# Does Intolerance of Uncertainty Influence People's Trust in Science?

Amber Sykes

S3766918

Department of Psychology, University of Groningen

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Supervisor: dr. Anne Marthe van der Bles

Second evaluator: dr. Marloes Huis

In collaboration with: Shea Casby, Leontina Runze, Alexandra Schmiezek and Milica Vucinic.
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**Abstract**

The COVID-19 pandemic has shown the relevance of effective science communication, including the inevitable uncertainty within science. It is widely assumed that trust in science would suffer from too much transparency about scientific uncertainty - yet this is not empirically evident. Building upon prior research, the current study dives into this topic by testing whether uncertainty communication and different communication sources influence people's levels of trust in scientific information about COVID-19. Further, it will be examined if the trait intolerance of uncertainty (IU) has an impact on trust. An online study ($N$ = 399) was conducted where participants read a text about booster shots of the COVID-19 vaccine, which included either uncertainty or not, and was attributed to one of three different sources (government, scientists, and scientists via. social media). Results indicated that even though participants perceived induced uncertainty, neither uncertainty communication nor differing sources influenced trust into the given information. Also, IU did not seem to have an effect. It is implied that trust is not negatively influenced by uncertainty communication, which would underline the notion establishing more openness and transparency of science.

*Keywords:* science communication, uncertainty, intolerance of uncertainty, trust, COVID-19 pandemic

## Does Intolerance of Uncertainty Influence People's Trust in Science?

Effective science communication is not to persuade but to inform and share knowledge in a transparent manner, so that a solid base for decision-making can be provided for the audience (Fischhoff & Scheufele, 2013). This involves communicating what is certain but also what is uncertain in science (Van der Bles, 2019). The relevance of effective science communication became evident in the ongoing COVID-19 pandemic. Since the coronavirus outbreak in September 2019, the pandemic has advanced globally – with consequences such as estimated 414,6 million cases of people being infected with the virus and 5,8 million consequent deaths worldwide in February 2022 (John Hopkins University, 2022). It remains uncertain how long the pandemic will go on and how extensive the consequences will be.

This uncertainty seems to be intensified by the increased exposure to misinformation, fake news, and conspiracy theories (Bavel et al., 2020). The question of how people should distinguish misinformation from credible sources seems to be increasingly prevalent. Given the uncertain circumstances, one might think that it seems unfavourable to educate the general audience about the uncertainty within scientific findings: It is widely assumed that more transparency around uncertainty in science decreases trust in scientific findings and scientists themselves (Roozenbeek, 2020). Building upon this assumption, it seems even less useful to fuel the pandemic-infused uncertainty, confusion, and mistrust with even more (scientific) uncertainty. On the other hand, to facilitate thorough decision-making for people, information should be provided transparently – including the uncertainty around that information.

Therefore, the present research aims to examine the effect of uncertainty communication on people's trust in COVID-19 information. Specifically, the effects of communication sources, comparing people's reactions to information communicated by the government, scientists, and scientists via. social media will be investigated. Additionally, individual differences in how people react to communicated uncertainty will be considered.

The present paper therefore focuses on one of those individual differences, namely, intolerance of uncertainty (IU). According to Buhr & Dugas (2002), IU is a construct that grasps the struggle with uncertainty, emerging from negative assumptions and expectations about this uncertainty. In consequence, perceived uncertainty elicits more negative reactions in people who are intolerant of uncertainty. It will be studied whether people with high intolerance of uncertainty react differently to communication of scientific uncertainty (about the coronavirus) compared to people who are more tolerant of uncertainty.

**Past Research on Science Communication**

Past research has examined ways to make science communication more effective. For science communication to be successful, the communicator needs to be perceived as credible by the audience – which involves being viewed as competent and trustworthy (Fiske & Dupree, 2014). How do people seem to perceive scientists and science communicators in that regard? In a study by Fiske & Dupree (2014), it was examined how the participants perceived people of several occupations: Scientists were viewed as being highly competent but not very warm. In other words, they are respected and acknowledged in their expertise but seem not very trustworthy. Fiske & Dupree (2014) highlighted trust to be a crucial factor for credibility, as trust influences the perception of the messages' validity as well as being a predictor for attention that is given to the communicator.

Blastland et al. (2020) also argue in favour of the notion that trust is an important factor, which can be established by transparency about the scientist' motivations and intentions. Here, openness about discordance between scientists as well as limitations and uncertainty of scientific findings can display truthful intentions of scientists. This implies that scientific uncertainty should be communicated as it is essential for building trust in scientists and demonstrates credibility and transparency of science. When reporting scientific findings, uncertainty around those can be well communicated by providing "numerical ranges with a

point estimate" of the findings (Van der Bles et al., 2020). Giving away those specific indicators of uncertainty, the public would have the possibility to form an opinion themselves on how much they think the uncertainty affects the credibility of the given statement.

**Current Communication of Scientific Uncertainty**

The current state of the communication of scientific uncertainty is that it is often not clearly shared with the general population (Fischhoff, 2012). This may have multiple reasons: It seems as it is often assumed that communicating uncertainty reduces trust in scientific findings (Roozenbeek, 2020). This assumption may have developed due to general knowledge of human preferences and behaviour: As summarized by Fischhoff (2012), it is feared that sharing uncertainty in science might lead to the impression of bad science as people generally seem to disapprove of uncertainty. Yet, the reluctance in communicating scientific uncertainty is not only based on the assumption that uncertainty communication reduces trust. According to Osman et al. (2018), it is also accompanied by perceived difficulty on the side of scientists to display uncertainty appropriately and comprehendible. He states that scientists struggle to find informative ways of communication as scientific uncertainty is an abstract concept. It is feared that misunderstandings may lead to biases in the general population.

To examine the prior mentioned assumption, that uncertainty communication reduces trust, Van der Bles et al. (2020) conducted a series of studies. Specifically, they examined whether trust in the number and communicator were impacted by differing forms of uncertainty communication (verbal vs. numerical expressions of uncertainty). The study's context was information about unemployment rate in the UK, current count of tigers in India, and the increasing temperature of the earth's surface. The results suggest that trust in this information does not seem to be affected as much by communicated uncertainty as assumed. Overall, the decrease in trust is small and primarily found when uncertainty is expressed verbally. According to the researchers, this might be explained by individual differences in

interpreting vague words that are commonly used when scientists communicate uncertainty verbally (like “estimated” or “about”). Further, the results indicated that while trust in the numbers decreased, trust in the communicating source did not. Meaning people did not seem to view the uncertainty around numbers as a lack of credibility of the communicators. However, in the research of Van der Bles et al. (2020), the source of the presented information was not explicitly specified; participants were asked about “people responsible for the numbers.”. Thus, it is not known yet if different sources, for example, the government or scientists, would change people’s trust in information.

The effects of uncertainty communication on trust might not only be determined by the communication approach and who the communicator is. They might also depend on the reaction of the recipient towards uncertainty generally. The global circumstances due to the COVID-19 pandemic make the existential aspects of life very uncertain. Dealing with this uncertainty in daily life for a prolonged period can be quite challenging, which becomes evident in the global decline of mental health during the pandemic (Taquet et al., 2021). One might assume this holds especially true for people who struggle with uncertainty. Thus, one can question whether those people respond differently, potentially stronger, to communicated uncertainty than people who struggle less with it. In the following, the concept of intolerance of uncertainty (IU) is introduced as it defines the struggle with uncertainty.

## Intolerance of Uncertainty

### *Definition and Development of the Construct*

According to Farias et al. (2021), IU is an internal, trait-like construct. It can be defined as a cognitive bias, which reflects “an individual’s dispositional incapacity to endure the aversive response triggered by the perceived absence of salient, key, or sufficient information, and sustained by the associated perception of uncertainty” (Carleton, 2016, p. 31). In more practical terms, people with a high intolerance of uncertainty perceive

ambiguous stimuli as more threatening when they cannot ensure safety for themselves. What follows are negative beliefs about uncertainty and its consequences (Dugas & Robichaud, 2007). Thus, IU negatively influences perception, interpretation, and behavior towards ambiguous and /or uncertain stimuli (Dugas et al., 2005). Formerly, the concept of IU was introduced in a clinical context as it was supposed to be a factor explaining the maintenance of generalized anxiety disorder (McEvoy et al., 2019). Recent evidence suggests that IU as an internal factor, can be generalized to not only anxiety disorders but to diverse psychopathology, as it has transdiagnostic properties (Gvozden et al., 2021).

Beyond the psychopathological scope, IU has also been linked to anxiety and worry in non-clinical samples (Dugas et al., 2005). In multiple studies, possible influential factors on worry like depression were controlled for and the association between IU, anxiety, and worry persisted (Dugas et al., 2005). This implies that IU is also influential in a non-clinical population, and it is therefore relevant to examine its consequences. Further, high levels of IU have been associated with biased recall and interpretation while processing information (Dugas et al., 2005). According to Dugas et al. (2005), participants with high IU perceive inconclusive information as far more threatening and interpret those significantly more negatively than participants with low IU. They concluded that information processing in people with high IU makes them more aware of possible negative outcomes - this greater availability of threatening information may bias interpretation, which in turn fosters worry and anxiety. Altogether, IU influences information processing and consequentially, anxiety.

### *Intolerance of Uncertainty in the COVID-19 Pandemic*

Research has examined IU during the COVID-19 pandemic, concluding that IU is a predictor of higher distress during the pandemic (Saulnier et al., 2021). Additionally, IU is associated with COVID-19 specific worries and maladaptive behaviors like catastrophizing and stockpiling (Saulnier et al., 2021). This implies that people with high IU seem more

severely affected by stressors of the COVID-19 pandemic. In a study by Gvozden et al. (2021), it was examined how IU and trust in political and health institutions influences fear of the coronavirus. The researchers hypothesized that trust in institutions would reduce the fear of the coronavirus and of the pandemic generally by reducing worry and fostering a sense of control. As predicted, the results reflected an indirect influence of IU via. worrying on the fear of the coronavirus (Gvozden et al., 2021). Interestingly, the variable 'trust in health institutions' impacted fear of the virus and consequences the most via. IU. This aligns well with earlier research stating that higher trust in institutions during threatening situations goes hand in hand with lower levels of fears and anxiety (Tateno & Yokoyama, 2013). Given the above-mentioned findings, one could argue that effects of more uncertainty on people with higher IU are associated with lower trust in institutions and thus, also lower trust in the information those institutions give away[1].

To conclude, evidence is given how impactful IU can be for anxiety and worry tendencies. If and how that in turn affects trust is relevant to examine as that could be considered in science communication – especially when uncertainty communication is carried out during uncertain times.

**The Present Research**

The present paper examines how the communication of uncertainty of scientific findings influences trust in information about booster vaccines against COVID-19 and in communicating sources, and whether this is different for people with high compared to low intolerance of uncertainty. Three hypotheses are investigated:

First, it is hypothesized that trust in the number and in the message will be lower when uncertainty is communicated compared to when it is absent, across sources and among all

[1] It should be mentioned that the study by Gvozden et al. (2021) was conducted in April 2020 and that the World Health Organization officially declared the pandemic on March 11, 2020. Thus, inference from the results now in February 2022, where the pandemic is still a global issue, might be of limited use as fear of the virus and the consequences of the pandemic possibly increased since April 2020.

participants. Here, it is further explored whether participants high in IU trust the message even less, leading to the second hypothesis: It is hypothesized that participants with high IU trust the message less when scientific uncertainty is communicated compared to when scientific uncertainty is absent from the message. Third, we are interested in comparing different sources of information. According to Fiske & Dupree (2014), scientists are usually more trusted than politicians, yet the current pandemic context, communication about COVID-19 is in many countries done both by politicians and governmental agencies, as well as scientists and scientific institutions connected to governments. Therefore, in this context these two categories (i.e. government vs scientists) might be blended together in the perception of the general public, so that there might be no difference in trust. Therefore, when comparing trust in the different sources that provide the message, in the present study it is hypothesized that trust in the government and scientists is similar across all participants.

The context of the study evolves around booster vaccines against COVID-19, where a message about the effectiveness of a booster shot is manipulated in two ways to measure changes in trust. First, information is presented with numerical and verbal uncertainty or without uncertainty. Second, information is provided by varying sources (the government, scientist, or scientists via. social media) to measure changes in trust. Here, social media as a communication source is part of the design because much of (scientific) communication takes place within social media (Pollett & Rivers, 2020). Thus, it is of interest if information by scientists on social media would be trusted differently compared to communication on traditional outlets. Yet, the current work will not examine the social media condition further given this topic falls outside of the scope of the present research.

## Method

### Participants

This study was conducted in the context of a Bachelor Thesis project at the Rijksuniversiteit Groningen. To determine the required sample size, a priori power calculation was performed by utilizing G*Power. According to the results, 251 participants were necessary to detect a medium effect size of 0.25 (assuming $\alpha = 0.05$ and power of 0.95). Based on this, it was decided to recruit at least 300 participants with Prolific and additionally, as many as possible by personal networking. Hence, the sample consists of 302 participants recruited with Prolific, who live in the Netherlands and speak Dutch as their mother tongue or fluently; they were paid £1.- (€1.19) for participation. 97 participants were recruited via. the network of the students who conducted their Bachelor thesis and snowball sampling. For those, participation was on a voluntary basis and there was no compensation given. After excluding 106 participants the final sample consisted of 399 respondents (211 females, 176 males, 10 other, $M_{Age} = 27.37$, $SD = 8.83$). The sample can be considered highly educated as the majority of participants (86.9%) have a bachelor's degree or a higher academic degree. Currently, 382 of the participants had their residency in the Netherlands while 17 participants had their residency in Germany. Of those, 306 participants have decided to carry out the experiment in Dutch, whereas 76 performed it in English and 17 in German.

**Research Design and Procedure**

The study consisted of a 2 (uncertainty: present vs. absent) x 3 (source: government vs. scientists vs. scientists via. social media) between-subjects experimental design. After approving to the informed consent form, participants were assigned randomly to one of the six experimental conditions, where they were asked to read a short report about the effectiveness of booster-shots of the COVID-19 vaccine. Here, the difference between the reports was uncertainty communication being present was vs. being absent from the message. Uncertainty was expressed verbally and numerically. This is observable in the following text, which participants read:

> *A recent report by [The Dutch Ministry of Health vs. Dutch Journal for Medical Science (NVMW) vs. Dutch Journal for Medical Science (@NVMWeng)] states that the protection against COVID-19 decreases over time after being vaccinated. This means that people are [might be] more susceptible to getting infected with the virus, though with less severe symptoms and a lower risk of hospitalization. A third vaccine dose, or "booster shot", [could] refreshes immunity to similar levels as when first fully vaccinated. With a booster shot of the Pfizer vaccine (Biontech) the effectiveness rate [may] increases to 95.6% [(with some uncertainty around this number: the estimate is expected to be between 89.3% to 98.6%))], which is equal to the effectiveness rate when first fully vaccinated. A boost in immunity is also expected for alternative brands of the COVID-19 vaccine.*

Even though the source was manipulated, the information and numbers about the effectiveness of the booster shot which participants were presented with were based on data provided by scientific sources (Pfizer, 2021). Further, the manipulated information and numbers were presented in a layout of respective sources to ensure ecological validity of the design. Further information of each condition on framing of the information and the layouts of sources providing those, can be found in Appendix A. After reading the text of the assigned condition, participants were asked to answer questions about the content of the text and personal questions. A debrief followed, where the function and ambition of the study was clarified. This study was approved by the Ethical Committee Psychology of the University of Groningen. The questionnaire was developed with the online survey software Qualtrics. Depending on the indicated residency, the questionnaire was adjusted to information of the respective government of that residency and adjusted according to the indicated language preference. Here, the materials were given in either Dutch, German, or English.

**Measures**

***Manipulation Check***

Two items served as a manipulation checks for the ability to comprehend the given information, the first being "What was the estimated effectiveness rate of the booster shot reported in the text? Please write down what you remember." (*Open-ended answer)* and the second being "Did the text imply uncertainty about this number?" *(Yes, No, I don't know, I don't remember*).

***Action Intentions***

The action intentions of participants were measured. Here, action intention was assessed with four items: First, with the question "If it were offered to you, how likely would you be to take a booster shot?" (*Not likely at all - Very likely, I already had one*). Then, with three statements where agreement with those was to be indicated: "After reading this text, I would recommend getting a booster shot to a friend.", "I always wear a face mask when it is institutionally recommended." and "I always adhere to the social distancing rules." (*Completely disagree - Completely agree*).

***Trust***

Based on Van der Bles et al. (2020), the key dependent variables of the present research were established by combining several items, given sufficiently high correlations between those. All items were measured on a 7-point Likert scale. *Perceived uncertainty* was formed by the items "To what extent do you think that this number is certain or uncertain?" (*Very uncertain – Very certain)* and "How much uncertainty do you think there is about this number?" (*No uncertainty at all – A lot of certainty*), $r = -.69$. *Trust in the number* was established by the items "How reliable do you think this number is?" (*Not reliably at all – Very reliable),* "How trustworthy do you think this number is?" (*Not trustworthy at all – Very trustworthy*) and "To what extent do you believe this number to be credible?" (*Not trustworthy at all – Very trustworthy)*, $\alpha = .94$. *Trust in the message* consists of the items

"How much do you trust the information about the efficacy of booster shots given in the message you have just read?" (*Not at all - Completely*) and "How reliable do you think the information about the efficacy of booster shots given in the message you have just read is?" (*Not reliable at all – Very reliable), r* = .84. *Trust in source* was assessed with "To what extent do you think the people who wrote this text are trustworthy?" (*Not trustworthy at all – Very trustworthy*) and "To what extent do you think the people who are responsible for the numbers about the effectiveness of the booster shot are trustworthy?" (*Not trustworthy at all – Very trustworthy*), *r* = .59.

***Intolerance of Uncertainty Scale***

In order to assess participants' intolerance of uncertainty, the Intolerance of Uncertainty Scale with 12 items (IUS-12) by Carleton's et al. (2007) was included. This scale consists of two factors called prospective and inhibitory IU, where the former expresses cognitive consequences of IU (such as the need for predictability) and the latter reflects behavioural consequences of IU (such as behavioural paralysis) (McEvoy, 2016). These factors are combined to a global factor, representing overall IU. The IUS-12 is accepted and widely used within IU research (Hong, 2015). Higher scores correspond to higher intolerance of uncertainty. The scale includes items such as "When it's time to act, uncertainty paralyses me." for assessing inhibitory IU and items such as "Uncertainty keeps me from living a full life" for prospective IU (see Appendix B for complete scale). Answers were rated on a 5-point Likert-type scale (1 = *Not at all characteristic of me*, 5 = *Very characteristic of me*). The IUS-12 has very good internal consistency (α = .88).

For the analyses, participants were divided into two groups, low and high IU based on their score of the IUS-12. Participants were assigned to the high IU group (*n* = 179) with scores above 33, including that score, and as low IU with scores below 33 (*n* = 177). This cut-off score was calculated based on the median score of the sample (*Median* = 33).

### *Psychological Distress*

General psychological distress of the participants over the past two weeks was measured with the PHQ-4 Scale by Khubchandani et al. (2021). The scale consists of items such as “Feeling nervous, anxious or on edge” and those being assessed on a 4-point Likert-type scale (1 = *Not at all*, 4 = *Almost every day*).

### *COVID-19 Measures*

First, perceived severity of COVID-19 was assessed with the item “Coronavirus is a serious infection for me to contract.” on a 7-point Likert-scale (1 = *Strongly disagree*, 7 = *Strongly agree*). Further, information about the current vaccination status was asked (*Yes*, *No*, *Prefer not to say).*

### *Demographics*

Participants were asked to indicate demographic characteristics, those being age, gender, and current employment status. Also, they were asked to indicate their socioeconomic status whereas there was no obligation to answer that and to answer a self-report item about their subjective social status.

### *Additional Measures*

The following measures were also assessed: feeling thermometers about the emotional state after reading the information as well as feelings towards certain groups of people as well as political and social attitudes towards the government of one’s current residency and social media related communication measures. As these fall outside of the scope of the present research, they will not be reported on in depth. Methodological details about those are provided in Appendix C.

## Results

### Preliminary Analysis

Within the process of data cleaning, participants were removed from further analysis due to varying reasons. Seven participants have not agreed to the informed consent form and 62 participants have not completing the experiment to a sufficient extent, where no answers on the key dependent variables was the reason to classify an assessment as non-sufficient. Thus, the final sample consists of 399 participants for the statistical analysis.

The independence of observations was given as participants were randomly allocated to conditions. The normality of the sample was examined with the aid of QQ-plots and the Shapiro-Wilk test. According to those, the data are non-normal: The QQ-plots had high deviation at the ends of the plot lines, which indicates high kurtosis. The Shapiro-Wilk tests were significant in both manipulations and all dependent variables, such as for the manipulation 'uncertainty communication being absent' on the dependent variable *perceived uncertainty* ($W(200) = .905$, $p < .001$). This indicates a violation of this assumption yet given the large sample and analysis of variance (ANOVA) being a robust technique, it was decided to perform the analyses as planned. To examine the homoscedasticity of the sample, the Levene's test was performed. Here, the only dependent variable *perceived uncertainty* manipulated by communicated uncertainty was significant ($F(1,397) = 3.98$, $p = .048$), which showed significant differences in error variance between the groups. There is reason to assume that this assumption is mildly violated. Yet, ANOVA remains robust against such violation when group sizes of the manipulations are roughly equally split, which is the case in the present study. Still, one must keep those violations in mind and be careful when interpreting the outcomes.

## Inferential Analysis

### *The Effects of Uncertainty Communication and Source*

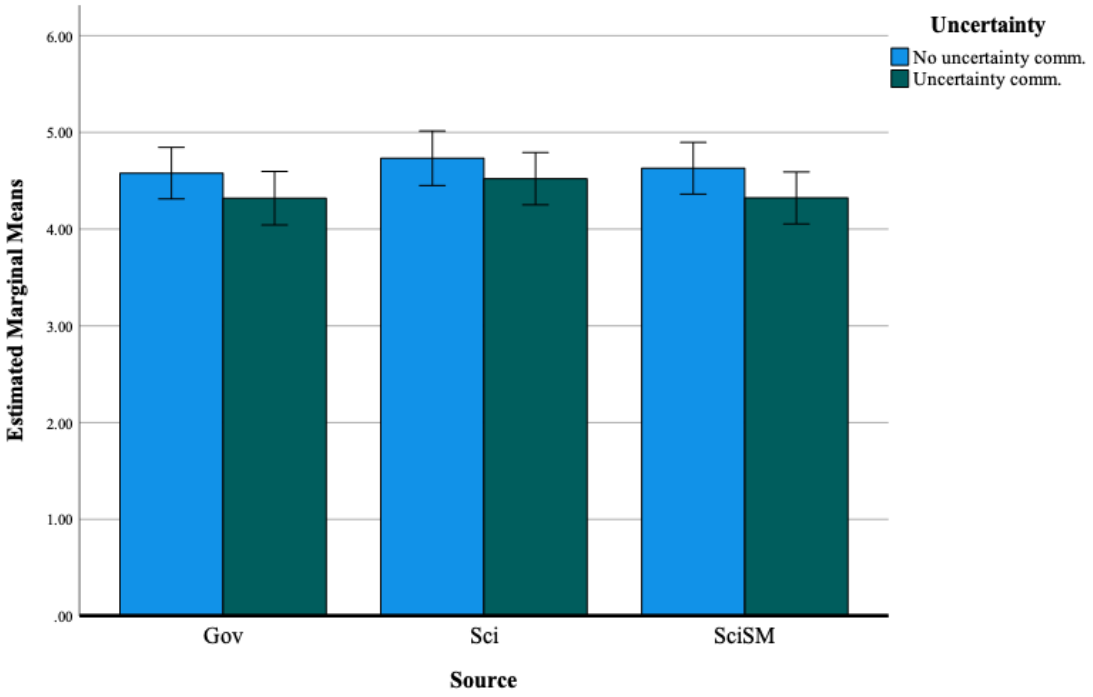
It was hypothesized that trust will be lower when uncertainty is communicated compared to when it is absent. Further, it was predicted that trust in the sources government

and scientists is similar across all participants. To examine those hypotheses, a series of univariate 2 (Uncertainty [not communicated, communicated]) x 3 (Source [Government, Scientists, Scientists on social media]) analyses of variance (ANOVA) were carried out.

For *perceived uncertainty,* this analysis resulted in a significant main effect of uncertainty ($F(2,387) = 5.26$, $p = .022$; partial $\eta 2 = .013$). Yet, the effect size is small. As displayed in Figure 1, when uncertainty was communicated by, for example, the government condition, participants perceived the number in the text to be more uncertain ($M = 4.32$, $SD = 1.28$) than when no uncertainty was communicated ($M = 4.58$, $SD = 1.09$). No main effect for source ($F(2,393) = .95$, $p = .389$) nor an interaction effect ($F(2,393) = .06$, $p = .942$) between the independent variables was found. These results imply that the uncertainty, which was aimed to be communicated, has been perceived by the participants, independent of source.

**Figure 1**

*Perceived uncertainty across sources and with communicated uncertainty either present or absent*

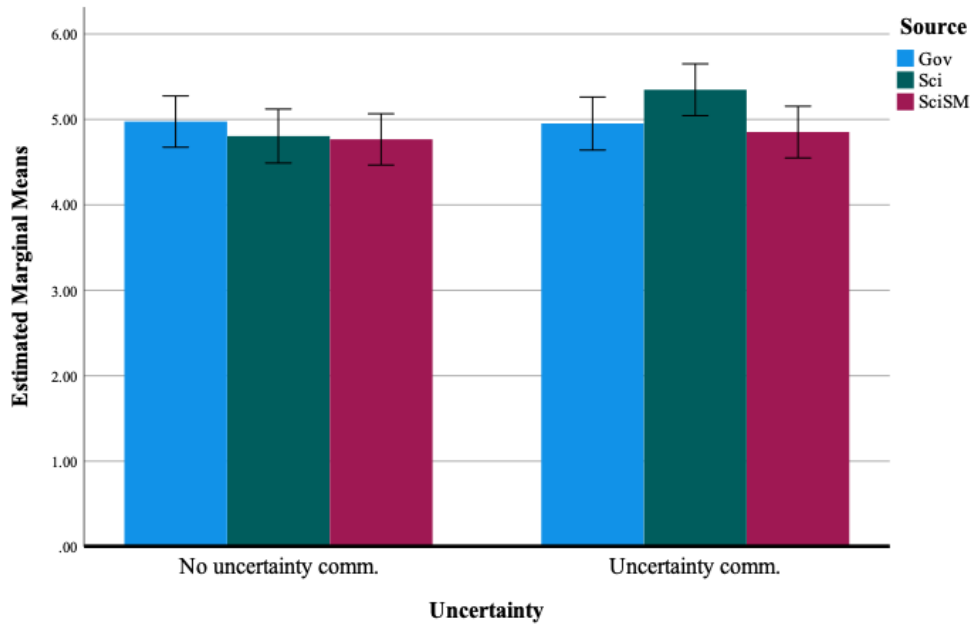


*Note.* Estimated marginal means of *perceived uncertainty* (Error bars show 95% CI).

For the dependent variable *trust in the number*, the ANOVA revealed no significant main effect of communicated uncertainty ($F(2,393) = 2.52$, $p = .113$) nor of source ($F(2,393) = 1.49$, $p = .226$). There was also no interaction effect between the two independent variables ($F(2,387) = 1.83$, $p = .162$). Thus, trust in the number itself does not seem to be affected by communicated uncertainty or by source. Even though no significant effect was found, it is worthy to mention a trend, which can be observed in Figure 2: Participants may trust the number more when it was communicated by scientists and uncertainty was present ($M = 4.64$, $SD = 1.07$), compared to when uncertainty was absent ($M = 4.39$, $SD = 1.18$). This would imply that scientific uncertainty communication by scientists is associated to more trust.

**Figure 2**

*Trust in the number across sources and with communicated uncertainty present and absent*




*Note.* Estimated marginal means of *trust in the number* (Error bars show standard errors).

To examine effects on the dependent variable *trust in the message*, the ANOVA showed no significant main effects neither for uncertainty ($F(2,393) = .79$, $p = .375$) nor for source ($F(2,393) = 1.34$, $p = .263$) were found. No interaction effect between those two variables ($F(2,393) = 1.50$, $p = .223$) was found either. This suggests that the experimental manipulations did not influence the trust in message. The priorly observed trend is also present in the analysis of this dependent variable: Participants trusted the message more when it was communicated by scientists and uncertainty was communicated ($M = 5.10$, $SD = 1.26$), compared to when uncertainty communication was absent ($M = 5.20$, $SD = 1.22$).

When running the ANOVA on the dependent variable *trust in the source*, no main effects for uncertainty ($F(2,393) = .23$, $p = .630$) nor source ($F(2,393) = .871$, $p = .419$) were found. Likewise, no interaction effect ($F(2,393) = .875$, $p = .418$) between those two variables was found. Thus, the manipulations of the current study did not affect the trust of participants in the source. As before, the prior described trend is visible in the context of this dependent variable.

To conclude, the described findings indicate that there is a difference between the groups in perceived uncertainty while there is no difference between the groups for trust in the number, trust in the message and trust in the source – despite uncertainty being communicated or not. Thus, no evidence is given to support the hypothesis, that trust will be lower when uncertainty is communicated compared to when it is absent. Further, the hypothesis, that trust in the sources government and scientists is similar across all participants, was supported as no differences between trust in the government and scientists were found.

### *The Influence of Intolerance of Uncertainty*

It was hypothesized that participants with high IU trust the message less when scientific uncertainty is communicated, compared to when scientific uncertainty is absent

from the message. To examine this, analyses of variance (ANOVA) are carried out as previously, including IU as a third independent variable. The format of the analyses of variance then being 2 (Uncertainty [not communicated, communicated]) x 3 (Source [Government, Scientists, Scientists on social media]) x 2 (Intolerance of uncertainty [low, high])[2].

Results about the effect of communicated uncertainty, source, and IU score on the dependent variable *perceived uncertainty* are in accordance with the results present above. The ANOVA revealed a significant main effect for communicated uncertainty ($F(1,387) = 5.47$, $p = .020$, partial $\eta 2 = .011$ ). When uncertainty was communicated, participants perceived the number in the text to be more uncertain ($M = 4.64$, $SD = 1.07$) than when no uncertainty was communicated ($M = 4.39$, $SD = 1.18$). There was no main effect for source ($F(2,387) = 1.045$, $p = .353$) and no interaction effect between communicated uncertainty and source ($F(2,387) = .04$, $p = .958$). Additionally, the analysis did not show a main effect for IU ($F(1,387) = .55$, $p = .458$). Further, no interaction between IU and communicated uncertainty ($F(1,387) = .15$, $p = .700$), nor between IU and source ($F(2,387) = 1.51$, $p = .222$) nor between communicated uncertainty and source and IU ($F(2,387) = .82$, $p = .440$) has been found. The results imply that the communicated uncertainty was perceived by the participants compared to when uncertainty communication was absent. In addition, these results suggest that people who are highly intolerant of uncertainty do not perceive more uncertainty than people who are more tolerant of uncertainty.

Considering the overlap of results and similarity of analysis compared to the prior paragraphs, the following will be focused on the results yielded by IU as a dependent

[2] Besides these analyses of variances, analyses with communicated uncertainty and source as independent variables and IU as covariate were run, to cover for all the possible variances. No significant effects were found then either.

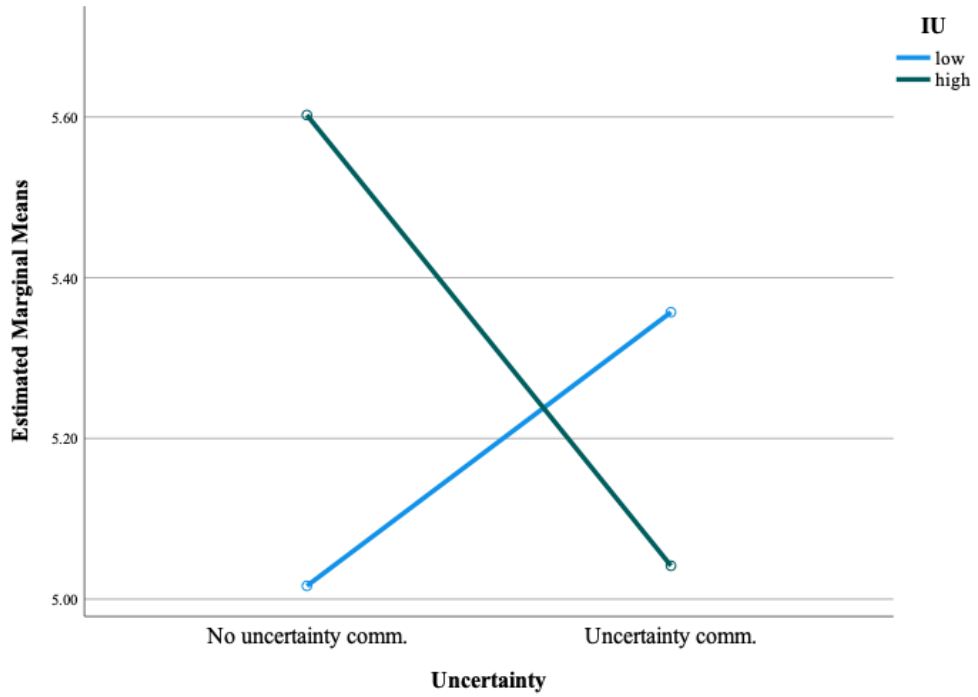
variable. Main effects of communicated uncertainty and source and their interaction effects are presented in Appendix D.

The ANOVA run to examine the effect of IU score on the dependent variable *trust in the number*, revealed no main effect for IU ($F(1,387) = .10$, $p = .748$). Further, no interaction between IU and communicated uncertainty ($F(1,387) = .92$, $p = .338$), nor between IU and source ($F(2,387) = .072$, $p = .931$), nor between communicated uncertainty and source and IU ($F(2,387) = 1.00$, $p = .369$) has been found. These results suggest that people who are highly intolerant of uncertainty do not trust the number less than people who are more tolerant of uncertainty.

When examining the effect of IU score on the dependent variable *trust in the message*, no main effect for IU ($F(1,387) = .00$, $p = .979$) was given away. There is a significant interaction effect between IU and communicated uncertainty ($F(1,387) = 5.02$, $p = .026$, partial $\eta 2 = .013$), yet the effect is small. This is best observable in Figure 3, where the profile plot of trust in the message, when the government was the communicating source is displayed. There, lines are not running parallel, so the effect of uncertainty interacts with IU - this means that communicated uncertainty affects people with low IU differently than people with high IU. One can see that when uncertainty is communicated, people with high IU trust the message less, while the opposite pattern holds for people with low IU. There is no interaction effect between IU and source ($F(2,387) = .404$, $p = .668$) nor between communicated uncertainty and source and IU ($F(2,387) = .62$, $p = .537$).

**Figure 3**

*Trust in the message communicated by the government among people with low and high IU and with communicated uncertainty present and absent*



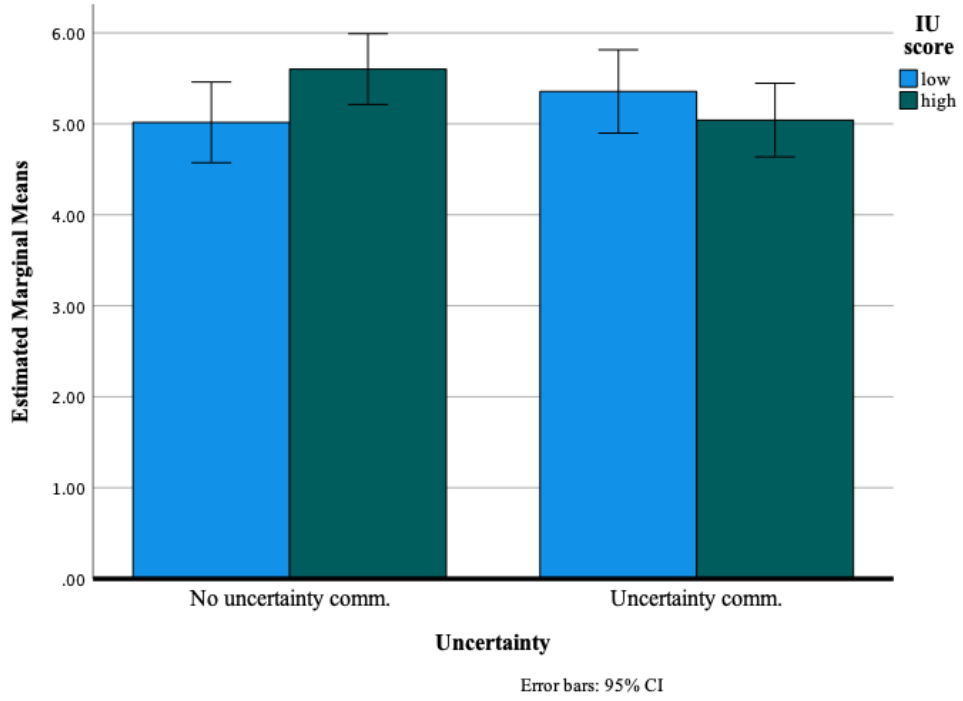

*Note.* Estimated marginal means of *trust in the message*.

Results of analysis of the effect of IU score on the dependent variable *trust in the source*, revealed no main effect for IU ($F(1,387) = .18$, $p = .667$). Further, no interaction between IU and communicated uncertainty ($F(1,387) = .00$, $p = .993$), nor between IU and source ($F(2,387) = .81$, $p = .445$), nor between communicated uncertainty and source and IU ($F(2,387) = .78$, $p = .460$) has been found. Thus, *trust in the source* itself does not seem to be associated with intolerance of uncertainty.

Regarding all dependent variables, a trend can be observed in the respective profile plots: Compared to participants low in IU, those with high IU trust information provided by the government more if no uncertainty was communicated. This trend is observable clearest in the dependent variable trust in the message as demonstrated in Figure 4. Even though it has not been significantly indicated in the current study yet might be of interest in future research.

**Figure 4**

*Trust in the message communicated by the government among people with low and high IU and with communicated uncertainty present and absent*




*Note.* Estimated marginal means of *trust in the message* (Error bars show standard errors).

Altogether, the analyses indicate that intolerance of uncertainty does not significantly affect perceived uncertainty, trust in the number, trust in the message and trust in the source. Thus, no support for the second hypothesis, that participants with high IU have lower trust when uncertainty communication is present, was found.

**Explorative Analyses**

Independent of the hypotheses, the data were further explored to examine whether IU related to the measures of psychological distress, action intention and perceived severity of the coronavirus. Pearson correlation coefficients were computed to examine these relationships. A moderate correlation between high IU and psychological distress was found ($r(397) = .367$, $p < .001$), indicating that people intolerant of uncertainty experienced more psychological distress in the past two weeks compared to those more tolerant of uncertainty.

A small correlation between high IU and action intention was found ($r(397) = .098$, $p = .05$). This implies that people intolerant of uncertainty were more likely to recommend getting a booster shot, wear a face mask and adhere to social distancing rules. No correlation between high IU and perceived severity of the coronavirus was found ($r(397) = .094$, $p = .06$), but it is observable that this was close to the significance threshold. This would indicate that people with high IU do not perceive the coronavirus as a serious infection.

## Discussion

During the COVID-19 pandemic, effective science communication is of great relevance to make scientific findings accessible and comprehendible to the public. Substantial to scientific findings is the uncertainty around them but effects of communicating scientific uncertainty are highly controversial. Building upon prior findings by Van der Bles et al. (2020), the purpose of the current study was to gain a better understanding of the potential impact of communicated uncertainty, communication source and intolerance of uncertainty on trust in scientific information. Here, results demonstrate that neither of those influence trust in scientific information about and during the COVID-19 pandemic.

### Theoretical Implications

The seemingly indifference towards induced uncertainty raises a question: How is it possible that people, living in uncertain times, are exposed to scientific uncertainty in the study and do not seem to be affected by it? It is empirically evident that uncertainty might evoke anxiety and worry (Dugas et al., 2005). As we speak about experiencing uncertainty as a feeling (Bar-Anan et al., 2009), being confronted with scientific uncertainty does not seem to provoke such strong feelings as uncertainty in a clinical context would. It could be argued that in the context of the pandemic, people have become more aware of role of uncertainty in COVID-19 science. Given the novelty of the virus, people were much more exposed to uncertain information compared to pre-pandemic life. Hence, it seems logical that people

would get used to and have accustomed to this uncertainty to some degree over the course of the pandemic. Following this argument, it is interesting to pay attention to the observed trend within the current study, where participants may trust scientists more who communicated uncertainty in the present data. This is a hint to a possible finding, which has not been observed before and following this up is of particularly great interest for future research: It would underline the suggestion that people may appreciate openness about scientific uncertainty and build trust with it rather than losing it.

Relating this argument to prior literature, one can plausibly explain the differences between findings of Van der Bles et al. (2020) and the current work. Three main differences in the execution of the studies stand out. First, the contexts in which information was provided, differed in the degree it affected participants. While Van der Bles et al. (2020) provided information on, for example, the count of tigers left in India, the current study provided information about the effectiveness of booster shots against the coronavirus. Participants experience more real-life implications of the latter topic, as they are currently and directly affected by it. As the pandemic is possibly a reason for more awareness of uncertainty, this might not provide an emotionally neutral ground to assess reactions towards uncertainty.

A second difference of the studies is the way communicators of uncertainty were examined. The current study builds upon Van der Bles et al. (2020) findings and has implemented different communicator sources into the design to examine potential differences in trust depending on the communicating source. As it was predicted, people did not seem to differentiate between the trustworthiness of sources. It seems as if the sources, government and scientists, are blending together as communicators of information during the COVID-19 pandemic – both are communicating scientific findings and ideally aim towards working closely together. For example, this close collaboration is observable in Germany as the

government is advised by an interdisciplinary scientist committee about further steps in the pandemic (Tschirner & Albrecht, 2021). Further, both government and scientists, communicate the scientific findings yet to different extents. Thus, during the pandemic participants might have perceived them as conflated. Building upon that, it could be interesting for future research to examine whether people view the government and science as two separate entities or rather as one.

A third difference is that Van der Bles et al. (2020) compared purely numerical vs. verbal statements, while the current study did not make such a distinction – uncertainty was communicated numerically and verbally. The present results are partly consistent with the previous findings by Van der Bles et al. (2020). Their research did suggest no decrease in trust when uncertainty is expressed numerically, yet a small decrease of trust when uncertainty is communicated verbally. As the manipulation of the current study was a mix of verbal and numerical expressions, a slight decrease in trust was expected but not found. Again, the potentially established awareness of uncertainty during the COVID-19 pandemic could be an explanation for those results.

**Influence of Intolerance of Uncertainty**

Participants of the current study seemed indifferent towards communicated uncertainty, which was also the case for people high in IU. At face value, this finding seems counterintuitive as IU itself describes the evocation of a negative reaction towards a stimulus perceived as uncertain. Yet, another explanation might shed light on these findings: The construct IU depicts the experience of uncertainty and not being able to sit with that (Bar-Anan et al., 2009). In a clinical context, people with high IU would react more strongly to uncertain stimuli, for example to cues of social exclusion (Gorka et al., 2018). It could be argued that the reaction might not be the same for a stimuli like scientific uncertainty. Meaning there might be a difference in how people react to scientific uncertainty, or

uncertainty within a scientific context. If scientific uncertainty does not provoke strong emotions in people, the lack of difference between participants, high and low in IU, can be explained. What speaks against this argumentation is the observed interaction between communicated uncertainty and IU, which affected outcomes of trust in the message. This finding suggests that communicated uncertainty lowers trust levels when a person has high IU. Yet, the effect is not as large that valid conclusions can be drawn from only this finding. Future research could examine this in particular to see if the interaction of IU and communicated uncertainty influencing trust holds true.

The current work also provides insight about the link of IU and the COVID-19 pandemic. During exploratory analyses, an association between IU and psychological distress was found, which is in accordance with prior research by Saulnier et al. (2021): They concluded that IU is a predictor for higher distress about the COVID-19 pandemic. Further, this might explain the finding in this work that people with high IU are more likely to recommend getting a booster shot, wear a face mask and adhere to social distancing rules. It seems plausible that higher distress about the pandemic results in higher willingness to act according to pandemic measures. Future research could examine this claim further. According to the exploratory analyses, IU did not seem to be associated with the perception of the coronavirus as a serious infection. Yet, the meaningfulness of this result remains unclear due to the nearly significant result. Future research could investigate the validity of this further with a larger sample.

**Limitations**

The lack of significant findings might also be explained by the limitations of the study itself. A practical limitation would be the timeframe when the survey was made available to participants. In December 2021, when the data were collected, the booster shots were quite extensively discussed in media. The presence of this topic in daily life through scientific and

political debates and personal involvement might have substantially affected the results of this study. The attention was focused directly on the booster shots, but the general context of the current pandemic might have been influential enough: it might be that people were generally very aware of uncertainty already. As for now the pandemic declared as such almost three years ago and changes of political courses due to the unpredictability of the pandemic progress are no news anymore. Future research could apply the study design to a context of which people are less affected by: A less knowledgeable and prevalent topic might be better to study effects of the manipulations on a more neutral ground.

Several methodological issues might limit the generalizability of the findings. First, the degree of manipulation might have been too weak. Here, key words have been used to manipulate the perceived uncertainty, such as “may” and “could”. Further, a confidence interval around the communicated number was provided. Based on previous work, one would expect an effect here – yet in the context of the pandemic, the cues might not have been strong enough to elicit an effect. Second, the applied sampling strategy might not have ensured enough representation in the sample - for example, most participants have a highly academic educational background. It seems plausible that people with lower educational standards might respond less trusting to communicated uncertainty simply due to the lack and familiarity of scientific knowledge. Here, future research could aim towards more representative sampling by including people with a less educational background.

**Conclusion**

Despite the limitations, this research has enhanced our understanding of the relationship between communicated uncertainty, communicating source and trust. The present study provides evidence that the trust in scientific information is not decreased when scientific uncertainty is communicated and despite who communicates this. Moreover, results give a first sign of uncertainty communicated by scientists might even enhancing trust. To our

knowledge, this has not been directly linked yet but hopefully, current research will stimulate further investigation of this important area. Further, it is possible that scientific uncertainty does not evoke strong reluctance in people who are intolerant of uncertainty.

During the COVID-19 pandemic, scientific information is present in daily life. Thus, trust in science and its communicators is of extreme relevance as for example, trust serves as an emotional buffer against distress (Gvozden et al., 2021). In the frame of this study, information communicated by the government and scientists seem to be accepted despite uncertainty. Although the generalizability of this must be established by future research, the present study has provided clear evidence to further challenge the belief that scientific uncertainty communication harms trust. It is of societal interest to make science communication most effective, especially in intense situations like the pandemic. Working with findings like this gives a chance for advocation of more transparency in science rather than to shy away from it.

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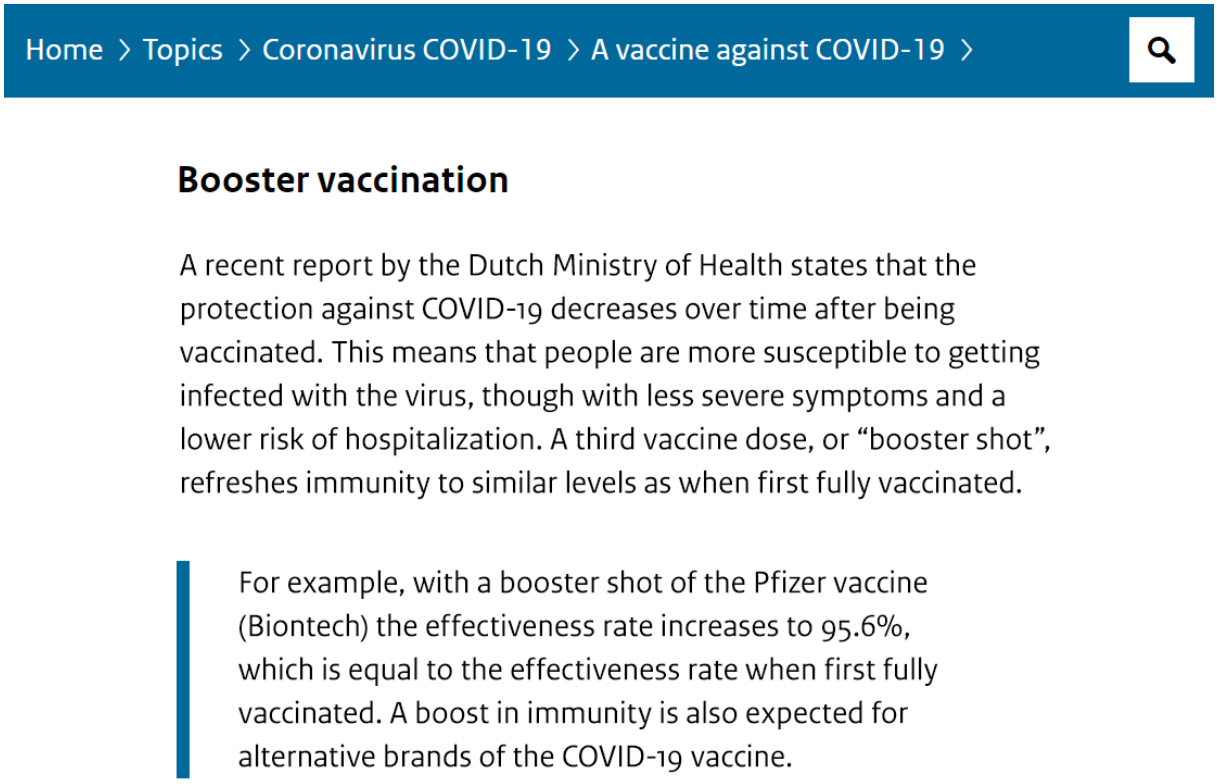
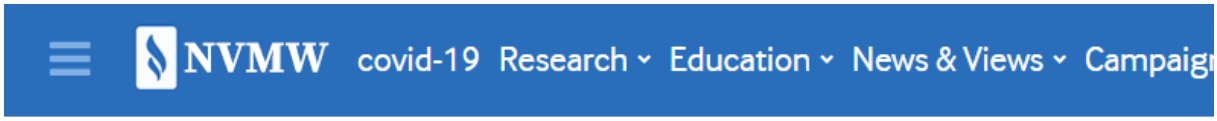
## Appendix A

### Framing and layouts of the manipulations

***Condition: Government, no uncertainty***



***Condition: Scientists, no uncertainty***

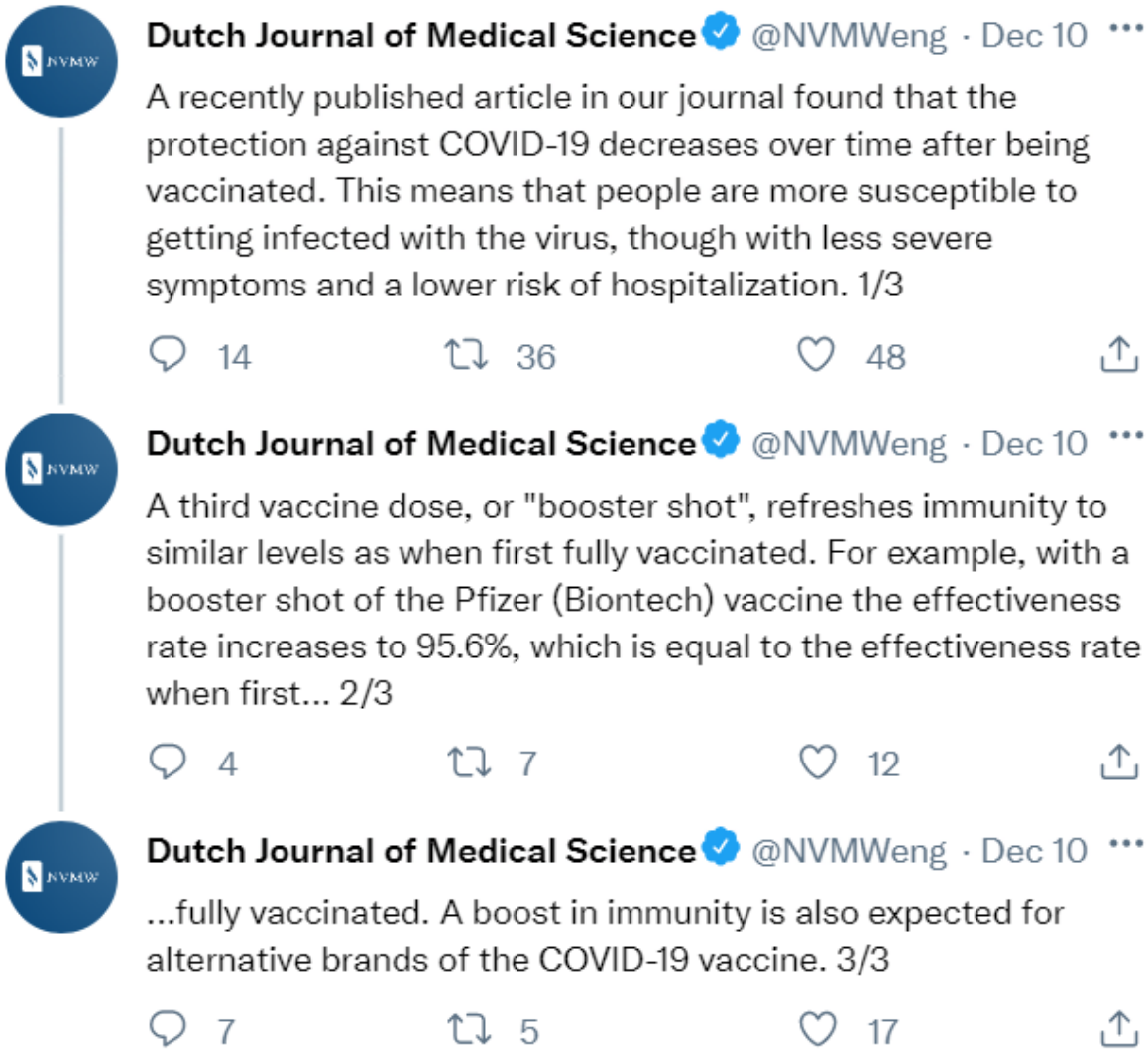



Article | Related content | Metrics | Responses

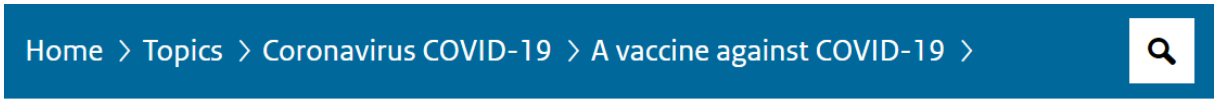
## Booster Vaccination

A recent article in the Dutch Journal for Medical Science (NVMW) states that the protection against COVID-19 decreases over time after being vaccinated. This means that people are more susceptible to getting infected with the virus, though with less severe symptoms and a lower risk of hospitalization. A third vaccine dose, or "booster shot", refreshes immunity to similar levels as when first fully vaccinated. For example, with a booster shot of the Pfizer vaccine (Biontech) the effectiveness rate increases to 95.6%, which is equal to the effectiveness rate when first fully vaccinated. A boost in immunity is also expected for alternative brands of the COVID-19 vaccine.

***Condition: Scientists via. Social Media, no uncertainty***



***Condition: Government, uncertainty***



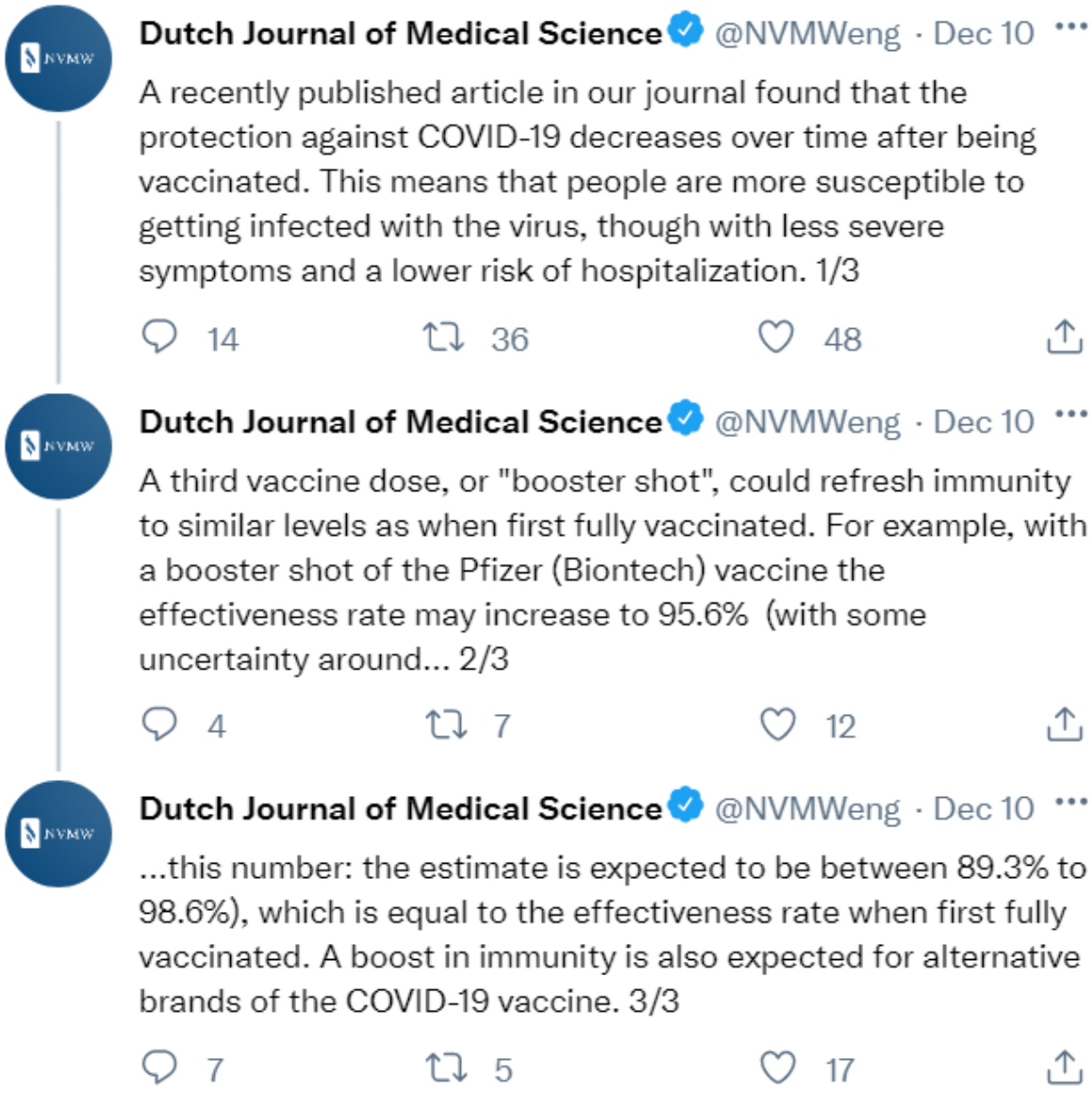

## Booster vaccination

A recent report by the Dutch Ministry of Health states that the protection against COVID-19 decreases over time after being vaccinated. This means that people might be more susceptible to getting infected with the virus, though with less severe symptoms and a lower risk of hospitalization. A third vaccine dose, or "booster shot", could refresh immunity to similar levels as when first fully vaccinated.

> For example, with a booster shot of the Pfizer vaccine (Biontech) the effectiveness rate may increase to 95.6% (with some uncertainty around this number: the estimate is expected to be between 89.3% to 98.6%), which is equal to the effectiveness rate when first fully vaccinated. A boost in immunity is also expected for alternative brands of the COVID-19 vaccine.

***Condition: Scientists, uncertainty***

***Condition: Scientists via. Social Media, uncertainty***



## Appendix B

**Items Intolerance of Uncertainty Scale – 12**

1. Unforeseen events upset me greatly.

2. It frustrates me not having all the information I need.

3. One should always look ahead so as to avoid surprises.

4. A small, unforeseen event can spoil everything, even with the best of planning.

5. I always want to know what the future has in store for me.

6. I can’t stand being taken by surprise.

7. I should be able to organize everything in advance.

8. Uncertainty keeps me from living a full life.

9. When it’s time to act, uncertainty paralyses me.

10. When I am uncertain, I can’t function very well.

11. The smallest doubt can stop me from acting.

12. I must get away from all uncertain situations.

# Appendix C

## Additional measures

### *Feeling thermometer*

Participants were asked to indicate how they feel towards certain groups (*Civil servants, Scientists, Politicians, Journalists, Content creators on social media*). First, from 0 – very cold/negative, to 10 – very warm/positive, and second, from 0 – not competent, to 10 – completely competent. This is based on the warmth-competence map by Fiske & Dupree (2014).

### *Political and social attitudes*

Trust in the current government and science were of interest. First, participants were asked to indicate their agreement with the following statements: "I trust the Dutch government.", "I trust Dutch politicans.", "I trust scientists.", "I trust scientific knowledge." (*Strongly disagree – strongly agree).* Second, it was of interest to measure satisfaction, identification as well as beliefs about the current government. Hence, six items, derived from the European Social Survey, were provided: "Thinking about the Dutch government, how satisfied are you with the way it is doing its job?" (*Very dissatisfied – very satisfied*), "On the whole, how satisfied are you with the way democracy works in the Netherlands?" (*Very dissatisfied – very satisfied*), "On the whole, how satisfied are you with the present state of the economy in the Netherlands?" (*Very dissatisfied – very satisfied*), "On the whole, how satisfied are you with how the government is managing the coronavirus crisis?" (*Very dissatisfied – very satisfied*), "How interested would you say you are in politics – are you…" (*Not at all – very interested*) and "To what extent do you identify with the current parties?" (*Not at all – a great deal*). Further, participants were asked to report their political orientation (*conservative - liberal*).

### *Communication measures*

The intention to share provided information was assessed with two items: “After reading this text, I would share this information with others on Social Media.” (*Not likely at all – very likely*) and “After reading this text, I would share this information with a friend.“ (*Not likely at all – very likely*). Further, four items to measure social media usage were included. Here, a statement for the context was provided: “In the following, we will ask you about your social media usage. By social media we refer to platforms such as Facebook, Instagram, Twitter, Youtube, TikTok, Reddit, and Pinterest.”. Then participants were asked to answer the following questions: “How often do you use these sites in total?” (*Never, I do not have accounts – multiple hours per day*), “Thinking ahead, how often do you plan on using these sites in the upcoming months?” (*Never, I do not have accounts or plan to delete or activate them. – multiple hours per day*), “How often do you use Twitter specifically?” (*Never, I do not have accounts – multiple hours per day*) and “How trustworthy do you find Twitter as a company?” (*Not at all trustworthy – very trustworthy*).

## Appendix D

**Table 1**

*Two-Way Analyses of Variance in Communicated uncertainty, Source and Intolerance of uncertainty and their respective main and interaction effects*

| Measure | Uncertainty | | | Source | | | Uncertainty and source | | |
|---|---|---|---|---|---|---|---|---|---|
| | *F* | *p* | $\eta^2$ | *F* | *p* | $\eta^2$ | *F* | *p* | $\eta^2$ |
| Perceived uncertainty | 4.36 | .037 | .011 | .97 | .380 | | .05 | .949 | |
| Trust in number | 2.85 | .92 | | 1.52 | .22 | | 1.62 | .199 | |
| Trust in message | .94 | .334 | | 1.27 | .28 | | 1.13 | .326 | |
| Trust in source | .31 | .575 | | .714 | .49 | | .75 | .473 | |