert, or inadvertent support of a particular policy or class of policies" (Lackey 2007: 13). A question that remains is therefore, how the communication of scientific uncertainty affects scientists' trustworthiness when they also express their motive to advocate for specific policy options. Assumingly, scientists who advocate may experience a loss of trustworthiness when they fail to disclose prevailing scientific uncertainty and show persuasive communication behavior similar to any other stakeholder group (Kienhues/Jucks/Bromme 2020). At the same time, it may be argued that scientists who express their motive to advocate, but are transparent about scientific uncertainty will be seen as trustworthy as they are intending to provide a solution without any persuasive agenda. Hence, some scholars suggest that scientists should openly disclose uncertainties, especially when communicating publicly about research results that are related to political issues (Blastland et al. 2020, Paek/Hove 2020).

In the present study, first, it is tested whether the explicit communication of scientific uncertainty (as opposed to no explicit communication of scientific uncertainty) does indeed strengthen the ascribed trustworthiness of a scientist. Second, it is scrutinized whether the effect of expressing one's motive to advocate (vs. to inform) on the ascribed trustworthiness of a scientist depends on whether the scientist explicitly communicates scientific uncertainty or not.

2 Theoretical and empirical background

2.1 Uncertainty communication and perceived trustworthiness

Reflections upon uncertainty and trust are closely intertwined. In the absence of uncertainty, there would be no need for trust; recipients could blindly believe what the most achieved experts say or strive for full understanding of the science themselves. However, the integral presence of scientific uncertainty demands that laypeople judge an expert's trustworthiness. Technically, scientific uncertainty may arise at every stage of the research process (Walker 1991) and derives from various sources, such as lack of knowledge, flawed use of

research assumptions, measurement inadequacies, or expert disagreement (van der Bles et al. 2019).

Because scientific knowledge is not only inherently uncertain but is also highly complex and specialized (Bromme/Goldman 2014), it follows that laypeople's understanding of science is bounded (Bromme/Goldman 2014). That is, it is neither reasonable nor feasible for laypeople to strive for a full understanding of scientific topics themselves to make first-hand evaluations – for example by analyzing original research data (e. g., "What is true?"). Instead, it is more practicable for laypeople to rely on second-hand evaluations by assessing the trustworthiness of a source (e. g., "Whom to trust?") (Hendriks/Kienhues/Bromme 2016c). Yet, depending on external expertise also comes with the risk of being misinformed. Such a vulnerability is constituent for trust (Mayer/Davis/Schoorman 1995) and, hence, also demands a "leap of faith" (Engdahl/Lidskog 2014: 708). Importantly, this does not mean people blindly follow an expert's opinion; instead, people appear to be vigilant (Sperber et al. 2010) and make informed trustworthiness judgements (Bromme 2020). As has been argued theoretically and supported by empirical studies, this entails assessing a source's competence and pertinence (expertise) as well as judging non-epistemic characteristics (Wilholt 2013). For example, whether the source appears transparent and honest (integrity) and whether the source is perceived to harbor good intentions toward the public (benevolence) (Hendriks/Kienhues/Bromme 2015).

2.1.1 Mixed effects of uncertainty communication on trustworthiness

Disclosing scientific uncertainty presumably influences how a judgement of trustworthiness may be made. This is because portraying uncertainty does not simply mean that information is added, but it shapes "the meanings, interpretations, implications, and schema activated regarding the ambiguity, imprecision, and confidence of the message and the messenger" (Gustafson/Rice 2020: 4).

Empirical results on how the communication of scientific uncertainty affects the perceived trustworthiness of a scientist appear mixed. This may be because scholars have investigated the effects of various features of uncertainty communication, such as varying concerning issues (Jensen/Hurley 2012, Gustafson/Rice 2019) or different portrayals of uncertainty (Gustafson/Rice 2020). With specific reference to uncertainty communication during the COVID-19 pandemic, one scoping review showed the following (Ratcliff/Wicke/Harvill 2022): the communication of ambiguity and inconsistency of COVID-19 related information mostly resulted in lower trustworthiness ratings ascribed to scientists and health officials (Kreps/Kriner 2020, Gretton et al. 2021, Simonovic/Taber 2022), while none of the investigated studies detected a corresponding positive effect. Furthermore, two experimental studies did not show any effect of uncertainty communication on trustworthiness (Janssen/Hendriks/Jucks 2021, Kelp/Witt/Sivakumar 2022). When discussing these results, Ratcliff/Wicke/Harvill (2022) pointed out that the negative effects of uncertainty communication on trustworthiness tend to occur when uncertainty is portrayed as consensus uncertainty (i. e., as a controversy among experts or evidence), which has been found to lead to lower credibility ratings as compared to other portrayals of uncertainty (for an overview, cf. Gustafson/Rice 2020). Reviews generally dealing with the effects of conveying uncertainty in public science communication outside the COVID-19 pandemic, however, concluded that disclosing uncertainty does not necessarily have detrimental effects on scientists' perceived trustworthiness: communicating uncertainty has either resulted in more positive source evaluations or was not found to have a

significant effect, while negative effects have rarely been observed (van der Bles et al. 2019, Gustafson/Rice 2020).

2.1.2 Why uncertainty communication may strengthen a scientist's trustworthiness

A communicator's language style generally is an important cue for assessing the trustworthiness of a source (König/Jucks 2019). When the source applies a self-critical style of communication (e. g., the communication of uncertainty), this might be particularly well respected and expected in the field of science communication (Jensen 2008), as it corresponds to "what it means to speak as a scientist" (Zehr 2017: 4). However, scientists themselves generally report that they are vigilant about disclosing uncertainty, as they worry about fostering public criticism toward their field of research (Post/Maier 2016) or fear that their results could be misinterpreted and exploited by interest groups (Post 2016). Similarly, some scholars illustrate the potential risks of publicly disclosing uncertainties, as doing so can be used to give rise to the politicization of uncertainty (Oreskes/Conway 2011, Bolsen/Druckman 2015, Simon 2020). Others further argue that it may have detrimental effects on scientists' trustworthiness when science fails to do its part in providing reliable and clear answers to important societal questions (Osman/Heath/Löfstedt 2018).

While these potential constraints show that scientists who transparently lay out uncertainties make themselves more open to critique, this self-chosen vulnerability may be precisely what makes a scientist appear trustworthy. Presumably, such is particularly the case for the two dimensions of trustworthiness integrity and benevolence. This assumption is in line with the "stealing thunder effect" (Williams/Bourgeois/Croyle 1993), which suggests that sources of information are perceived as more credible when they themselves preemptively reveal possible counterarguments before such arguments could be used against them. Hendriks/Kienhues/Bromme (2016a, 2016b) observed that a scientist was perceived as more benevolent and as having more integrity when they admitted a flaw or addressed ethical considerations about their own study than when this was done by an unaffiliated expert. Similarly, Jensen (2008) found that a primary scientist was perceived as more trustworthy (here, trustworthiness did not include the dimension of expertise) when discourse-based hedges (i. e., sentences including limitations of the study's results) were attributed to them in news coverage of cancer research than when no hedging was included; yet, such an effect did not occur when the hedging was attributed to an unaffiliated researcher.

When experts make themselves vulnerable by revealing uncertainties in their claims, this might shape how the communicative intentions of a communicator are perceived (cf. intentionalist models; Krauss/Fussell 1996). For instance, according to the humility heuristic, it is reasonable to argue that people consider the disclosure of uncertainty itself to be an indicator that the communicator wants to avert claiming something wrong and to instead provide the most adequate information (Skipper 2021). Hence, a scientist who expresses uncertainty might reflect informative but not persuasive intentions. Steijaert/Schaap/Riet (2020) showed that when a communicator disclosed uncertainty, they were less likely to be attributed with communicator bias (i. e., the communicator would be expected to convey a message that is not truthful). This resulted in higher trustworthiness ascriptions than when no uncertainty was communicated. Similarly, Altenmüller/Nuding/Gollwitzer (2021) observed that while the expression of self-criticism did not harm a scientist's reputation, the disclosure of a lack of self-criticism did.

Communicating scientific uncertainty might not only indicate vulnerability and point to honest intentions, but it may also be perceived as an accurate reflection of scientists' knowledge and its limits (Tenney et al. 2007). This may be particularly relevant for assessing a source's expertise. Tenney et al. (2007) found that even though a confident witness is generally deemed as credible, they lose more credibility than an uncertain witness if – in hindsight – it turns out they were mistaken. Furthermore, Kreps/Kriner (2020) argued that while downplaying uncertainty in model projections can foster public trust in science in the short term, on the long term the reversal of such projections may lead to an erosion of public trust in science. Based on the considerations from above, we formulated the following hypothesis:

> ***1 Hypothesis (main effect):*** A scientist who communicates uncertainty is perceived as more trustworthy (having more expertise, integrity, and benevolence) than a scientist who does not explicitly communicate uncertainty.

2.2 On the interplay between uncertainty communication and advocacy

When scientists touch upon political issues, they might not only be expected to carefully consider the current status of knowledge and limitations, but also to make direct and concrete suggestions. Discussions have long focused on what role (if any) scientific experts ought to play within the science-policy interface (Pielke 2007, Spruijt et al. 2014) and whether they should even explicitly engage in policy advocacy at all. Namely, some scholars suggested that science (allegedly objective) and advocacy (subjective) are fundamentally incompatible (Ruggiero 2010) and, thus, lead to a loss of scientists' credibility (Lackey 2007). Notably, these discussions have mostly been debated from a theoretical and a normative perspective (Nelson/Vucetich 2009, Goodwin 2012).

Empirical studies indicate, however, that the effects of advocacy communication on trustworthiness cannot bluntly be narrowed down to one simple effect. Thus, whether advocacy communication *generally* does harm or good may not be the meaningful question to ask. Instead, interactions with various other factors may be worthwhile to consider. For instance, Palm/Bolsen/Kingsland (2020) found that while a scientist and an undefined source of information are perceived as less trustworthy when recommending *individual* behavioral changes against climate change, the explicit communication of policy recommendations did not affect participants' ratings of trustworthiness. In a similar vein, Cologna et al. (2021) did also not find that a scientist who openly supports climate policies and protests calling for climate action is perceived as less credible than a scientist who explicitly states that they do not. While the experiment by Cologna et al. (2021) referred to rather unspecific policies (e. g., "certain climate policies") and lacked a control for the public support of the suggested policies, a study by Kotcher et al. (2017) stressed that advocating for very specific policy options does not harm a scientist's credibility. Nonetheless, this depends on the popularity of the specific policy that is being suggested and is moderated by participants' political orientation (Beall et al. 2017). Advocating for a policy that is broadly supported by the public might, in fact, even increase a scientist's credibility ascription (Beall et al. 2017).

Similarly, how a scientist's expressed motive to advocate impacts their trustworthiness may be influenced by the fact whether they explicitly communicate uncertainty or not. While Rabinovich/Morton/Birney (2012) found that the fit between recipients' expected motives (information vs. persuasion) and the actual message style (informative vs. persuasive) resulted

in higher trustworthiness ratings, the following line of reasoning could also be assumed with reference to Eagly/Wood/Chaiken (1978): when a scientist reveals their motive to advocate but does not explicitly communicate uncertainty, they are in fact communicating adverse to a typical scientific discourse style (Zehr 1999). Hence, their intentions might be perceived as clearly more persuasive and calculating than the ones of a scientist who merely intends to inform about current research results. This might then impact the trustworthiness of the scientist negatively. Yet, by openly communicating scientific uncertainty when expressing their motive to advocate, a scientist might convey that they are not attempting to persuade but that they are honestly intending to provide the best available solution for a political question. This positive expectancy violation might then lead to higher ratings of trustworthiness. From the fact that scientists are increasingly asked to take a stand in socio-political debates and to propose solutions (Cologna et al. 2021, Wissenschaft im Dialog/Kantar 2021) the following may also be claimed: a scientist who communicates scientific uncertainty and at the same time expresses their motive to advocate may be perceived as more trustworthy than a scientist who is only motivated to inform and communicates uncertainty, but in this way also does not show their interest to stand up for the good of society. Such considerations might be mostly apt regarding integrity and benevolence ratings.

In line with this reasoning, no main effect of the expressed motive to engage in public science communication (to inform vs. to advocate) is expected. Instead, we expect an interaction between the communication of scientific uncertainty and the expressed motive:

> ***2a Hypothesis (interaction effect):*** We expect the motive to advocate to impact a scientist's trustworthiness ratings (having more integrity and benevolence) positively when uncertainty is explicitly communicated, and negatively when uncertainty is not explicitly communicated.

While hypothesis 2a refers specifically to integrity and benevolence as two dimensions of trustworthiness (Hendriks/Kienhues/Bromme 2015), there is a lack of empirical evidence that allows the formulation of a direct hypothesis on expertise. Therefore, we leave it as open research questions:

> ***2b Research question:*** How is a scientist's perceived expertise affected when they disclose their motive to advocate (vs. to inform)?

> ***2c Research question:*** Does the effect of disclosing their motive to advocate on perceived expertise depend on whether a scientist explicitly communicates uncertainty or does not do so?

3 The present study

In the present study we, first, aimed to test whether the communication of scientific uncertainty strengthens the ascribed trustworthiness (expertise, integrity, benevolence) of a scientist. Second, we investigated whether the effect of expressing one's motive to advocate (vs. to inform) on the ascribed trustworthiness of a scientist depends on whether the scientist explicitly communicates scientific uncertainty or not.

To test the hypotheses formulated above, we conducted a 2 (explicit communication of uncertainty: yes vs. no) x 2 (motive to engage in public science communication: to inform vs. to advocate) between-subject experimental design. Put differently, this experimental design

provides insights into how each of the two independent variables (1) explicit communication of uncertainty (yes vs. no) and (2) motive to engage in public science communication (to inform vs. to advocate) as well as their interactions impact the dependent variables. Furthermore, participants' prior attitudes toward COVID-19 vaccinations were accounted for as a covariate, as past research has shown that participants' topic-specific prior attitudes have an overall impact on their trustworthiness ratings (Janssen/Hendriks/Jucks 2021, Hendriks/Janssen/Jucks 2022).

In the experimental study, all participants were asked to read a short fictitious but evidence-based informational text. The text was presented in the form of a newspaper interview with a scientist about further COVID-19 vaccinations and future vaccine adjustments. First, in the interview, we varied whether or not the researcher explicitly communicates the uncertainty about the available scientific evidence (explicit communication of scientific uncertainty: yes vs. no). In the uncertainty condition, uncertainty was communicated by mentioning limitations and caveats of the available scientific knowledge. In the no uncertainty condition, no information about the uncertainty or certainty of scientific information was mentioned. Second, we manipulated whether the researcher expressed their motive to engage in public science communication to provide information or to publicly advocate (motive to engage in public science communication: to inform vs. to advocate). An overview of experimental materials can be seen in the Appendix. The present study was preregistered (osf.io/psy6k). A full overview of data, analyses, materials and items used, as well as additional results can be found online (osf.io/d8pgk).

4 Methods

4.1 Data acquisition and sample description

Data acquisition took place from the 19th to the 20th of May 2022 and was done via the online platform Prolific (prolific.co) approaching a German sample. At that time in Germany, there was no official recommendation from the Standing Committee on Vaccination for the vast majority of the population to be vaccinated a fourth time against COVID-19, even though such a vaccination recommendation was made, for example, for people over 70 years of age (Robert Koch Institut 2022).

On average, participants took 10 minutes and 16 seconds to complete the experiment (*SD* = 5 minutes and 6 seconds) and were rewarded with 3.50 Euros for their participation. In total, *N* = 547 participants took part in the experiment. After applying exclusion criteria, the final sample included *N* = 503 participants (33 participants were excluded because they had not received at least one vaccination against COVID-19[1], 6 participants were excluded because they took under 4 minutes to complete the survey, and 5 people were excluded because they took longer than 35 minutes to complete the survey). On average, participants were *M* = 29.7 years old (*SD* = 9.3). Of the sample, 54.5 % was male, while 43.5 % was female and 1.6 % diverse (2 participants did not disclose their gender). Most participants held a university degree (53.7 %), while 28.2 % had an advanced technical college or higher education entrance, 9.5 % had successfully finished a vocational training, 8.4 % held a secondary or intermediate school certificate, and 1 person finished school without qualification. The majority of the sam-

[1] We decide to exclude these participants as we expected them to be generally characterized by an inclination toward science denial (Jylhä et al. 2022).

ple spoke German as their native language (84.1 %), while 15.9 % claimed that German was not their native language. Of those, 10.0 % had been speaking German since childhood, and the rest has been speaking German on average for 9.4 years (*SD* = 8.2). Answers provided to the open-ended questions also assured us that all participants were proficient German speakers.

4.2 Procedure

EFS Unipark was applied to create an online survey. First, participants were informed about the study's purpose and procedure. Second, participants were asked about their attitudes toward vaccinations against COVID-19. Afterward, participants were to read a short text in which a scientist was interviewed about the effectiveness of further and possibly adjusted COVID-19 vaccines. After reading the text, participants were asked to answer several items regarding dependent and descriptive variables. At the end, participants provided demographic information about themselves and were debriefed.

4.3 Measures

Of main interest were the effects regarding the three dimensions of trustworthiness, i. e., expertise, integrity, and benevolence as well as participants' prior attitudes toward COVID-19 vaccines. In order to inform our main findings further, we additionally included measurements on participants' perceived credibility of the scientist's future research results (Altenmüller/Nuding/Gollwitzer 2021), and looked at how the two independent factors impact participants' perceptions of the communicator's communication goals and attribution to scientific evidence and political views (Kotcher et al. 2017). Further details on these measurements and results can be found online (osf.io/d8pgk). Two qualitative items were not evaluated further for the purpose of this study.

4.3.1 Prior attitudes toward COVID-19 vaccinations

Participants' prior attitudes toward COVID-19 vaccinations were measured using three items (Cronbach's α = .96; scales from 1 = *do not agree at all* to 7 = *strongly agree*; e. g., *"In my opinion vaccinations against the coronavirus are important"*).

4.3.2 Manipulation checks

To check whether participants were able to correctly recognize the communication of uncertainty and the scientist's exposed motive to engage in public science communication, two manipulation checks were included. First, participants had to rate the statement "*In the interview, the scientist claims that the research results are tentative and uncertain*" with either a *yes* or *no.* Second, participants had to specify whether the scientist mostly saw their responsibility in informing about research results or to shape social decision-making processes ("*The scientist from the interview sees their task primarily in informing about research results/in helping to shape social decision-making processes*"). Participants who failed manipulation checks were *not* excluded from the sample as this may have distorted experimental findings, for example by leading to a confound of preexisting beliefs and experimental measurements (Varaine 2022).

4.3.3 Epistemic trustworthiness

The *Muenster Epistemic Trustworthiness Inventory* (METI; Hendriks/Kienhues/Bromme 2015) was used to measure how trustworthy the participants rated the communicating scientist to be. In total, the METI contains 14 pairs of opposing adjectives that have to be rated on a 7-point semantic differential reflecting three subscales: expertise (6 items; Cronbach's α = .95; e. g., *competent – incompetent*); integrity (4 items; Cronbach's α = .90; e. g., *fair – unfair*), and benevolence (4 items; Cronbach's α = .90; e. g., *responsible – irresponsible*). Each subscale was treated as a separate dependent variable, and for each one the arithmetic mean was calculated.

5 Results

We used SPSS (28) to conduct multiple analyses of covariance (ANCOVAs). The statistical model included (1) explicit communication of uncertainty (yes vs. no) and (2) motive to engage in public science communication (to inform vs. to advocate) as independent factors and (3) prior attitudes toward COVID-19 vaccinations as a covariate. Tests were two-tailed, and the alpha level was set at .05. We report η^2_p as effect size and interpret .01 as a small effect, .06 as a medium effect, and .14 as a large effect. For statistically significant covariates we further report Pearson's correlation coefficient to indicate the relationship between covariates and dependent variables. Means are provided in Table 1.

Table 1: Means and Standard Deviations for the Dependent Variables by Explicit Communication of Uncertainty (Yes vs. No) and Motive to Engage in Public Science Communication (to inform vs. to advocate)

Uncertainty communication	Yes		No	
Motive	To inform	To advocate	To inform	To advocate
Epistemic trustworthiness				
Expertise	5.90 (0.94)	5.65 (1.14)	5.14 (1.13)	5.22 (1.10)
Integrity	5.93 (0.95)	5.64 (1.12)	5.30 (1.11)	5.19 (1.04)
Benevolence	5.79 (0.99)	5.45 (1.19)	5.23 (1.14)	5.09 (1.06)

Note: Standard deviations are shown in brackets.

5.1 Descriptive Results

The four experimental groups were equally sampled with 124–128 participants in each condition. Groups did not differ in terms of age, gender, highest educational degree, or number of native speakers nor regarding their prior attitudes (all *p*-values ≥ .199).

Regarding manipulation checks, significantly more participants correctly recognized the communication of uncertainty in the experimental conditions in which uncertainty was communicated (235 out of 272), while significantly more participants correctly denied the presence of uncertainty communication in the experimental conditions in which no uncertainty was communicated (211 out of 231; $\chi^2(1) = 302.02$, $p < .001$, $V = .78$). The majority of participants also correctly recognized the scientist's motive to advocate (192 out of 197) and correctly recognized the scientist's motive to inform when this was experimentally manipulated (247 out of 306; $\chi^2(1) = 293.01$, $p < .001$, $V = .76$).

On average, participants held rather favorable attitudes toward vaccinations against COVID-19 (M = 6.4; SD = 1.1).

5.2 Ratings of epistemic trustworthiness

5.2.1 Summary of results

First, hypothesis 1 was confirmed. The scientist who explicitly communicated scientific uncertainty was evaluated with higher expertise, integrity and benevolence as opposed to a scientist who did not explicitly communicate scientific uncertainty.

Second, when the scientist expressed their motive to advocate for specific policy recommendations, they were ascribed less benevolence, but it did not affect how much expertise or integrity was ascribed to the scientist. Regarding hypothesis 2a (and research question 2b and 2c), the disclosure of the scientist motive to advocate (or to inform) on trustworthiness ratings was not dependent on whether the scientist explicitly communicated scientific uncertainty or not.

Third, it was shown that participants' prior attitudes toward COVID-19 vaccinations were positively related to their expertise, integrity, and benevolence ratings. This is, participants' topic-specific prior attitudes became significant as a covariate.

5.2.2 Results in detail

Expertise. Ascribed expertise ratings were significantly higher when the scientist communicated uncertainty than when they did not, $F(1, 498) = 39.97$; $p < .001$; $\eta^2_p = .07$. No other differences occurred, $p \geq .088$. More favorable prior attitudes corresponded with higher ratings of the scientist's expertise ($r = .13$).

Integrity. Ascribed integrity ratings were significantly higher when the scientist communicated uncertainty than when they did not, $F(1, 498) = 35.53$; $p < .001$; $\eta^2_p = .07$. No other differences occurred, $p \geq .050$. More favorable prior attitudes corresponded with higher ratings of the scientist's integrity ($r = .18$).

Benevolence. Ascribed benevolence ratings were significantly higher when the scientist communicated uncertainty than when they did not, $F(1, 498) = 24.79$; $p < .001$; $\eta^2_p = .05$. Benevolence ratings were perceived as significantly lower when the scientist expressed their motive to advocate than when they conveyed their motive to inform, $F(1, 498) = 5.11$; $p = .024$; $\eta^2_p = .01$. The interaction effect did not reach significance, $p = .327$. More favorable prior attitudes corresponded with higher ratings of the scientist's benevolence ($r = .21$).

6 Discussion

The present study investigated how the communication of scientific uncertainty affects the perceived trustworthiness of a scientist when the scientist either expresses their motive to inform or their motive to advocate. Results showed that communicating scientific uncertainty appears to strengthen a scientist's trustworthiness (expertise, integrity, benevolence). However, the effects of a scientist's expressed motive to advocate (vs. to inform) on trustworthiness ratings did not depend on the communication of uncertainty. *Independently* of whether uncertainty was or was not explicitly communicated, the disclosure of the scientist's motive to

advocate did not significantly affect the scientist's ascribed expertise and integrity, but it did lead to significantly lower benevolence ratings.

More specifically, in line with hypothesis 1, when the scientist disclosed uncertainty, they were perceived as having more expertise, integrity, and benevolence. Accordingly, additional results showed that the scientist's future research was judged as more credible when the scientist explicitly addressed scientific uncertainty than when this was not the case. Apart from the beneficial effects of uncertainty communication on trustworthiness that were observed in this study, it should be noted that the underlying mechanism for these effects cannot yet be fully explained. Additional analyses regarding the perception of communicative goals, however, indicate that the explicit communication of uncertainty shaped how the communicative goals of the scientist were perceived. This in turn may have affected trustworthiness ratings. The communicative intentions of the scientist were perceived as more informative and as less persuasive when they communicated scientific uncertainty than when they did not explicitly do so. Future studies could follow up on this and scrutinize how the perceived communicative motives of a scientist mediate the effects of uncertainty communication on trustworthiness (Steijaert/Schaap/Riet 2020). Notably, the manipulation of scientific uncertainty was rather explicit and direct, as the scientist, for example, clearly expressed that some claims needed to be qualified, or that some information was still lacking. Possibly, such explicit expression might have been viewed as an indicator of the scientist's humility, potentially leading to more positive trustworthiness judgements. To test this further, future studies could, as Altenmüller/Nuding/Gollwitzer (2021) did, control for communicator likability. Another approach could be to test whether it makes a difference when a scientist simply communicates uncertainty, for example lack of data, or whether they highlight that they themselves report limited knowledge about data (i. e., communicate intellectual humility; Porter et al. 2022).

With regard to hypothesis 2a (and research questions 2b and 2c), our data did not support our expectation that the effect of disclosing one's motive to advocate (vs. to inform) on trustworthiness depends on whether or not uncertainty is communicated. *Independently* of the communication of uncertainty, results showed that when the scientist expressed their motive to advocate, they were perceived as less benevolent than when they highlighted their motive to merely inform (small effect). Expertise and integrity ascriptions were not significantly affected by the scientist's expressed motive to engage in public science communication (to inform vs. to advocate). It was assumed that when a scientist "speaks up like a scientist", that is communicates uncertainty while advocating, this may result in a gain of trustworthiness, as this signals their honest engagement to find the best solution. However, even though additional results indicated that the scientist's claims were viewed as less shaped by their political views when they conveyed uncertainty, the disclosure of scientific uncertainty did not affect whether the scientist's statements were judged to be mainly influenced by the interpretation of scientific results. That is, the disclosure of scientific uncertainty might not have been seen as an indicator of scientificness, as we had assumed theoretically. Hence, it is possible that the expression of scientific uncertainty applied was not apt, or in itself not sufficient enough to convey that the scientist was acting according to scientific (e. g., disinterested) norms for the good of society.

Uncertainty can be conveyed through a variety of linguistic expressions (Janich 2020). Possibly, a different expression of scientific uncertainty, such as offering two-sided arguments, may indicate clearly that a scientist applies a reasoned consideration of information and takes various pieces of evidence into account. This may then also signal more strongly the scientist's honest engagement to provide the best solution possible (Mayweg-Paus/Jucks 2018, Hendriks/

Janssen/Jucks 2022). This impression may be enhanced by providing laypeople with additional information about uncertainty, for example, how it arose (Hendriks/Jucks 2020) and why considering scientific uncertainty is essential to provide a basis for informed decision-making. Future research could also investigate whether a more strongly expressed scientific discourse style (Thomm/Bromme 2012) influences the effects of the expressed motive to advocate (vs. to inform) on trustworthiness. This could be done by combining different indicators of scientific discourse features, such as using technical language (Thon/Jucks 2017, Zimmermann/Jucks 2018), referencing different sources of information (Thiebach/Mayweg-Paus/Jucks 2015), or applying a generally self-critical style of communication (Jensen 2008).

However, even though the communication of uncertainty was not found to influence the effects of the scientist's expressed motive on trustworthiness, it also did not harm ascribed expertise and integrity ratings when the scientist disclosed their motive to advocate. Yet, it did result in a small negative effect on benevolence ratings. This contrasts the findings by Cologna et al. (2021), who observed that a scientist is judged to be *more* benevolent when they openly support climate policies and call for climate protests (as opposed to explicitly not doing so). In order to find out more about the effect that communicating advocacy has on trustworthiness, future studies could replicate the study at hand by varying whether or not *concrete* advocacy statements are communicated (Kotcher et al. 2017). In addition, the concept of advocacy communication could be studied in a more nuanced way, for example, the effects of advocacy communication on trustworthiness may vary depending on the epistemic basis on which a recommendation is made (i. e., opinion-based vs. data-based) or with which affiliation a scientist is related to (i. e., political vs. scientific institution).

7 Limitations

The results of this study may be strongly topic and context specific, as a German sample was examined in the context of the German COVID-19 vaccination policy at a certain point of time in the COVID-19 pandemic. Such context may have influenced perceptions of uncertainty communication (Simmerling/Janich 2016) and how the expression of the scientist's motive was evaluated. This is because participants may have been more used to these factors in the context of the pandemic than they would have been in other thematic contexts. Similarly, Schrögel/Humm (2020) argue that empirical investigations as well as theoretical stances on the issue of policy advocacy have mostly referred to the field of climate change (communication) and to conservation science. In such contexts, it should be considered that political engagement may be rather anticipated than in other domains, since, for example, climate change is a highly politicized issue that has been put on the political agenda by the scientific community itself. The same could be argued for issues related to the COVID-19 pandemic, which were not only politicized quickly (Dunwoody 2020) but have also been characterized by a great amount of uncertainty.

Apart from the specific context in which the present study was conducted, the experimental materials addressed the specific issue of vaccinations against COVID-19. On the one hand, there is empirical evidence supporting our line of argumentation that transparency and uncertainty communication about vaccine efficacy can promote trustworthiness of public health officials (Petersen et al. 2021) and does not reduce vaccination intent (Kerr et al. 2021, Batteux et al. 2022). On the other hand, it should be kept in mind that vaccine communication is a sensitive issue as it is linked to quite a personal decision. This may pose special demands that

have to be taken into account (Penţa/Băban 2018, Brummernhenrich/Jucks 2019), such as for example people's prior vaccine attitudes (Kelp/Witt/Sivakumar 2022).

Furthermore, different to the representation of uncertainty communication in the present study, uncertainty communication often does not occur in the form of individual expressions, but through the various statements aggregated in an entire discourse (Simon 2020, Janich/Rhein/Simon 2023). Further research could refer to discourse analytic results of uncertainty communication using a more real-world approach. Lastly, text genre also limits the interpretation of results, as our study used a one-to-many communication setting (for a different communication setting cf. Lautenschläger/Rhein 2022).

8 Conclusion

Uncertainty is an integral part of the scientific endeavour and should not be omitted in the context of public science communication. This study clearly shows that *the lack of* hints to uncertainty negatively affects the perceived trustworthiness of the communicator. This is first and foremost a good message: including explicit hints to uncertainty can strengthen trustworthiness-evaluations. In the context of COVID-19-communication, the message might either be formulated the other way around: a scientist may experience a loss of ascribed expertise, integrity, and benevolence, if they do not point to the uncertainty of evidence. As our study used a 2x2 between-subject design, this lack of uncertainty communication can be interpreted as a direct effect. However, expressing the motive to advocate also showed a negative effect on a scientist's benevolence ratings, independently of whether uncertainty was communicated or not. Results on this second factor are not that straightforward. Future research might investigate how communicating one's own motives (to inform respectively "take a stance", Vaupotič/Kienhues/Jucks 2022) contributes to experts' trustworthiness.

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APPENDIX

Overview of original experimental materials

Note. The overview of the original experimental materials illustrates the experimental manipulations that were made in the experimental conditions: First, the scientist either expressed their motive to inform (underlined once) or their motive to advocate (underlined twice). Second, they either explicitly communicated scientific uncertainty (printed in bold in square brackets) or they did not. An English translation of all experimental materials is provided online (see osf.io/d8pgk).

Interview mit Wissenschaftlerin Prof. Quindt

Erste, zweite, dritte Impfung – und jetzt?

Prof. Quindt forscht zusammen mit ihrem Forschungsteam zu Coronavirus-Impfstoffen.
Die Wissenschaftlerin spricht öffentlich über ihre Forschung, um über den wissenschaftlichen Erkenntnisstand zu informieren. // um konkrete politische Forderungen abzuleiten. **[*Dabei thematisiert sie auch Punkte, die wissenschaftlich noch ungeklärt sind.*]**

Frage: Bringen angepasste Impfstoffe, also zum Beispiel Omikron-angepasste Impfstoffe, einen großen Zusatznutzen?
Prof. Quindt: Aus Laborstudien mit Affen und Mäusen lässt sich schließen, dass ein spezifischer Omikron-Impfstoff **[wahrscheinlich]** keinen großen Zusatznutzen gegenüber einem herkömmlichen Impfstoff hat. **[Es fehlen aber auch noch weitere Forschungsergebnisse, die eine endgültige Aussage ermöglichen.]**

Grundsätzlich ist es mir als Wissenschaftlerin auf jeden Fall wichtig, die Öffentlichkeit über diese fachlichen Themen zu informieren. // zur politischen Entscheidungsfindung beizutragen. Insofern möchte ich mich auch bei der Frage einbringen, ob und wann geimpft wird.

Frage: Wie schätzen Sie den Nutzen einer vierten Impfung ein?
Prof. Quindt: Anhand von großen Datensätzen aus Israel lässt sich ableiten, dass die vierte Impfung einen Zusatznutzen hat, aber dieser nicht besonders groß ist. [**Es ist aber unsicher, ob sich diese vorläufigen Ergebnisse auch langfristig genauso zeigen werden.**] Ich sehe es als meine Aufgabe an, solche Erkenntnisse mit der Öffentlichkeit zu teilen. // die meiner Meinung nach beste Handlungsempfehlung vorzuschlagen und zu unterstützen.

Frage: Möchten Sie unseren Lesern und Leserinnen noch etwas mitgeben?
Prof. Quindt: Es ist wichtig, dass wir aus der Wissenschaft die Erkenntnisse weitergeben und wir die Öffentlichkeit über Fachinhalte informieren. // auf Grundlage der Erkenntnisse klar Position beziehen und wir gesellschaftliche Entscheidungsprozesse aktiv mitgestalten. [**Die Tatsache, dass wissenschaftliche Erkenntnis immer auch mit Unsicherheit versehen ist, gehört unvermeidlich dazu.**]