The Effect of Communication Source and Uncertainty Communication on Trust in COVID-19 Information

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Abstract

The ongoing COVID-19 pandemic has increased the need for transparent science communication strategies in recent years. Scientific findings are the basis of many policy decisions, specifically for health- and safety regulations during the pandemic. Previous research demonstrates that factors such as the communication source, uncertainty communication, and individual characteristics can impact people's trust in scientific information. In this study (N = 463), we used a 2 (uncertainty vs. no uncertainty) x 3 (government website vs. scientific article vs. scientists via social media) between-subjects design to examine the effects of the communicator source on trust in information about COVID-19 booster vaccines. In addition, we examined the association between psychological distress and trust. Overall we obtained varied results regarding previous research, as we found no effects of the source, or uncertainty communication on trust, while psychological distress was negatively correlated with trust. We conclude that scientific findings may be communicated more transparently. The implications of this study are further discussed.

Keywords: science communication, COVID-19, trust, uncertainty communication

The Effect of Communication Source and Uncertainty Communication on Trust in COVID-19 Information

The ongoing COVID-19 pandemic has increased the need for transparent science communication strategies in recent years. Weingart and Guenther (2014) define science communication as "the crucial link between the world of knowledge production and the general public" (p. 2). Scientific knowledge underlies policy decisions in many contexts, ranging from politics to education (Jucan & Jucan, 2014). However, for scientific knowledge to inform decision-making, it needs to be communicated to the relevant stakeholders first. Thus, science communication is a crucial part of policy creation and allows members of society to form opinions about and trust in those policies (Huber et al., 2019; Bogner & Torgersen, 2005). Considering the current COVID-19 pandemic, the importance of science communication strategies becomes apparent as scientific findings in this area are crucial for designing public safety regulations and health recommendations. A practical example of this is the implementation of measures against the newest COVID-19 strain, Omicron. Scientific findings of the characteristics of Omicron are the basis for politicians' and policymakers' decisions.

This raises the question of how science communication can contribute to trust in scientific findings. Hence, the present study investigates three influences that could impact trust in scientific information about COVID-19 booster vaccines. First, we will look at differences in levels of trust when the source presenting the information is a governmental website, a scientific article, or scientists operating via social media (Twitter). Second, we will examine the association between the psychological distress levels of the recipient and trust levels. Third, we will explore the impact of the communication of scientific uncertainty on trust levels. To understand different properties of trust, we measured trust in the message, trust in the source, and trust in the number.

Communicator credibility

An essential focus of previous research regarding trust in science communication has been the source of the communication. Fiske and Dupree (2014) argue that perceived expertise and trust are crucial components of communicator credibility. Perceived expertise can either lead to agreement or scrutiny, depending on the level of motivation of the recipient. However, Fiske and Dupree suggest that what makes a recipient automatically believe in a message is trust. People trust others similar to them and thus identify as part of their group, which seems to serve as a socially adaptive strategy.

In their study, Fiske and Dupree (2014) conducted an online survey to measure views on American jobs in terms of emotions, warmth, and competence dimensions. As previously established, trust is a crucial component for conveying a message effectively. However, Fiske and Dupree (2014) argue that perceptions of competence and warmth determine trust in a group. Interestingly, their survey found that scientists are perceived as competent but not warm, which translates into respect but not necessarily trust. A possible consequence might be that information appears less credible since the scientist's intent is unclear.

Opposingly, Weingart and Guenther (2016) have different views on the trustworthiness of specific types of groups. Scientists, among others, are perceived as highly trustworthy because they serve the common good. In contrast, politicians are perceived as less trustworthy, mainly because they must make promises they cannot hold, compromises for rational decision-making, and act to ensure their legitimacy.

Furthermore, science communication provided by government entities seems to be less credible than science communication originating from scientists (Weingart & Guenther, 2016). Hence, this research leads us to expect that when considering trust in the source, information from scientists might be more trusted than information from the government. In the current pandemic, information on COVID-19 is reported by both the government and

scientists. We think that examining whether the source of communication influences people's trust in information about COVID-19 is highly relevant. In particular, we want to look into the difference between government and scientists as sources.

Characteristics of the recipient

As Fiske and Dupree (2014) argued, the characteristics of the recipient of the information are essential for developing trust. Following this notion, Olagoke et al. (2020) report valuable insights about the association between psychological distress, physical well-being, and trust in the government during the COVID-19 pandemic. In their study, Olagoke et al. (2020) measured mental well-being through psychological distress scales. Their findings showed that psychological distress was negatively associated with public trust in the government and perceived self-efficacy in health-protective behavior. In addition, it was positively associated with the perceived severity of the COVID-19 pandemic. This connection between trust and psychological distress is critical in the context of COVID-19, as it has been shown that the pandemic outbreak had a severe influence on psychological distress (Wang et al., 2020). Conclusively, these findings demonstrate that individual characteristics, such as psychological distress, are influenced by the COVID-19 pandemic and strongly associated with trust in the government's risk communication.

Thus, this research aims to investigate whether individuals who report higher psychological distress symptoms might trust information about COVID-19 less. Moreover, we will investigate whether psychological distress levels might change the way participants react to COVID-19 information communicated by the government compared to scientists. It is imperative to study whether people who experience more psychological distress might react differently to information about COVID-19 as the pandemic appears to influence people's mental health.

Uncertainty Communication

Another influential property of science communication that might impact trust in science is concerned with the disclosure of uncertainty. Contradictory evidence has been ample concerning the effects of uncertainty communication on trust in recent years (Hendricks & Jucks, 2020; Kelp et al., 2021; Van der Bles et al., 2020). Van der Bles et al. (2020) conducted five studies to investigate the role uncertainty communication plays in people. They presented topics such as global warming, the number of tigers in India, and the unemployment rate in the UK. They measured trust through trust in numbers (presented information) and trust in the source (communicator). Across the five experiments, results show that verbal communication of uncertainty decreased trust more than numerical communication, primarily for trust in the number. Verbal uncertainty communication only evoked a reduction in trust when the subjects perceived the uncertainty. Keywords like "estimated" did not seem to convey uncertainty adequately. Numerical uncertainty communication did not influence people's trust in the source of information, whereas verbal uncertainty communication had a small effect. Interestingly, prior beliefs about the topic seemed to influence trust. Conclusively, Van der Bles et al. (2020) found little evidence that numerical uncertainty communication decreased trust, thus evoking little psychological reactance. However, verbal uncertainty communication did seem to have a small decreasing influence on trust levels.

In contrast, findings by Kelp et al. (2021) demonstrate varied results. They assigned participants to low or high uncertainty communication conditions and presented them with COVID-19 vaccine information. While the level of uncertainty did not seem to impact participants' trust, the pre-experimental trust levels in science determined trust in the study, which is in line with Van der Bles et al. (2020). Similarly, Hendricks and Jucks (2020) found that the communication of uncertainty did not affect trust in the presented information (the impact of climate change on ocean life) or the source presenting the information.

While important, previous research topics (Hendriks & Jucks, 2020; Van der Bles et al., 2020) are not directly consequential for people's everyday lives. In contrast, information on the COVID-19 pandemic is highly consequential in an everyday setting. Therefore, uncertainty communication might influence trust differently when the information is salient in people's everyday lives. Even though the levels of uncertainty did not influence trust in COVID-19 information in findings by Kelp et al. (2021), we expect decreased trust levels when uncertainty is communicated since the uncertainty manipulation in this study will be composed of both numerical and verbal uncertainty properties.

Information channels

Another critical factor is the information channel a finding is communicated over. According to Newman et al. (2017), social media has become the primary news source for 33% of young adults and 7%-21% of other age groups. This leads us to believe that the information channel through which information is conveyed might impact trust formation in science. Previous research suggests several controversial points regarding social media and scientific trust. According to Weingart and Guenther (2016), the uncontrolled nature of social media news coverage can lead to decreased public trust.

In contrast, Kim et al. (2013) demonstrate how social media coverage can increase network heterogeneity and civic engagement for some individuals. Following this change in news consumption, science communication evolved into a new direction. Van Dijk and Alinejad (2020) discuss how science communication, in the traditional sense, relied on a linear information flow from scientists to governments to news outlets and lastly, to the public. However, social media led science communication into a more circular model, where shared views on social media by non-experts influence public views on science and policymaking. Huber et al. (2019) studied the role of social media across 20 countries via survey research. They found a positive association between social media news usage and trust

in science across countries. Most importantly, trust in science was higher for social media use than traditional news.

COVID-19 information is not solely communicated through traditional media, such as newspapers, but also increasingly through social media, such as Twitter. Therefore, due to the contentious findings we previously elaborated on (Weingart & Guenther, 2016; Kim et al., 2013; Van Dijk & Alinejad, 2020; Huber et al., 2019), it is vital to explore the differences in trust when communicating information through social media and more traditional scientific articles.

This study

This research aims to identify the effect of three sources, namely scientists, the government, and scientists through social media (Twitter), on trust in scientific information in the context of the COVID19 pandemic. In addition, we will examine the effect of communicating uncertainty vs. not communicating uncertainty. Further, we will look at psychological distress as a characteristic of the recipient. The study takes place during the ongoing COVID-19 pandemic, which will shed light on new insights regarding public trust in scientific findings and psychological well-being during a crisis.

We propose the following hypotheses: First, we predict that trust will be higher when the source is scientists (i.e., presenting the information as a scientific article) as opposed to the government (i.e., a government website). Second, we want to explore whether there is a difference in trust when communicating a scientific message through social media (Twitter) compared to when communicating it through a scientific article. Third, we predict that trust will be higher when no uncertainty about the message is communicated in contrast to when uncertainty is communicated. Fourth, trust will be higher for people who experience less psychological distress based on the PHQ-4 scale (Kubchandani et al., 2021). Similarly, we

want to explore whether there is an interaction between psychological distress and the source of the presented information.

Method

Participants

This study is conducted as a part of a bachelor thesis project at the Rijksuniversiteit Groningen. We aimed to collect data from around 300 participants based on a priori power calculation by using G*Power. According to this, we needed 251 participants to obtain a medium effect size of 0.25 when assuming $\alpha = 0.05$ and a power of 0.80. We collected participants through a convenience sample. One part of the sample ($N = 180$) was recruited via the network of bachelor students and snowball sampling. These participants volunteered and did not receive compensation for their participation. The majority of the sample ($N = 319$) was collected via Prolific, an online platform for conducting research. They were selected to live in the Netherlands and speak Dutch fluently and received 1£. Participants were eligible for participation if they resided in Germany or the Netherlands and were at least 18 years old.

The study includes the data of 499 participants, out of which 36 were excluded from participation due to unsuitable residency/ declined data processing consent. The age of the participants ranged from 18 to 72 years ($M = 29.8$, $SD = 11.8$). Responses were collected within two weeks. In total, 116 participants had their residency in Germany, while 347 participants had their residency in The Netherlands. Furthermore, the distribution shows a total of 257 women, 193 men, 10 non-binary/diverse, and three participants who preferred not to answer. Ethical approval was obtained from the Ethical Examination Board of the Rijksuniversiteit Groningen. All participants gave their informed consent before participating in the study and were debriefed afterward.

Study Design and Procedure

The study had a 2 (no uncertainty vs. uncertainty) x 3 (government vs. scientists vs. social media) between-subjects design, with six conditions in total. The participants were placed into the conditions by randomization. We manipulated the source of the message the participants received by showing them a text communicated by either scientists, the government, or scientists on social media, which served as the independent variable. In addition, the message either did or did not contain scientific uncertainty. The following text was presented to participants when no uncertainty was communicated:

> *"A recent report by* [see Table 1] *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 the immunity to similar levels as when first fully vaccinated. 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".*

Half of the participants were shown a text with uncertainty communication. The following keywords were used to communicate uncertainty: "A booster shot could refresh immunity [...]", "The effectiveness rate [...] might increase to 95.6%". Furthermore, a 95% CI was used to signal further uncertainty: "[...] with some uncertainty around this number: the estimate is expected to be between 89.3% to 98.6%". All numbers are based on an online report by Pfizer Inc. and BioNTech SE (Pfizer, 2021).

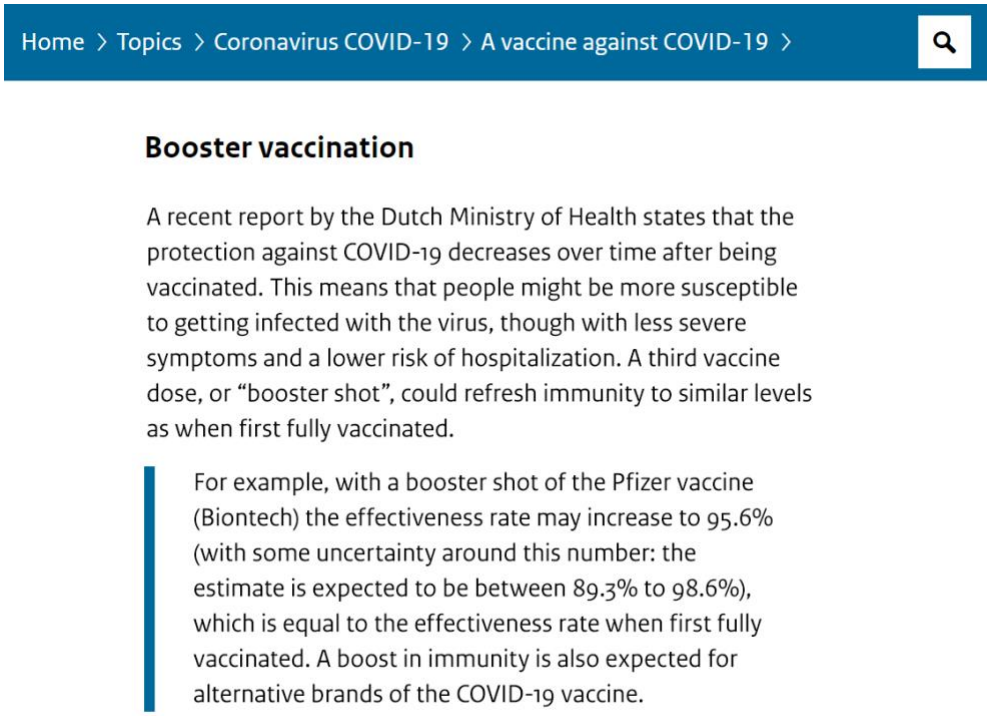
Figure 1 illustrates the government website condition with uncertainty communication. Appendix A (Figure A1-A18) presents a visual representation of each condition in English, German, and Dutch. At the beginning of the text, depending on their

condition, the participants were informed that the report was published by the actual title of a government website or a made-up scientific journal (See Table 1 for an overview).

The design of the government image resembled the actual government website for each country: blue and white for the Netherlands and black, gray, blue, and white for Germany. The scientific article conditions simulate what the respective journal's website could look like with a blue header, a logo, subcategories ("Article," "Related content," "Metrics," "Responses"), and the text. Likewise, the social media condition resembled a Twitter post with three parts to fit the text. The profile publishing the post was indicated with the same logo as the scientific article conditions and the date December 10.

Figure 1

English Manipulation of Government Uncertainty Condition



Afterward, we measured the dependent variables, namely current feelings, perception of uncertainty, trust (in the source, message, and number), action intentions, trust/opinions about the government, intolerance of uncertainty, psychological distress, perceived severity of the COVID-19 pandemic and social media usage. Several of these measures (current feelings, action intentions, trust/opinions about the government, intolerance of uncertainty, perceived severity, and social media usage) fall outside the scope of the current research, and their methodological details are presented in Appendix B. The questionnaire was administered through the online platform Qualtrics. A survey link has been sent to the recipients to receive the invitation to partake in the study. The questionnaire took approximately eight minutes to fill out.

Table 1

Source Text Manipulation Titles

Language of the presented Text	Government Website	Scientific Article	Social Media Outlet
English	Dutch Ministry of Health	Dutch Journal for Medical Science (NVMW)	Dutch Journal for Medical Science (NVMW) via Twitter Post
German	Bundesministerium für Gesundheit	Deutsche Fachzeitschrift für Medizinische Wissenschaft (DFMW)	Deutsche Fachzeitschrift für Medizinische Wissenschaft (DFMW) via Twitter Post
Dutch	Ministerie van Volksgezondheid	Nederlands Vakblad voor Medische Wetenschapen (NVMW)	Nederlands Vakblad voor Medische Wetenschappen (NVMW) via Twitter Post

Note. For the government website, real titles were used, whereas the scientific journal titles were made up. The social media condition also incorporates the scientific journal title, displayed in a Twitter design.

Measures

Measures such as current feelings, action intentions, trust/opinions about the government, intolerance of uncertainty, perceived severity, and social media usage fall outside the current research scope. Appendix B presents the methodological information for these measures. The measures included in this research are described in the following paragraphs.

Manipulation Checks

Two items were used as a manipulation check: “What was the estimated effectiveness rate of the booster shot reported in the text? Please write down what you remember“ (open question), and “Did the text imply uncertainty about this number?”. Response options were “yes,” “no,” “I don’t know,” and “I don’t remember”.

Demographics

Two items were measuring with age and gender to gather demographic data. Additionally, participants were asked for their residency.

Trust

Trust was measured through three categories: trust in numbers, trust in the message, and trust in the communicator source. First, to measure trust in numbers, three items were administered: “How reliable do you think this number is” (1 = not reliable at all to 7 = very reliable), “How trustworthy do you think this number is?” (1 = not trustworthy at all to 7 = very trustworthy), and finally, “To what extent do you believe this number to be credible?” (1 = not at all to 7 = completely). Together these items had a Cronbach’s alpha of $\alpha = .942$.

Second, two items were administered to measure trust in the message: “How much do you trust the information about the efficacy of booster shots given in the message you have just read?“ (1 = not at all to 7 = completely) and “How reliable do you think the information about the efficacy of booster shots given in the message you have just read is?” (1 = not at all to 7 = completely). These items were significantly correlated $r = .854$, $p < .001$, and were

combined by taking the mean of their individual values. For exploratory purposes, we additionally included two items in this section that are outside the scope of the current research and will not be reported on further ("How uncertain does this information make you feel?" (1 = very uncertain to 7 = very certain) and "How much do you trust information about the efficacy of booster shots in general?" (1 = not at all to 7 = completely).

Third, two items were used to measure trust in the communicator source: "To what extent do you think the people who wrote this text are trustworthy?" (1 = not at all to 7 = completely) and "To what extent do you think the people who are responsible for the numbers are trustworthy?" (1 = not at all to 7 = completely). These questions, which also were significantly correlated $r = .754$, $p < .001$, were used to measure the participants' trust in the source.

Perception of uncertainty within the message

In addition, perception of uncertainty around the numbers about the effectiveness rates of the booster shot was measured. The following two items were used: "To what extent do you think that this number is certain or uncertain?" (1 = very uncertain to 7 = very certain), "How much uncertainty do you think there is about this number" (1 = very uncertain to 7 = very certain) $r = .490$, $p < .001$.

Psychological Distress

Psychological distress was measured with the self-report assessment PHQ-4 Scale (Kubchandani et al., 2021), consisting of four items. Participants were asked, "Over the last 2 weeks, how often have you been bothered by the following problem…". The first two items are related to anxiety symptoms "feeling nervous, anxious or on edge," and "not being able to control or stop worrying," while the other two items were intended to measure depressive symptoms such as "feeling down, depressed or hopeless," "little interest or pleasure in doing things". Response options ranged from 1 = not at all to 4 = almost every day. The higher the

score on the PHQ-4, the higher the reported psychological distress. We created a new variable for psychological distress by summing up the four items of the PHQ-4 scale and ended up with a PHQ-4 score indicating the severity of psychological distress. Cronbach's alpha for this is 0.849. To test an interaction effect between psychological distress as indicated by the PHQ-4 score and source, we created the PHQ-4 scale as a factor, with values from 4 to 7 being coded as low psychological distress (N = 230) and values from 8 to 16 as high psychological distress (N = 227) based on a median split.

Results

Assumptions

We chose the following measures to control for the assumptions of the ANOVAs. We assume no violations for independence since every participant was only sampled once, and participants answered the questionnaire independently of other participants. The Shapiro-Wilk test for normality was executed, which showed significant results in each group for all trust in the message (See Appendix C, Table C1), trust in the source (See Appendix C, Table C2), and trust in the number (See Appendix C, Table C3). Therefore the data cannot be treated as normal (based on this test). In addition, we performed Levene's test, which showed non-significant results for trust in the message (See Appendix C, Table C4), trust in the source (See Appendix C, Table C5) and trust in the number (See Appendix C, Table C6). Thus, equal variances across groups can be assumed. Due to our large sample size (N = 463), we assumed that the ANOVAs were robust against the non-normality and performed the analysis as planned.

Regarding the manipulation check, out of 230 participants in the no uncertainty condition, 155 correctly reported no uncertainty was communicated, 37 reported that uncertainty was communicated, 11 did not know, and 27 did not remember. For the 233 participants in the uncertainty condition, 184 correctly reported having seen uncertainty being

communicated, 35 reported no uncertainty was communicated, three did not know, and 11 did not remember. We conclude that the manipulation was successful.

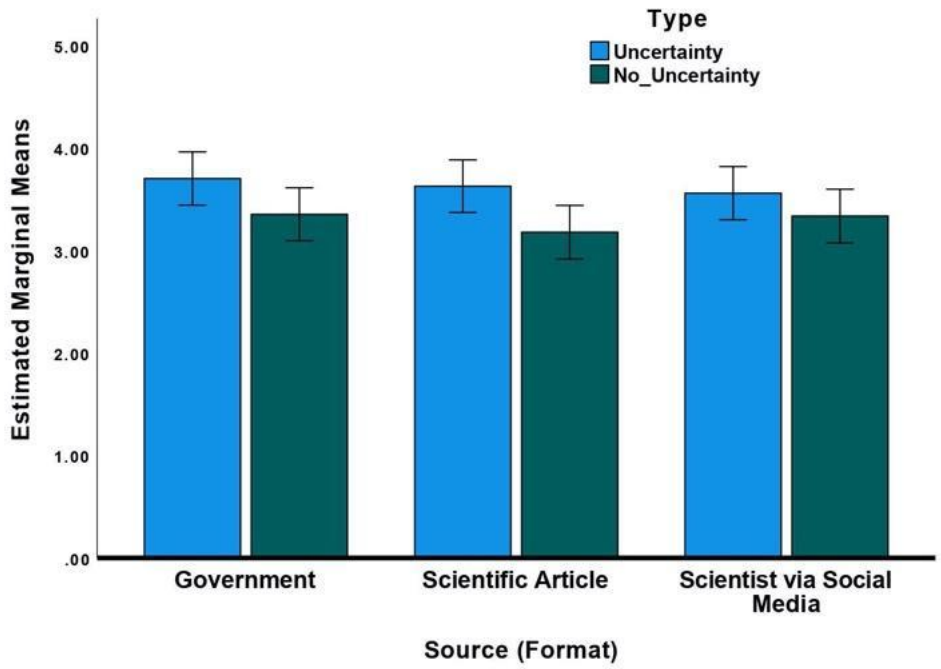
Participant's Trust

To investigate the effects of communication source and uncertainty communication on participant's trust in the COVID-19 information, we carried out a series of 3 (source: government vs. scientific article vs. scientist via social media) x 2 (uncertainty communicated vs. no uncertainty communicated) ANOVAs for each of the following dependent variables: perceived uncertainty, trust in the number, trust in the message and trust in the source.

First, the ANOVA with perceived uncertainty as the dependent variable was conducted to check whether participants perceived more uncertainty when explicitly communicated. This showed no significant main effect of the source $F(2, 457) = 0.46$, $p = .631$, $\eta^2 = .00$. No significant interaction effect between source and uncertainty communication could be found either $F(2, 457) = 0.38$, $p = .693$, $\eta^2 = .00$. However, a significant main effect for uncertainty communication was found $F(1, 457) = 9.95$, $p = .002$, $\eta^2 = .02$. Figure 2 presents the results. To further investigate this effect, we looked at the difference in marginal means between no uncertainty communication and uncertainty communication. As expected, the comparison showed that the perceived uncertainty was significantly higher when uncertainty was communicated $M = 3.63$, $SD = 1.16$ compared to when it was not $M = 3.29$, $SD = 1.16$, $M_{\text{Uncertainty}} - M_{\text{No Uncertainty}} = 0.340$, $p = .002$, 95% CI [0.128, 0.552].

Figure 2

Estimated Marginal Means of Perceived Uncertainty



Note. A significant difference in means can be observed for uncertainty communication (type).

Surprisingly, when using trust in the number as the dependent variable of the ANOVA, no significant main effect could be observed for either the source $F(2, 457) = 0.71$, $p = .490$, $\eta^2 = .00$ or the uncertainty communication $F(1, 457) = 1.21$, $p = .272$, $\eta^2 = .00$. Furthermore, no significant interaction effect between the two independent variables has been found $F(2, 457) = 0.16$, $p = .856$, $\eta^2 = .00$.

Similarly, for the ANOVA having trust in the message as the dependent variable no significant main effect could be seen for the source $F(2, 457) = 0.30$, $p = .739$, $\eta^2 = .00$ nor for the uncertainty communication $F(1, 457) = 0.36$, $p = .547$, $\eta^2 = .00$. Moreover, there was no significant interaction between the source and the uncertainty communication $F(2, 457) = 0.23$, $p = .795$, $\eta^2 = .00$.

Lastly, when using trust in the source as the dependent variable of the ANOVA we could again not observe a significant main effect for the source $F(2, 457) = 0.19$, $p = .824$, $\eta^2 = .00$ or the uncertainty communication $F(1, 457) = 0.12$, $p = .733$, $\eta^2 = .00$. Similar to the previous results, no significant interaction effect between the independent variables was found $F(2, 457) = 0.31$, $p = .736$, $\eta^2 = .00$. Thus, these results indicate that the communication source and uncertainty communication had no impact on participants' trust in the number, message, or source.

According to our first hypothesis, participants' trust was predicted to be higher when the information was presented in a scientific article compared to a government website. Interestingly, this hypothesis is not supported by these results, as no main effect of the source on either trust in the number, message or source was found. Correspondingly, our second hypothesis, predicting a difference in participant's trust when the information is presented in a scientific manner through social media (Twitter) compared to an article, was not supported by the analyses. Additionally, in our third hypothesis, we predicted that participants' trust would be higher when no uncertainty about the message is communicated compared to when uncertainty is communicated. This hypothesis was also not supported by the performed analyses. We have seen no significant main effect of uncertainty communication on trust in the number, message, or source.

Psychological Distress

To explore the relationship between participant's trust in COVID-19 information and psychological distress, we first examined the correlations between the participant's score on the PHQ-4 scale (Kubchandani et al, 2021) ($M = 7.9$, $SD = 3.1$) and their scores on the compound variables trust in the number ($M = 5.3$, $SD = 1.3$), $r(457) = -.100$, $p = .032$, trust in the message ($M = 5.2$, $SD = 1.3$), $r(457) = -.089$, $p = .054$ and trust in the source ($M = 5.4$, $SD = 1.2$), $r(457) = -.037$, $p = .426$. We can see that all three correlations are negative; however,

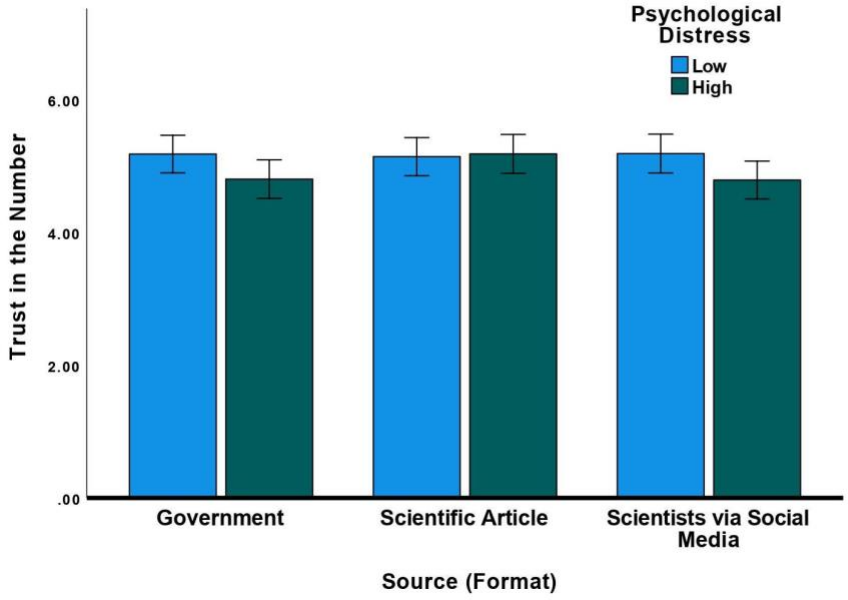
only the correlation between the PHQ-4 score and the trust in the message is significant. These correlations indicate that, across all conditions of the manipulation, people who reported high levels of psychological distress had lower scores for trust in the number, message, and source.

In order to look into another possible effect of psychological distress on trust, we performed a series of 3 (source: government vs. scientific article vs. scientist via social media) x 2 (low PHQ-4 score vs. high PHQ-4 score) ANOVAs with trust in the number, trust in the message and trust in the source as dependent variables.

With trust in the number as the dependent variable, the ANOVA showed no significant main effect of the source $F(2, 451) = 0.92$, $p = .401$, $\eta^2 = .00$ but a significant main effect of psychological distress was found $F(1, 451) = 4.17$, $p = .042$, $\eta^2 = .01$. No significant interaction effect between uncertainty communication and psychological distress was found $F(2, 451) = 1.42$, $p = .242$, $\eta^2 = .01$. As depicted in Figure 3, participants who reported high psychological distress trusted the number less ($M = 4.9$, $SD = 1.3$) than those who reported low psychological distress ($M = 5.2$, $SD = 1.3$), $M_{Low} - M_{High} = 0.245$, $p = .042$, 95% CI [0.009, 0.480].

Figure 3

Estimated Marginal Means of Trust in the Number



Note. A significant difference in means can be observed for trust in the number in the government and social media condition.

For the ANOVA with trust in the message as the dependent variable again no significant main effect of the source $F(2, 451) = 0.21$, $p = .808$, $\eta^2 = .00$ or psychological distress $F(1, 451) = 3.12$, $p = .078$, $\eta^2 = .01$ was found. Furthermore, no significant interaction effect was observed $F(2, 451) = 1.06$, $p = .384$, $\eta^2 = .01$.

In the last ANOVA using trust in the source as the dependent variable we could once more see no significant main effects for either the source $F(2, 451) = 0.13$, $p = .879$, $\eta^2 = .00$ or psychological distress $F(1, 451) = 1.86$, $p = .173$, $\eta^2 = .00$. Moreover, no significant interaction effect could be observed $F(2, 451) = 0.44$, $p = .646$, $\eta^2 = .00$

The results obtained in this analysis provide partial support for hypothesis 4a, predicting lower trust for higher psychological distress. We observed small negative correlations between all the compound trust variables and the PHQ-4 score of participants.

The correlations for trust in the number were significant, and trust in the message was just above the 0.05 threshold. This suggests that individuals with high psychological distress experience less trust in the presented information but not in the information's source. However, the performed analyses were not in accordance with hypothesis 4b, predicting an interaction effect between the source presenting the information and psychological distress. No significant interaction effect was found in either of the three performed ANOVAs. It should be noted that there was a significant main effect of psychological distress regarding trust in the number, which further supports hypothesis 4a.

Discussion

Science communication serves as a bridge between the public and new scientific findings, which is particularly important in the ongoing COVID-19 pandemic. Our study investigated whether communication source, uncertainty communication, and psychological distress influenced participants' trust in scientific findings. Taken together, the results showed that neither the source nor the uncertainty communication had an impact on the participants' trust. What seems to be the case is that the trust formation in the participants was independent of these manipulations in the context of COVID-19 information. In contrast, psychological distress was negatively associated with multiple trust indicators, which can be interpreted as a valuable finding in light of this study, as mental well-being can be strongly influenced by COVID-19 (Wang et al., 2020). Overall, we obtained varied results in regard to previous research.

Findings by Weingart & Guenther (2016) have led us to expect that information from scientists might be more trusted than information from the government when looking at trust in the source. Thus, we proposed that trust will be higher when the information is presented as a scientific article compared to a government website. In addition, other research showed varied findings of trust and social media (Weingart & Guenther, 2016; Kim et al., 2013; Van

Dijk & Alinejad, 2020; Huber et al., 2019). Hence, we wanted to explore the differences in trust when information is communicated through social media and scientific articles. Unexpectedly, our findings did not show an influence of the source on either trust in the message, source, or number. In contrast to previous research, participants in this study seemed to have trusted information equally, whether it was presented by a governmental entity, scientific article, or via social media. The incongruency of these results could be explained by the differing contexts in which the studies were conducted. For example, Kim et al. (2013) studied trust in social media in the context of political and civic engagement, while Huber et al. (2019) directly asked participants how much they trusted scientific sources. The topic of our study, namely COVID-19 related booster shots, could have impacted our findings. Specifically, COVID-19 information is presented by the government, scientific articles, and social media outlets; hence participants might not have regarded the source as an indicator of trustworthiness. This trend might not be applicable for different contexts, opening exciting avenues for future research.

A similar trend can be observed for the uncertainty communication manipulation in our study. Van der Bles et al. (2020) demonstrated that uncertainty communication could affect trust formation when communicated verbally instead of numerically. Inspired by this, we expected decreased trust levels when uncertainty was communicated in a text since we combined both numerical and verbal uncertainty. As opposed to our prediction, a text containing uncertainty information was trusted just as much as a text containing no uncertainty communication. These findings were in accordance with previous research by Hendriks and Jucks (2020) and Kelp et al. (2021). As we did not find any effects on trust, science communicators and government agencies might be encouraged to transparently disclose uncertainty about scientific findings. It is of chief importance to understand why uncertainty communication did not impact trust in previous studies (Hendriks & Jucks, 2020;

Kelp et al., 2021) as well as this study, opposed to previous research by Van der Bles et al. (2020). A critical factor influencing trust in scientific information is prior opinions about the topic. Due to the constant exposure to COVID-19 information in the past two years, participants likely formed an opinion prior to the study, which could have impacted our manipulations' effectiveness. Moreover, the way uncertainty was communicated varied across studies. This could be another reason why the results differ. Future research could focus on topics that are subject to prior opinions vs. novel topics and different means to communicate uncertainty to understand the underlying mechanisms behind uncertainty communication, trust, and context. Furthermore, future research might examine emotionally charged vs. neutral topics, as there might be a difference when the context of the information is taken into account.

As previously established, the COVID-19 pandemic can substantially impact psychological distress due to its direct impact on the public's everyday lives. Previous research (Fiske & Dupree, 2014; Olagoke et al., 2020) indicated that personal characteristics, such as psychological distress, can have a negative association with trust. Accordingly, we expected participants to trust information less when they reported higher psychological distress symptoms by the PHQ-4 scale (Khubchandani et al., 2020). In addition, we wanted to explore whether people who scored higher on psychological distress reacted differently to information communicated by either the government or scientists through a scientific article. Interestingly, we found the mean of psychological distress as indicated by the PHQ-4 scale to be almost double (M = 7.9, SD = 3.1) in comparison to Khubchandani et al. (2020) (M = 4.36, SD = 0.08). This seems to be in accordance with Wang et al.'s (2020) results that COVID-19 influences psychological distress. Investigating the PHQ-4 scale regarding different topics might prove essential in future research.

Strikingly, we observed a significant small negative correlation between psychological distress and trust in the number. A negative correlation between trust in the message and psychological distress that was not significant but missed the alpha value of 0.05 by 0.004. This implies that there is, indeed, a correlation that other researchers could examine further. Opposed to this, the score on the PHQ-4 scale did not change participants' trust in the source presenting the information. In practice, this could mean that people's mental well-being could influence their interpretation of information instead of their perception of the source. Similarly, trust might influence the risk perception of the severity of the pandemic and the necessity of health regulations. Thus, science communicators and government agencies should keep in mind that mental health, specifically psychological distress, can affect how people interpret the news, especially in light of the pandemic.

Limitations and Further Directions

Our study has multiple limitations that need to be considered when looking at our results. First, we carefully chose the topic of the COVID-19 booster vaccines due to its high relevance to the pandemic. However, what needs to be addressed is that information about this topic is constantly presented to most people across the globe. Consequently, people might have formed their opinions about the vaccination before partaking in the study. This might have severely limited our manipulations' effect on the participants since opinions prior to the study might not be susceptible to considerable changes. In addition, during the design of the study and data collection, new news about the new Omicron strain emerged, which might have further impacted participants' preliminary opinions. Furthermore, as the COVID-19 pandemic can be considered a global crisis, people might be wary of unknown information channels due to the quick spreading of false information. Accordingly, since our sources were made up, this could have influenced the effect of our manipulation. It must be noted that not only was the topic of our study concerned with the COVID-19 pandemic, but we specifically

looked at trust in vaccine information. Vaccines are, independent of the COVID-19 pandemic, a controversial topic, which is why responses to this type of information might have been charged with prior attitudes towards vaccines in general.

Second, the uncertainty manipulation of our study is suspect to more limitations. Even though our keywords and 95% CI resembled real-life uncertainty statements, it could be the case that participants did not perceive them as strong enough. It was shown in previous research (Van der Bles et al., 2020) that specific keywords do not communicate uncertainty adequately, for example, "estimated". The same might have been the case for the keywords chosen in the study ("could," "might"). However, the statement "[…] with some uncertainty around this number" and the following 95% CI should have been sufficient. Interestingly, in the context of COVID-19, people have been exposed to similar uncertainty statements from the beginning of the pandemic, which is why the expectation of uncertainty about COVID-19 related information might have impacted the effect of our manipulation. Further research could investigate which words are strong uncertainty keywords to strengthen the understanding of influential vocabulary in science communication.

Third, the choice of our sampling method is another limitation of this study. As this study is conducted as part of a bachelor thesis, only limited sampling options were available. Due to the participants being part of a convenience and snowball sample and not a random sample, our results could have been impacted. Many of the participants were highly educated young adults. It can be expected that empirical research methods are known to contain some degree of uncertainty by the sample. This could mean that the scientifically accurate communication of uncertainty might not significantly impact trust in the conveyed information. Future research could focus on a more varied sample of COVID-19 topics to establish a sounder result base.

Practical Implications

The practical implications of this study could be highly relevant for scientists and policymakers tasked with presenting novel results. We have found that the communication of uncertainty using standard scientific measures does not influence trust formation when scientific knowledge is communicated. This implies that scientists could transparently report their findings without sacrificing the possibility to impact the recipient of the information. Furthermore, no difference in trust formation was seen when different sources presented information. This means that newfound information can be reported most conveniently to the situation. Social media presents an intriguing possibility for fast and borderless distribution of information. Since psychological distress was seen to be correlated with trust (despite not being significant due to a minor deviation from the 0.05 threshold), mental health seems to be a crucial influence that needs to be considered by policymakers and science communicators. It must be noted that the high psychological distress scores were recorded during a pandemic, which inherently changed the lifestyle of many people due to safety restrictions. This is a distress factor that cannot be easily eliminated. However, it should be of interest to focus attention on mental-health programs that could strengthen collective trust in crises.

Conclusion

The role of science communication during the COVID-19 pandemic is of great importance due to fast-emerging policies and actions favoring public safety. While our study differs partly from previous research in terms of results, there is still a crucial conclusion to be drawn. In the context of the COVID-19 topic, whether the source of information is the government, scientists, or scientists via social media, does not influence people’s trust, nor does uncertainty communication. This can be interpreted as a positive result since scientists can communicate their findings transparently instead of concealing the inherent uncertainty of scientific research.

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Appendix A

Figure A1

English Manipulation of Government Uncertainty Condition

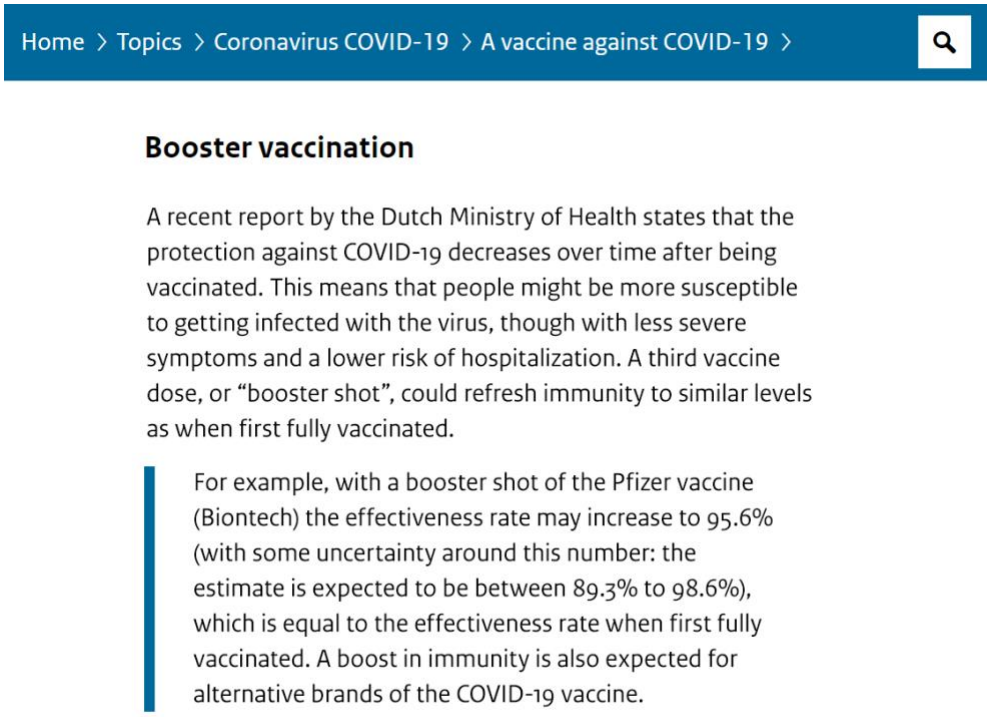

Figure A2

English Manipulation of Government No Uncertainty Condition

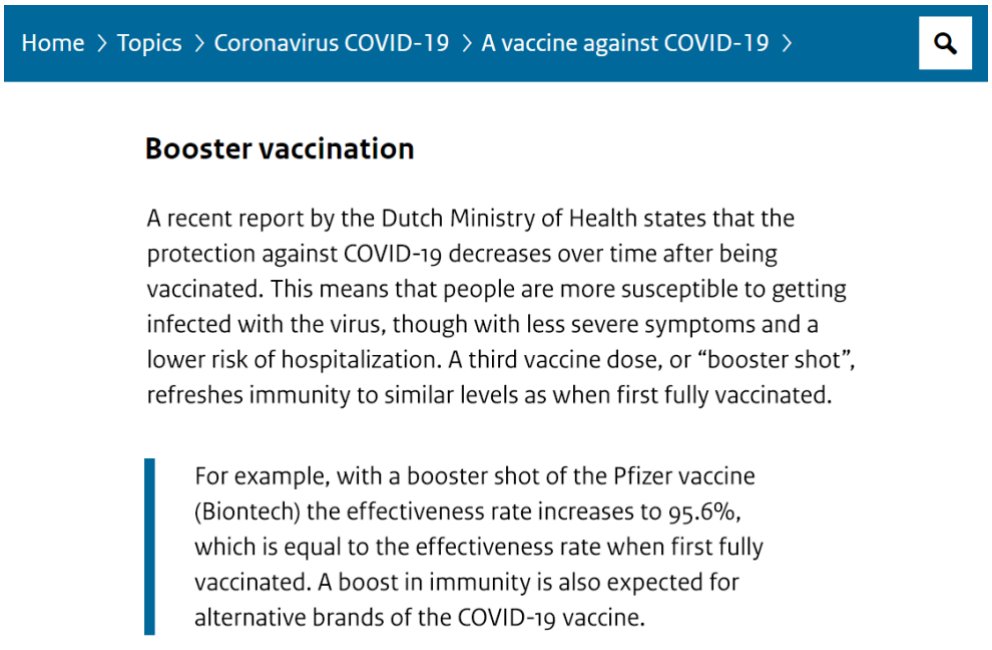

Figure A3

English Manipulation of Scientific Article Uncertainty Condition

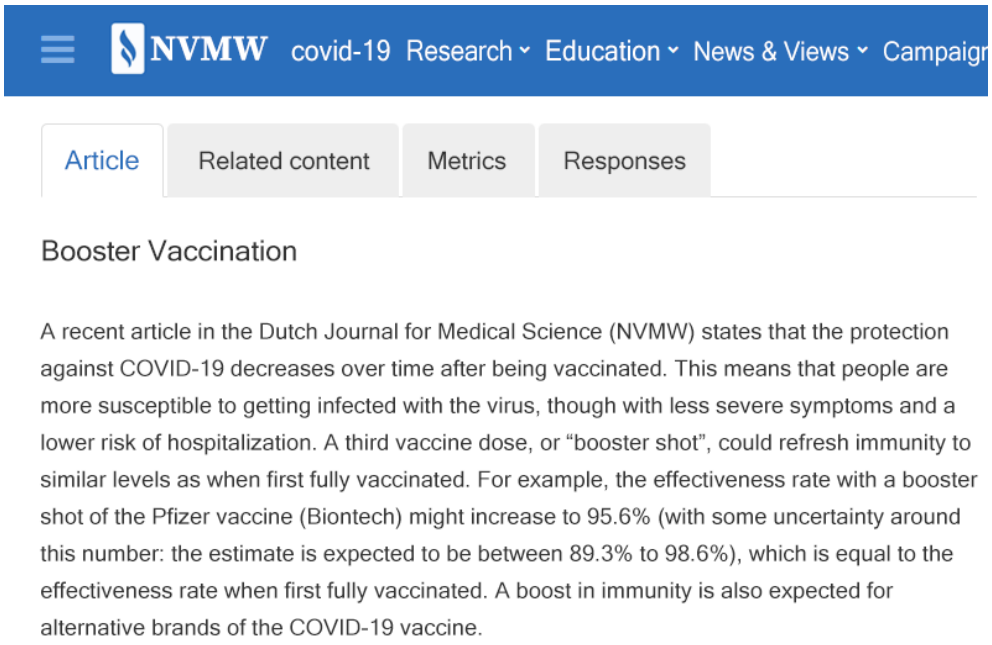

Figure A4

English Manipulation of Scientific Article No Uncertainty Condition

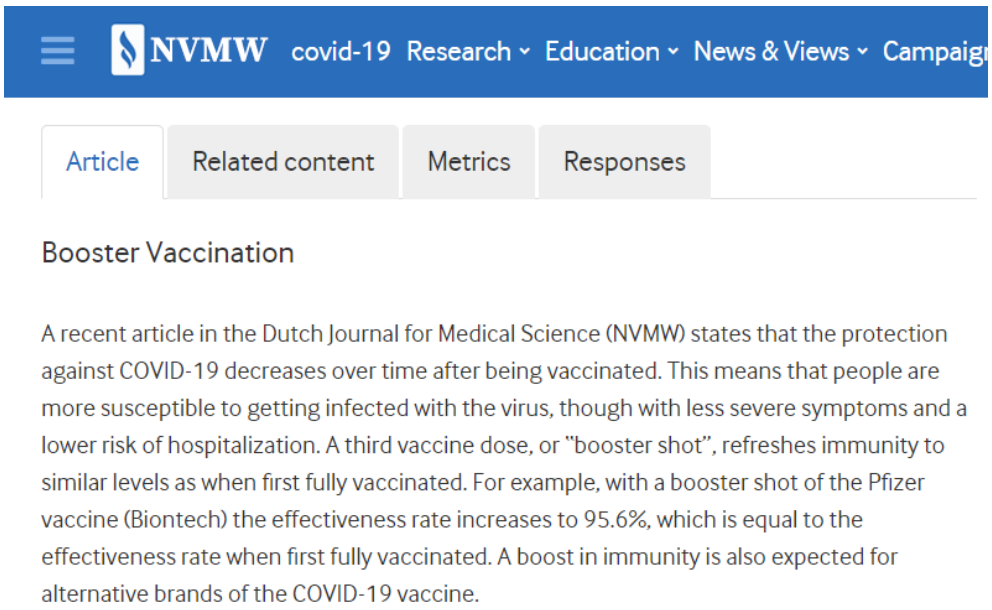

Figure A5

English Manipulation of Scientists via Social Media Uncertainty Condition

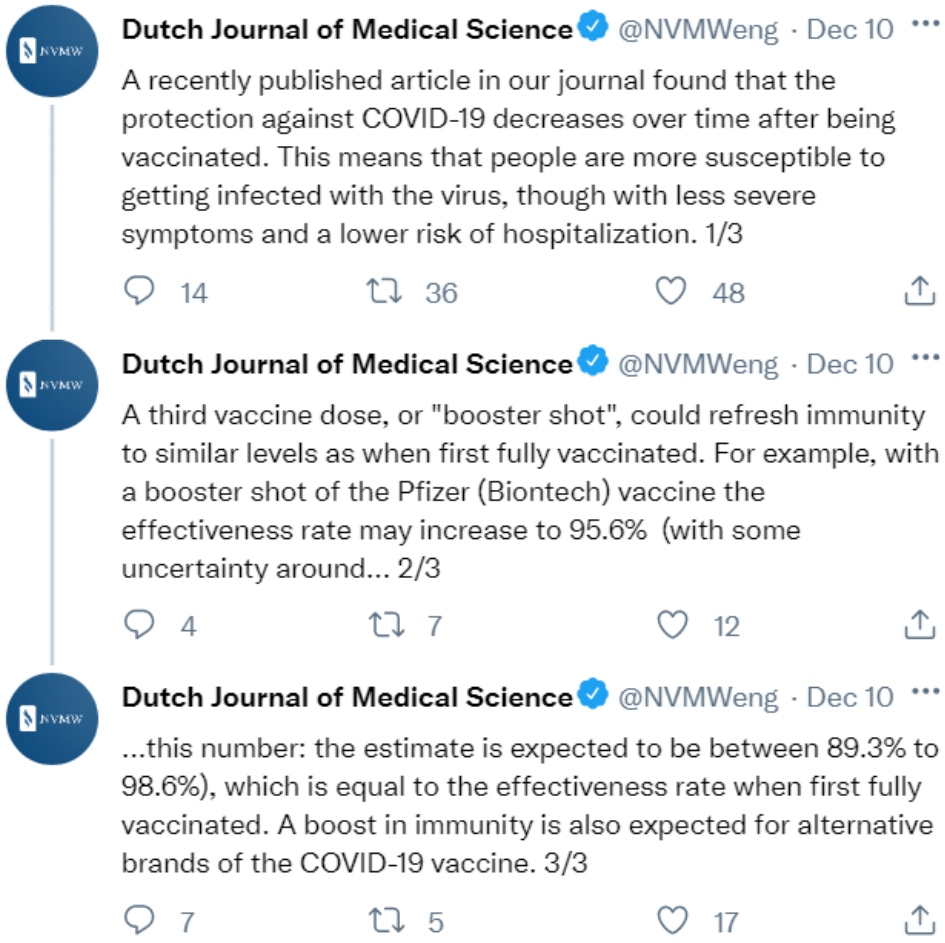

Figure A6

English Manipulation of Scientists via Social Media No Uncertainty Condition

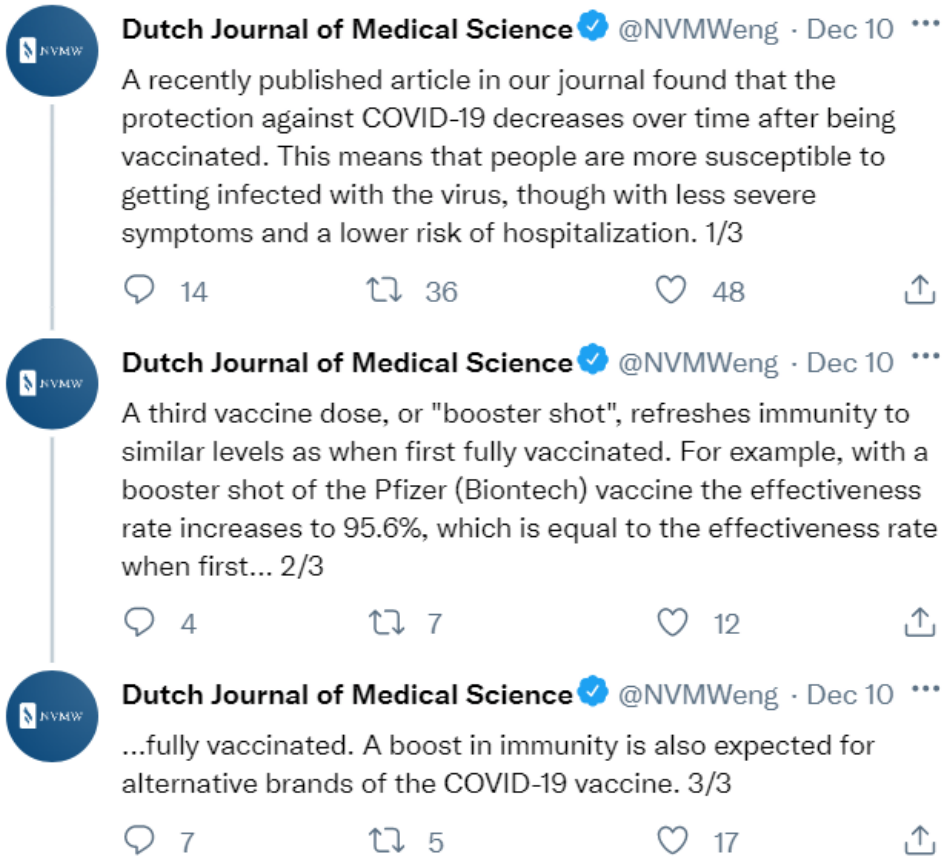

Figure A7

German Manipulation of Government Uncertainty Condition

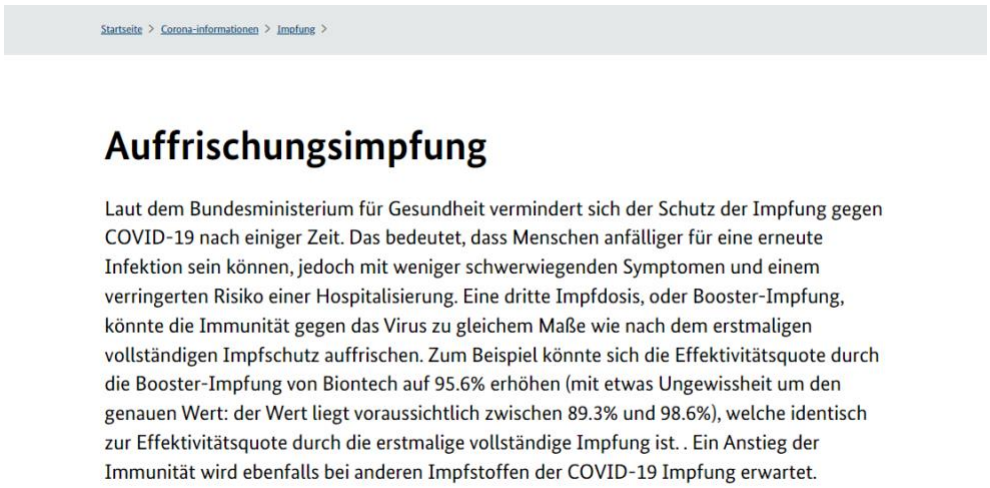

Figure A8

German Manipulation of Government No Uncertainty Condition

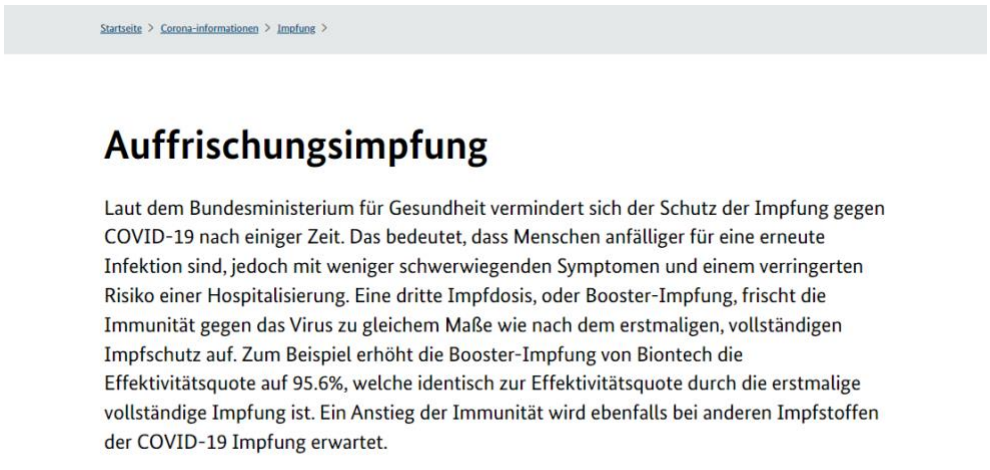

Figure A9

German Manipulation of Scientific Article Uncertainty Condition

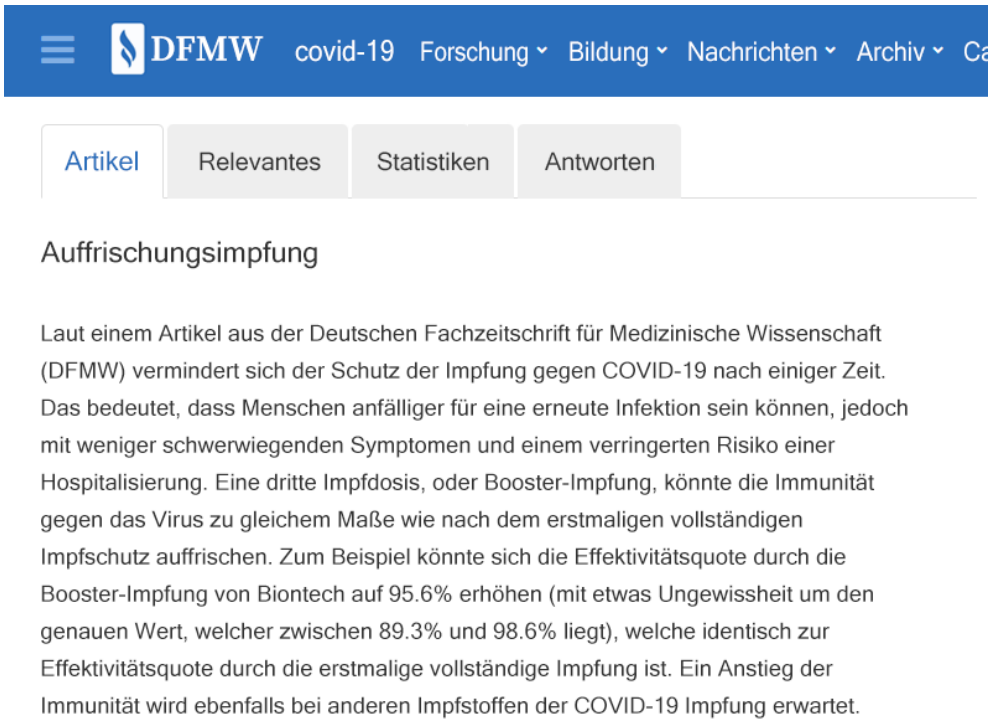

Figure A10

German Manipulation of Scientific Article No Uncertainty Condition

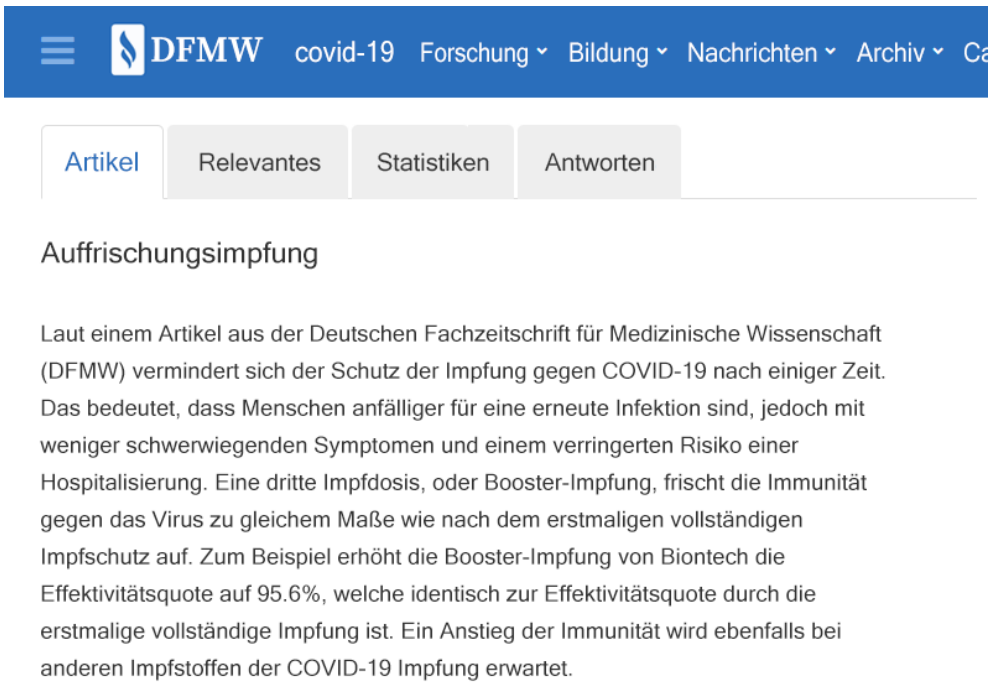

Figure A11

German Manipulation of Scientists via Social Media Uncertainty Condition

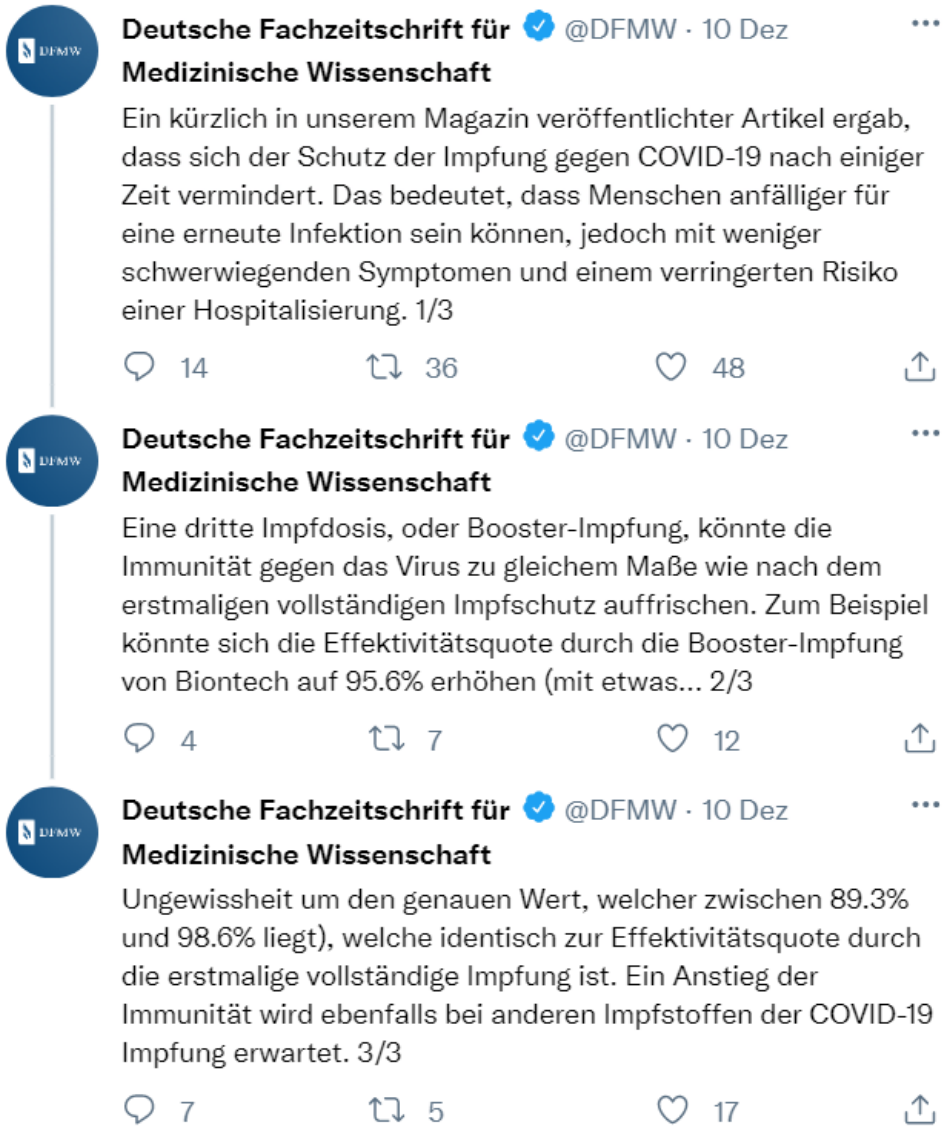

Figure A12

German Manipulation of Scientists via Social Media No Uncertainty Condition

Figure A13

Dutch Manipulation of Government Uncertainty Condition

Figure A14

Dutch Manipulation of Government No Uncertainty Condition

Figure A15

Dutch Manipulation of Scientific Article Uncertainty Condition

Figure A16

Dutch Manipulation of Scientific Article No Uncertainty Condition

Figure A17

Dutch Manipulation of Scientists via Social Media Uncertainty Condition

Figure A18

Dutch Manipulation of Scientists via Social Media No Uncertainty Condition

Appendix B

Action intention based on information in the message

We informed participants that they are going to be asked how they make use of the received information. Thus, action intentions were explored by asking participants whether they would receive a booster shot if the opportunity was given to them, whether they would recommend it to their friends, and two more questions about their adherence to COVID-19 safety regulations, for example: "I always wear face masks when it is institutionally recommended" (1 = *Strongly disagree* to 7 = *strongly agree).*

Feeling thermometer (based on warmth-competence map by Fiske et al. (2014))

To investigate the perceptions participants have about various types of groups of people, we used a feeling thermometer based on the warm-competence map by Fiske et al. (2014). Participants were asked to indicate how warm/positive or cold/negative they felt about civil servants, scientists, politicians, journalists, and content creators on a 10-point scale, and to what extent they perceived these same groups as competent or incompetent on a 10-point scale.

Trust and satisfaction in government of residency

Opinions and prior beliefs about the national government that has been in charge for the past 2 years has been assessed with 8 items from the European Social Survey (European Social Survey, 2012). The goal of this was to explore general trust levels in the government. First, participants had to respond to a set of statements, for example "I trust the Dutch/German government" (1 = *"Strongly disagree"* to 7 = "*Strongly agree")*. Second, satisfaction with the government was assessed with four items. For example, we asked "On the whole, how satisfied are you with the way democracy works in the Netherlands/Germany?" (1 = *"Very dissatisfied"* to 7 ="*Very satisfied"*). Lastly, three items were administered to explore political interest and orientation.

Intolerance of uncertainty scale (Carleton, Norton, & Asmundson (2007))

Intolerance of uncertainty in participants was measured by Carleton's et al. (2007) Intolerance of Uncertainty Scale (IUS-12) with 12 items in total. Participants had to indicate how much specific statements were characteristic of them. For example, "Unforeseen events upset me greatly", "I can't stand being taken by surprise" and "When I am uncertain I can't function very well" (1 = *not at all characteristic of me*, 5 = *very characteristic of me*).

Social media usage

We explored participants' social media usage and perceptions with a 4-item scale. Facebook, Instagram, Twitter, YouTube, TikTok, Reddit, and Pinterest were counted as social media. For example, we asked "Thinking ahead, how often do you plan on using these sites in the upcoming months?" (1 = *Never* to 7 = *Multiple hours a day*).

Perceived severity of COVID-19 pandemic

To examine the perceived severity of the COVID-19 pandemic inspired by Olagoke et al. 2020), one item was administered: "Coronavirus is a serious infection for me to contract" (1 = *Strongly disagree* to 7 = *Strongly agree).* Additionally, we offered an open response option in which the participants could express their personal thoughts about the COVID-19 pandemic.

Vaccination status

For vaccination status, we simply asked participants whether they are vaccinated *(Yes, no, prefer not to say).*

Socioeconomic status

Socioeconomic status was measured by asking participants to indicate their highest obtained educational qualification based on the European Social Survey. We asked about their current employment status with one item. Subjective Social Status was assessed using

the the MacArthur Scale of Subjective Social Status (Nancy Adler et al., 2000), which asks participants to rate themselves on a social ladder ranging from 0 to 10.

Appendix C

Table C1

Shapiro-Wilk Test for Normality for Trust in Message in Each Group Condition

Group Condition	Statistic	*df*	*p*
Government Website	.881	155	< .001
Scientific Article	.870	155	< .001
Scientist Social Media	.899	153	<.001
Uncertainty	.902	233	<.001
No Uncertainty	.866	230	< .001

Note. Tests the null hypothesis that residuals are normally distributed. All groups have significant results; therefore the data cannot be treated as normal.

Table C2

Shapiro-Wilk Test for Normality for Trust in Source in Each Group Condition

Group Condition	Statistic	*df*	*p*
Government Website	.904	155	< .001
Scientific Article	.919	155	< .001
Scientist Social Media	.878	153	<.001
Uncertainty	.924	233	<.001
No Uncertainty	.877	230	< .001

Note. Tests the null hypothesis that residuals are normally distributed. All groups have significant results; therefore the data cannot be treated as normal.

Table C3

Shapiro-Wilk Test for Normality for Trust in Number in Each Group Condition

Group Condition	Statistic	*df*	*p*
Government Website	.916	155	< .001
Scientific Article	.886	155	< .001
Scientist Social Media	.915	153	<.001
Uncertainty	.900	233	<.001
No Uncertainty	.917	230	< .001

Note. Tests the null hypothesis that residuals are normally distributed. All groups have significant results; therefore the data cannot be treated as normal.

Table C4

Levene's Test of Equality of Error Variances for Trust in Message

Basis of test[a,b]	Levene Statistic	*df1*	*df2*	*p*
Based on Mean	1.362	5	451	.238
Based on Median	0.938	5	451	.456
Based on Median and adjusted df	0.938	5	426.058	.456
Based on trimmed mean	1.196	5	451	.310

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups. Results are significant, therefore equal variance for all groups cannot be assumed.

[a]Dependent Variable: Trust

[b]Design: Intercept + Format + Type + Format * Type

Table C5

Levene's Test of Equality of Error Variances for Trust in the Source

Basis of test[a,b]	Levene Statistic	*df1*	*df2*	*p*
Based on Mean	0.495	5	451	.780
Based on Median	0.473	5	451	.797
Based on Median and adjusted df	0.473	5	430.303	.797
Based on trimmed mean	0.521	5	451	.761

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups. Results are significant, therefore equal variance for all groups cannot be assumed.

[a]Dependent Variable: Trust in Message

[b]Design: Intercept + Format + Type + Format * Type

Table C6

Levene's Test of Equality of Error Variances for Trust in Number

Basis of test[a,b]	Levene Statistic	*df1*	*df2*	*p*
Based on Mean	0.797	5	451	.552
Based on Median	0.567	5	451	.725
Based on Median and adjusted df	0.567	5	441.781	.725
Based on trimmed mean	0.697	5	451	.626

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups. Results are significant, therefore equal variance for all groups cannot be assumed.

[a]Dependent Variable: Trust

[b]Design: Intercept + Format + Type + Format * Type