Trust in Uncertain Scientific COVID-19 Information: The role of the Source and Intolerance of Uncertainty

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Abstract

The present research seeks to find insight into how to communicate scientific information effectively. Since science comes with uncertainties, it is important how to convey this type of uncertainty to the public without losing trust. In the context of COVID-19, this study manipulates uncertainty and different sources to find out the effects on trust. Moreover, it is tested whether intolerance of uncertainty influences trust. The study uses a dataset from an online study (*N*=197). Participants read a text about the effectiveness of the booster shot of the COVID-19 vaccine (Pfizer/Biotech). In the text was uncertainty either present or absent and communicated by a different source (the government vs. scientists). Findings show that although people perceived uncertainty when it was present, this did not affect their trust in the information or the source. Also, no effect of intolerance of uncertainty was seen. This suggests communicators can be more transparent in communicating scientific uncertainty.

Keywords: uncertainty, scientific communication, intolerance of uncertainty, COVID-19, trust.

Trust in Uncertain Scientific COVID-19 Information: The role of the Source and Intolerance of Uncertainty

In December 2019 the first outbreak of the coronavirus was identified in Wuhan China and declared as a worldwide pandemic in March 2020 (World Health Organization, 2020). In October 2022, the virus caused more than 6.5 million deaths and 624 million confirmed cases globally (John Hopkins University, 2022). The pandemic caused a lot of uncertainty worldwide (Rettie & Daniels, 2020). The absence of a vaccine forced the world to adapt to certain measures like social distancing and lockdowns. Even after the first vaccine was available uncertainty remained. For instance, there was uncertainty about the characteristic of the new Omicron variant, the effectiveness of measures, and the rise of misinformation and fake news (Apuke & Omar, 2021; Ferreira Caceres et al., 2022; Roozenbeek et al., 2020). As a result, the relevance of communicating scientific information became evident. More specifically, communicating scientific information effectively means informing transparently without persuasion, so that the audience is provided with a solid base for decision-making (Fischoff & Scheufele, 2013). This entails openly communicating the certainties, but also the uncertainties regarding the information (Van der Bles et al., 2019).

A general assumption is that communicating uncertainty causes people to trust the information less. In this context, one might think communicating uncertainty will do more harm than good because it feeds into the (scientific) uncertainty that is already present. Communicating uncertainty could convey the impression of incompetence, provoke criticism and decrease trust (Fischhoff, 2012). On the contrary, increasing openness and transparency about scientific uncertainty may re-establish public trust in science (Van der Linden & Löfstedt, 2019).

Uncertainty communication's effects remain unclear hence the goal of this research is to investigate whether presenting uncertain scientific COVID-19 information affects trusting

this information. Moreover, the effects of different sources of communication are investigated. The aim is to find out whether there are different reactions to the sources communicating, like the government and scientists. These sources play a big role in communicating to the public during the pandemic. Additionally, there is reason to think that not all people can tolerate this type of uncertainty; individuals differ in this respect. This paper will focus on Intolerance of Uncertainty (IU). This concept describes how people struggle to deal with uncertainty as a result of unfavorable expectations and beliefs about it (Buhr & Dugas, 2009). The present research also seeks to better understand if communicating uncertain scientific COVID-19 information elicits a different reaction in people who score high (versus low) on intolerance of uncertainty (IU).

Uncertainty Communication

The effects of communicating uncertainty have been studied across a wide variety of disciplines in the past (Van der Bles et al., 2019). First, it needs to be assessed what uncertainty is. According to the Cambridge Dictionary, the definition is "A situation in which something is not known or something that is not known or certain". Van der Bles et al. (2019) distinguish between two different kinds of uncertainty: aleatoric uncertainty about the future that we cannot know (e.g. what will happen tomorrow) and epistemic uncertainty about prior and current states that we do not know but theoretically could know (e.g. uncertainty because of limited methodology). The focus of this paper is on the latter because there are so far only mixed and limited findings on what the effects of communicating epistemic uncertainty are (Van der Bles et al., 2019). For instance, according to Johnson's research in 2003, uncertainty conveyed by estimated numerical ranges seems to (e.g. between 14.000 and 20.000) signal honesty and competency. Although it also conveys dishonesty and incompetence for other people. Other research showed no effect on perceived credibility when communicating uncertainties around estimates (Gustafson & Rice, 2019).

During the corona pandemic, especially in its first two years, all knowledge on which decisions and policies have been or are based has a certain degree of epistemic uncertainty. We do have numbers about the effectiveness of different vaccines for example, but these are associated with a certain degree of uncertainty because they are based on samples of a population and tested when a particular variant of the virus is dominant. Communicating this kind of uncertainty by the government and policymakers to the public could lead to a decrease in trust (Fischhoff, 2012).

Communicating Uncertain Scientific Information and Trust

The practice of science is always fraught with uncertainty, but uncertainty is not always clearly conveyed to the public (Fischhoff, 2012). It is often assumed that communicating uncertainty could lead to less trust in science by the public (Johnson & Slovic, 1995). On the other hand, transparency is also considered to be an essential part of trust in the government. A study by Grimmelikhuijsen et al. (2013) revealed that government transparency has a negative effect on trust in the government. This may be because experts are afraid that uncertainty could be seen as misplaced imprecision, or they expect the laypeople do not understand the uncertainties they are facing (Fischhoff, 2012). Furthermore, research by Algan et al. (2021) emphasizes the importance of trust in scientists in the context of the COVID-19 pandemic. They argue that trust in scientists is essential for compliance and support for nonpharmaceutical interventions (e.g. lockdowns and wearing facemasks in public areas). Thus, communicating uncertainty could have negative consequences on public trust and is therefore important to examine further.

A recent paper by Van der Bles et al. (2020) is one of the first to examine how communicating uncertainty influences public trust in numbers and their sources. Specifically, these authors focused on verbal (i.e. expressing uncertainty by using words like “estimated” or “could be higher or lower”) and numerical (i.e. expressing uncertainty by numbers e.g.

"between 17.000 and 30.000") uncertainty on perceived uncertainty and trust. They conducted a series of experiments across different topics, formats (verbal vs. numeric), and magnitudes (low vs. high). Uncertainty was communicated through numerical ranges and words in a short text. These texts had three topics for example the number of tigers left in India. Overall, the results showed only a small decrease in trustworthiness when communicating uncertain scientific information than when no uncertainty was communicated (no substantial differences in responses were found between topics and the magnitude of the uncertainty). In particular, the strongest effect was found when communicating uncertainty verbally. Van der Bles and collaborators suggest this might be due to individual differences in interpreting the words that communicate uncertainty (e.g. 'estimated" or "could"). Furthermore, in most numeric and verbal formats, trust decreased (except numerical range with point estimate and implicit verbal), while in none of the uncertainty formats compared to not communicating uncertainty, did trust in the source decrease. Building upon these results, the first hypothesis in the present research is:

H1: "*Trust in scientific COVID-19 information is lower when uncertainty is communicated in comparison to when no uncertainty is communicated"*

Van der Bles and collaborators used an "official report" as the source. Thus, they did not explicitly specify whom the source communicating was, to avoid source bias. This implies that sources like the government or a scientist could still potentially have different effects on trust.

Different Sources

As stated earlier, people's trust in information can be affected by the source of this information (Fiske & Dupree, 2014; Van der Bles et al., 2020). Scientists and governments have been under strain due to the pandemic. Thus, the point of interest in this research is to investigate these communication sources. Prior research suggests that the source

communicating could elicit different reactions (Fiske & Dupree, 2014). Particularly during the COVID-19 pandemic, these different sources are relevant. The study of Algan et al. (2021) suggests that the perceptions of the trustworthiness of scientists and the government may differ. Algan et al. (2021) conducted large-scale surveys in 12 countries on trust in scientists and the government during the COVID-19 pandemic. They found that the level of trust in scientists was an important determinant for adhering to the corona measures (e.g. social distancing), whereas the trust in the government was not. Moreover, according to Fiske and Dupree (2014), people base their decision on whom to trust on their perceived warmth and competence. They discovered that scientists were seen as highly competent, but scored average on warmth, and politicians were scoring low on both. Thus, there is reason to think that people will trust scientists more than they will trust the government. In addition, a study by Osman et al. (2018) suggests that scientists are seen as more trustworthy than the government. Hence, these different perceptions of the trustworthiness of scientists and the government make it interesting to look into. Based on these findings the second hypothesis is:

H2: "Trust in scientific COVID-19 information is higher when scientists are the communicating source, than when the government is the communicating source"

Concluding, factors affecting trust by communicating uncertainty can be both the way this is communicated (numerical vs. verbal) and the source of the communication (e.g. government vs. scientists). Moreover, as will be elaborated upon in the next paragraph, the impact of communicating uncertainty can also depend on the individual characteristics of the individual to whom is being communicated.

Intolerance of Uncertainty

The pandemic not only has had an impact on individuals' physical health but also on their psychological health (Brooks et al., 2020). Holmes et al. (2020) stated that mental health concerns and psychological factors influencing distress are a key priority during these times.

Long-lasting psychological distress in the population could have a big socioeconomic impact and in turn strain mental health services. Thus, it is important to acknowledge that people can react differently to this uncertainty.

In particular, people with high intolerance of uncertainty (IU) can react more strongly to uncertainty. IU is defined as an individual's dispositional tendency that comes from negative beliefs about uncertainty and its repercussions (Dugas & Robichaud, 2007). This is the inability to cope with uncertainty and the idea that negative things can happen without being able to anticipate such events (Carleton et al., 2007). People who are intolerant of uncertainty see ambiguity as threatening which leads to inaction and avoidance (Dugas et al, 2005; Heydayati et al., 2003). Furthermore, findings suggest high IU is associated with information processing bias (Dugas et al., 2005). People with high IU see ambiguous information more troubling than people with low IU. They are more focused on the negative outcomes of that information. Thus, IU affects the processing of information. Findings have shown IU is a significant risk factor in psychopathologies such as anxiety, depression, and panic disorders among both clinical and non-clinical populations (McEnvoy et al., 2019; Reizer et al., 2021). Meaning IU is relevant in non-clinical samples and therefore important to study its effects further.

Building upon this, this thesis will investigate how people high in IU will react to the specific context of the COVID-19 pandemic. There is some evidence of prior studies of people who are intolerant of uncertainty reacting in the context of pandemics such as H1N1. People who were intolerant of uncertainty assessed the virus as more stressful and less controllable and experienced a higher level of anxiety than people who are tolerant of uncertainty (Taha, Matheson & Anisman, 2013; Taha, Matheson, Cronin & Anisman, 2013). More recent studies show the negative effects of IU during COVID-19. It has been found that IU was positively associated with more anxiety, especially when they perceived the

coronavirus as more threatening (Bakioğlu et al., 2021; Del Valle et al., 2020; Marín-Chollom & Panjwani, 2022). This is in line with prior research showing that IU also interacts with threat perceptions and not only functions independently (Pepperdine et al., 2018); IU plays a role in the acquisition and maintenance of worries, which makes people score high on IU more prone to uncontrollable catastrophic thoughts about a threat (Ladouceur et al., 2000). In particular, IU seems to be a risk factor for COVID-19 safety behaviours and worries (Saulnier et al., 2022). To conclude, people with high IU are more affected by the uncertainty the pandemic brings than people with low IU.

Gvozden et al. (2021) studied how fear of the coronavirus was affected by IU and trust in governmental and medical institutions. Their model showed trust in institutions reduced the worrying and fear of the virus directly but also indirectly as it comes with a feeling of control which reduces the tendency to worry. The findings demonstrated an indirect impact of IU caused by stressing over the coronavirus. Suggesting people with high IU tend to worry more which intensifies the fear of the coronavirus and its consequences. They also found trust in health institutions has an impact on the fear of the coronavirus and its consequences directly and indirectly via IU. This seems to be in line with prior findings that trust in institutions is accompanied by reduced fear and anxiety in the context of health-threatening situations (Sapp & Bird, 2003; Cheung & Tse, 2008). Based on this one might assume that in times of uncertainty like the corona pandemic, people who are intolerant of uncertainty will have lower trust in institutions and the information they carry out. Thus, the third hypothesis will be:

H3: *"People scoring high on intolerance of uncertainty trust scientific COVID-19 information less than people scoring low"*

The Present Study

In sum, the present research seeks to investigate how people respond to uncertain

scientific COVID-19 information. The first hypothesis states that trust in scientific COVID-19 information is lower when uncertainty is present in comparison to when it is absent. Then, secondly, it is hypothesized that trust is higher when the source communicating is scientists than when the source communicating is the government. Next, it is hypothesized that people scoring high on IU will trust the information less in comparison to people scoring low on IU.

Specifically, the present study seeks to investigate communication factors that influence trust in COVID-19 information, in particular the booster shot. To this end, the source of the communication will be manipulated (government vs. scientists), and the effect of communicating with uncertainty and without uncertainty on trust.

Method

Participants

The present study used data from a study already conducted by a Bachelor Thesis group from the University of Groningen (Shea Casby, Leontina Runze, Alexandra Schmiezek, Amber Sykes and Milicia Vucinic). The students made the survey in both English and German (since some of them were German). Together with A.M. van der Bles,[1], this survey was translated into Dutch. Participants were recruited via a Qualtrics survey link on Prolific; all participants were living in the Netherlands and spoke Dutch fluently. The bachelor students also distributed the Qualtrics link to their network. I am only using the data from the Dutch survey via Prolific. The data collection through Prolific took one to two days and participants were paid €1.19 for participating. The survey was approved in advance by the Ethics Committee of Psychology (ECP).

A prior power calculation was performed by utilizing G*Power to determine the required sample size (Faul et al., 2007). This resulted in a minimum of 176 participants, for detecting a medium effect size (d = .5 and power of .95). In total 319 Dutch people were

[1] During this project, A.M. van der Bles was my initial thesis supervisor. She also supervised the Bachelor Thesis project.

recruited via Prolific. The third condition which was "Scientists on social media" (*N*= 102) was filtered out because it is outside the purview of the current research. Five participants were filtered out because they did not answer the manipulation check correctly (answers between 80-99% were taken as valid). Moreover, 14 participants had to be excluded due to incomplete data resulting in a final sample of 197 participants. All participants were living in the Netherlands. The mean age was 28.8 (*SD* = 9.7). Of the respondents 96 (48.8%) indicated being men, 97 (42.2%) indicated being women, and 4 (2.0%) indicated being non-binary or divers. The highest educational qualifications participants obtained or were pursuing were HBO Bachelor (29.4%), WO Bachelor (20.3%), and WO Master (28.4%). The current employment status of the participants was either student (36.0%), employed full-time (32.0%) or employed part-time (16.8%).

Procedure and Design

This study was based on a 2 (uncertainty: yes, no) x 2 (source: government vs. scientists) between-subjects experimental design[1]. The survey started by asking participants for their informed consent. The goal of the research was described as to gain a better understanding of how people interpret facts and numbers in messages about the COVID-19 vaccine. Moreover, the further procedure was briefly sketched (providing consent, reading a short article, duration of the questionnaire, and the required minimum age was mentioned). Moreover, it was stressed that the research was fully voluntary and anonymous. Finally, participants were asked to give their consent (with a click) and were also given contact information for any further questions.

Manipulation

After the participant gave consent, they were directed to one of the four different texts about the effectiveness of the COVID-19 vaccine. These conditions were predicated on

[1] In the original dataset there is an extra source condition called "scientists on social media". This paper will keep this condition out of consideration for further examination.

altering the communication source and including uncertainty or not. Either the government or scientists were the source of communication. For the government condition, the website of the Dutch Government was recreated and the message was added to the layout. As for the scientists' condition, the fictitious “Dutch Journal for Medical Science” was created. All conditions contained a standard text. The uncertainty condition contained verbal uncertainty by texts like ‘*might be’* and ‘*could*’. And numerical uncertainty by adding ‘with *some uncertainty around this number: the estimate is expected to be between 89.3% to 98.6%’*. See Appendix A for an overview of all four manipulated conditions.

The numbers mentioned in the texts are the real effectiveness rates (Pfizer, 2021). The logos and sources were created for high ecological validity. The demographics of the participant were asked (age, gender, highest educational qualification, and current employment status). Further, the participants did not know beforehand the exact nature of the manipulation, by not making explicit which other conditions are presented in the experiment. Finally, the participant was carefully debriefed about the actual purpose and details of the study and got the chance to comment on the study. When finished they were given €1.19 compensation.

Measures

Manipulation Checks

Manipulation checks consisted of two items. The first one was by asking what the estimated effectiveness rate mentioned was which was an open question. For the effectiveness rates, an answer in the range of 80-99% was considered an indication that the participant read the text. The second question was if the message implied uncertainty or not. Here they could answer: yes, no, I don’t know or I don’t remember. This question was to check whether the participant perceived to be in the condition they were directed to. This was also to check whether major inconsistencies between the directed condition and the perception of the

participant were found, which was not the case. There were no further consequences for the participants who answered incorrectly because this did not influence their answers to the variables.

Perceived Uncertainty

Perceived uncertainty was measured to show whether the manipulation was effective in that participants perceived the numbers to be more uncertain when uncertainty was communicated than when it is absent. Perceived uncertainty was measured by two items on a 7-point Likert-scale: "To what extent do you think that this number is certain or uncertain?" (*1 = Very uncertain* to *7 = Very certain)* and "How much uncertainty do you think there is about this number?" (*1 = No uncertainty at all* to *7 = A lot of uncertainty)* (*r*= .54). For the analysis the first item was reversed.

Trust

Three variables were distinguished into subscales to measure trust: Trust in the number, trust in the information, and trust in de communication source. All items were assessed by a 7-point Likert scale where 1 = *Not at all* to 7 = *Completely*.

Trust in the Number. The dependent variable of trust in the number (the effectiveness rate of the vaccine) consisted of three items: "How reliable do you think this number is?", "How trustworthy do you think this number is?" and "To what extent do you believe this number to be true?". The combined score of these items has high internal consistency ($\alpha = 0.94$).

Trust in the Information. The dependent variable of trust in the information consisted of two items: "How much do you trust the information about the efficacy of booster shots given in the message you have just read?" and "How reliable do you think the information about the efficacy of booster shots given in the message you have just read is?" These two items were combined to the variable trust in the information, due to a high

correlation ($r = 0.85$).

Trust in the Source. The dependent variable trust in the source consisted of two items: "To what extent do you think the people who wrote this report/article are trustworthy?" and "To what extent do you think the people who are responsible for the numbers are trustworthy?". These two items were combined due to a high correlation ($r = .75$).

Intolerance of Uncertainty

Intolerance of uncertainty was measured by the Intolerance of Uncertainty scale (IUS-12) (Carleton et al., 2007). This consists of 12 items which are scored with a 5-point slider where *1 = Not at all characteristic of me* to *5 = Entirely characteristic of me*. For example, "Unforeseen events upset me greatly" or "It frustrates me not having all the information I need". The combined score of these 12 items has high internal consistency ($\alpha = 0.88$). The total scores are used to assess global IU. See Appendix B for the complete scale.

For the analysis, IU was dichotomized into two groups based on a median split (*Median* = 34): High IU and low IU, based on their total scores on the IUS-12. With scores of 34 or above, participants were assigned to the high IU group ($N = 102$). If participants scored lower than 34, they were assigned to the low IU group ($N = 95$).

Psychological Distress

As mentioned before, high intolerance of uncertainty is linked to elevated levels of anxiety and psychological distress (Khubchandani et al., 2021; Taha et al., 2013; Reizer et al., 2021). For this reason, this paper also looks into the variable psychological distress. Psychological distress was measured by the PHQ-4 Scale (Kroenke et al., 2009). This scale consists of 4 items with a 4-point slider where *1 = Not at all, 2 = Several days, 3 = More than half of the days, and 4 = Almost every day*. The statements were, if you have been bothered over the past two weeks by: "Feeling nervous, anxious or on edge", "Not being able to stop or control worrying/worries", "Feeling down, depressed or hopeless" and "Little interest or

pleasure in doing things". The combined score of these four items has high internal consistency (α = 0.85).

Action Intentions

Action intentions were assessed by four items. Participants were asked how they would make use of the information they just read. The first one being "If it were offered to you, how likely would you be to take a booster shot?" where *1= Not at all* to *7= Very likely* or they could answer *8 = I already received a booster shot*. Followed by these three statements: "I would recommend a friend to take a booster shot", "I always wear a facemask when it is mandatory" and "I always adhere to the social distancing rules" where *1= Strongly disagree* to *7= Strongly agree*. The combined score of these four items has good internal consistency (α = 0.73)

Results

For the statistical analysis, the final sample consists of 197 participants. The distributions of conditions consisted of uncertainty present (*N*= 99) or absent (*N*=98) and the source communicating either government (*N*=97) or scientists (*N*= 100) and the IU groups high (*N*=102) or low (*N*=95). The assumption of independence is met because participants were randomly allocated to the conditions and filled out the survey independently. The data were checked for normality. The Shapiro-Wilk test indicated that all dependent variables and manipulations were significant, meaning that the data are non-normal. However, because of the large sample size and ANOVA being a robust technique, the planned analysis can still be done.

Levene's test of equality of error variances was conducted to test homoscedasticity. The dependent variables "*trust in the number*" $F(7, 189) = 2.23$, $p = .031$ and the dependent variable "*trust in the information*" $F(7,189) = 2.108$, $p = 0.064$ were (marginally) significant. Thus, the assumption of homoscedasticity is mildly violated. However, again, because the

group sizes of the manipulations are roughly evenly distributed, ANOVA remains robust against these violations. Descriptive statistics are shown in Table 1.

Table 1: *Means, Standard Deviations and Intercorrelations.*

Variables	*M*	*SD*	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Perceived uncertainty	3.5	1.1	(0.70)						
(2) Trust in the number	5.1	1.3	-.60**	(0.94)					
(3) Trust in the information	5.2	1.3	-.53**	.78**	(0.92)				
(4) Trust in the source	5.4	1.1	-.45**	.70**	.75**	(0.84)			
(5) Intolerance of uncertainty	34.2	8.8	.04	.04	.05	-.04	(0.88)		
(6) Psychological distress	2.0	.7	.14	-.11	-.07	-.09	.47**	(0.85)	
(7) Action intentions	5.6		-.42**	.59**	.60**	.64**	.17*	.04	(0.73)

Note. The Cronbach's alphas are shown in the upper diagonal.
N= 197
*$p < 0.05$, **$p < 0.01$

Inferential analysis

The first hypothesis was that when uncertainty is present, trust is lower than when it is absent. The second hypothesis was that trust is higher when the communicating source is scientists in comparison to when the communicating source is the government. The last hypothesis was that people who score high on intolerance of uncertainty trust the message less than people who score low on intolerance of uncertainty. To test this, a 2 (Uncertainty: yes/no) x 2 (Source: government/scientists) x 2 (Intolerance of uncertainty: low/high) analysis of variance (ANOVA) was conducted.

The Effect of Uncertainty Communication and Source

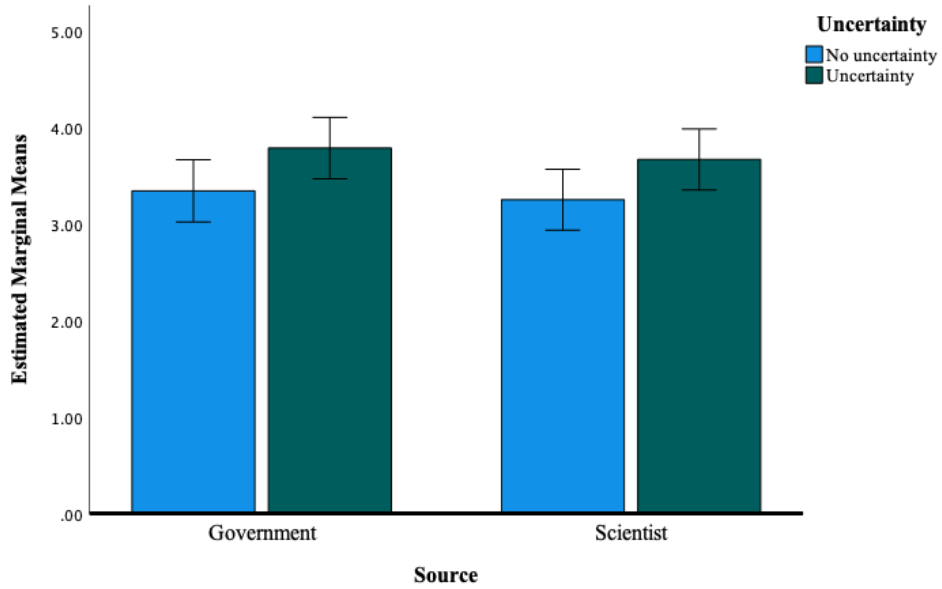
Perceived Uncertainty.

First, it was checked if the manipulation was effective in that participants perceived uncertainty when uncertainty was communicated in comparison to when it was absent. The ANOVA did result in a significant main effect for uncertainty, $F(1,189) = 7.11$, $p = .008$; partial $\eta^2 = .036$. When uncertainty was communicated, participants also perceived the

uncertainty that was present,(M = 3.73, SD = 1.14) than when it was absent (M = 3.30, SD = 1.11). This implies uncertainty has been perceived, independent of the source. This is displayed in Figure 1.

Figure 1

Perceived Uncertainty: Sources and Uncertainty



Furthermore, the ANOVA did not show a main effect for source $F(1,189)= .42$, $p= .517$, or the interaction effect for source and uncertainty $F(1,189)= .01$, $p= .933$.

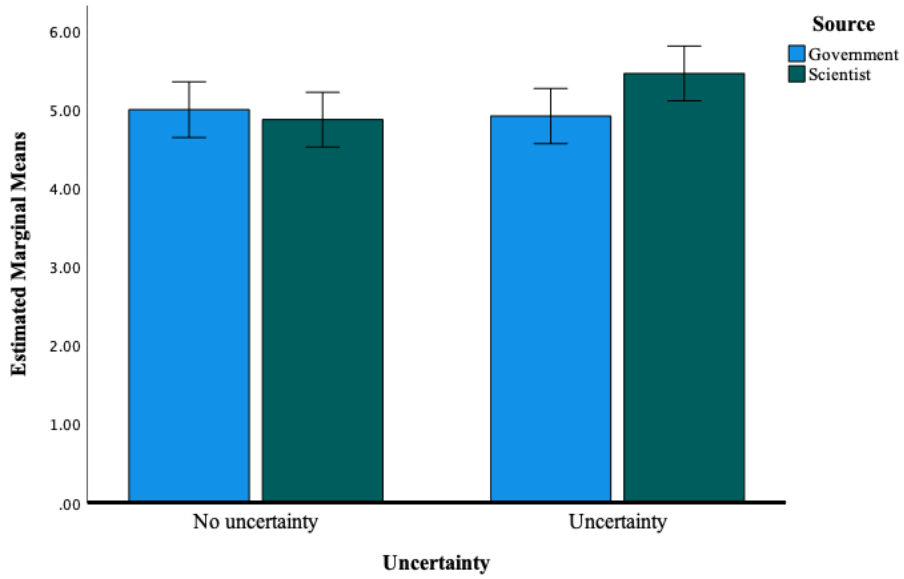
Trust in the Number, Trust in the Information and Trust in the Source.

Uncertainty communication resulted in no significant main effect on the dependent variable *trust in the number* $F(1,189) = 2.17$, $p= .142$, nor did source result in a significant main effect $F(1,189)= 1.50$, $p= .222$. This implies that uncertainty being absent or present and the source communicating did not affect *trust in the number*. The interaction effect of uncertainty and the source was marginally significant, $F(1,193)= 3.40$, $p= .067$. In the condition where uncertainty was communicated, *trust in the number* was higher when scientists ($M= 5.45$, $SD= .18$) were communicating than when the government was communicating. However, in the condition where no uncertainty was communicated, only a small difference is seen between

the sources. See Figure 2. This might suggest, scientists who communicate their uncertainty are more trustworthy. However, in the current study, these distinctions are not reliable and further research is needed to make such a claim.

Figure 2

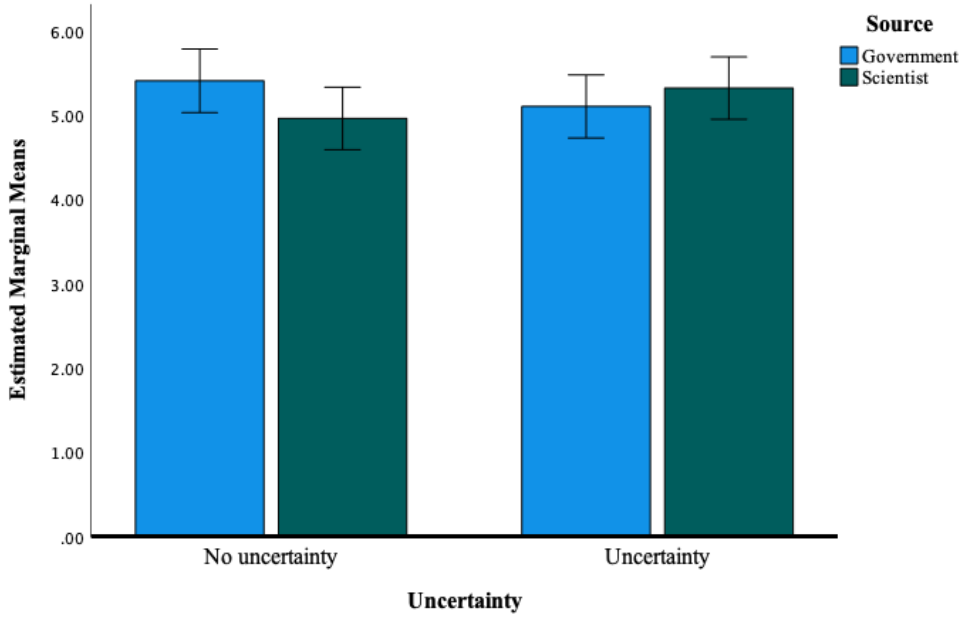
Trust in the Number: Sources and Uncertainty



For the dependent variable *trust in the information,* the ANOVA revealed no significant results either. No main effect for uncertainty, $F(1,189) = .04$, $p = .841$, and for source was found, $F(1,189) = .30$, $p = .588$. This means *trust in the information* was not affected by uncertainty being present or absent or both. The interaction effect was marginally significant $F(1,193) = 2.98$, $p = .086$. In the condition where uncertainty was present, trust in the information is higher in the scientists' condition than in the government condition. The reversed effect is true in the condition where uncertainty is absent. As displayed in Figure 3, trust in the information is higher in the government condition than in the scientists' condition.

Figure 3

Trust in the Information: Sources and Uncertainty



The dependent variable *trust in the source* did not reveal any significant results for uncertainty $F(1,189) = .01$, $p = .927$, and source $F(1,193) = .08$, $p = .778$. The interaction effect was not significant either $F(1,189) = 1.09$, $p = .298$. Whether there is uncertainty or not, or who the communicating source is, does not appear to influence *trust in the source*.

In conclusion, regardless of whether uncertainty is being communicated, the results show a difference among groups in perceived uncertainty. However, no differences among groups for *trust in the number, trust in the information* and *trust in the source* notwithstanding uncertainty being communicated or not. Therefore, no evidence was found to support the hypothesis that communicating uncertainty reduces trust. Neither was there evidence in line with the hypothesis that trust will be lower when the communicating source is the government rather than scientists.

The Effect of Intolerance of Uncertainty

The third hypothesis was that trust is lower for people scoring high on Intolerance of Uncertainty in comparison to people who are scoring low on Intolerance of Uncertainty. The

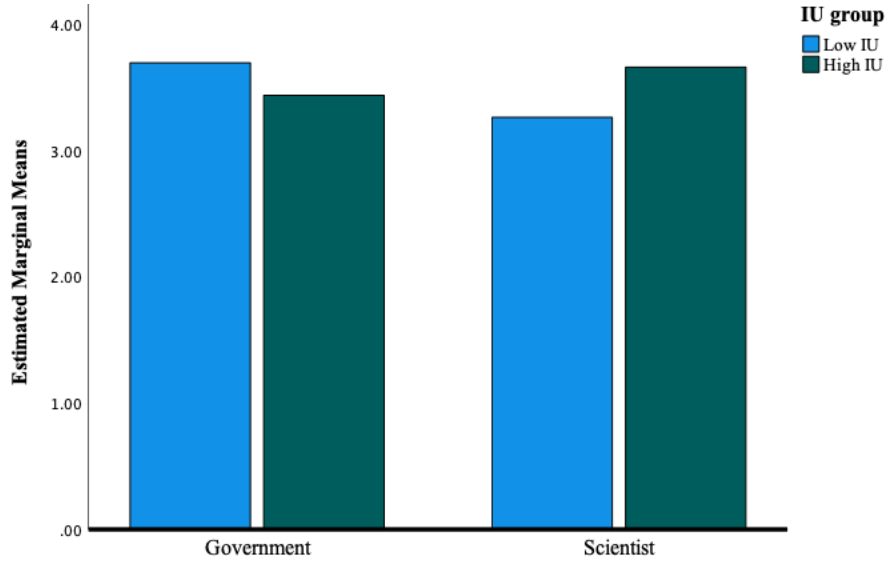
independent variable IU was also considered for the analysis. IU was dichotomized into two groups based on a median split (*Median* = 34). The same 2 (Uncertainty: yes/no) x 2 (Source: government vs. scientists) x 2 (IU: high/low) ANOVA was used.

Perceived Uncertainty.

No main effect was shown for IU on the dependent variable *perceived uncertainty* $F(1,189)= .19$, $p= .665$. Nor was there a significant interaction effect of uncertainty and IU $F(1,189)= .07$, $p= .797$. The interaction effect of source and IU $F(1,189)= 4.12$, $p= .044$ was significant. As shown in Figure 4, people scoring high on IU perceive the message to be more uncertain when scientists are communicating than people scoring low on IU. The opposite is true when the government is communicating. Then people scoring high on IU perceive the message to be less uncertain than people scoring low on IU. The three-way interaction effect of uncertainty, source and IU was not significant $F(1,189)= .54$, $p= .42$.

Figure 4

Perceived Uncertainty: Sources and IU Groups



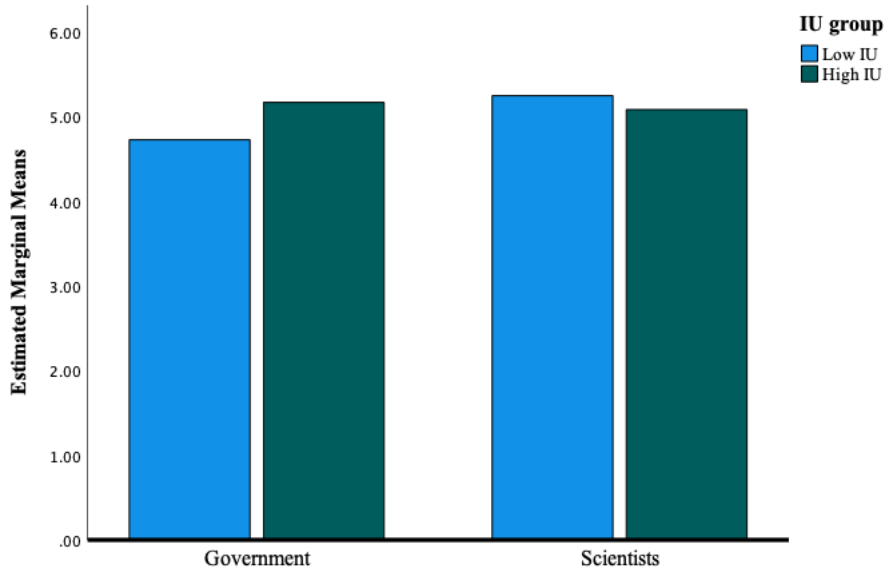
Trust in the Number, Trust in the Information and Trust in the Source.

IU did not result in a significant main effect for the dependent variable *trust in the number* $F(1,189) = .60$, $p= .438$ nor did the interaction effect of uncertainty and IU result in a

significant effect on *trust in the number* $F(1,89) = .24$, $p = .624$. The interaction effect of source and IU was marginally significant on $p < .10$ level. $F(1,189) = 2.91$, $p = .090$. People scoring high on IU trusted the number more when the government was communicating than people scoring low on IU. The opposite was true for when scientists were communicating. Then people scoring low trusted the number more than people scoring high (see Figure 5). However, the difference for is small and overall, no reliable conclusions can be drawn from this finding. No significant effect was found for the three-way-interaction effect of uncertainty, source and IU $F(1,189) = .31$, $p = .580$. This implies that intolerance of uncertainty has no effect on *trust in the number* and that this applies to both people scoring high on IU and people scoring low on IU.

Figure 5

Trust in the Number: Sources and IU Groups



IU did not result in a significant main effect on the dependent variable *trust in the information* $F(1,189) = .36$, $p = .552$. The interaction effect of uncertainty and IU was not significant either $F(1,189) = .37$, $p = .545$, nor the interaction effect of source and IU $F(1,189) = 2.47$, $p = .118$ and the three-way interaction effect of uncertainty, source and IU $F(1,189) =$

.21, p= .646. Thus, intolerance of uncertainty did not affect *trust in the information*; people scoring high on IU did not trust the information less than people scoring low on IU.

IU did not result in a significant main effect on the dependent variable *trust in the source* $F(1,189)$= .04, p= .853. Neither was there a significant interaction effect of uncertainty and IU $F(1,189)$= .01, p= .967, nor of source and IU $F(1,189)$= 1.72, p= .192 nor for uncertainty, source and IU $F(1,189)$= 2.67, p= .105. Hence, intolerance of uncertainty does not seem to affect *trust in the source*.

In conclusion, intolerance of uncertainty only had a significant interaction effect with source and IU on perceived uncertainty. People scoring high or low on IU perceived the sources to be different in uncertainty. People scoring high on IU perceive the message to be more uncertain when scientists are communicating than people scoring low on IU. The opposite is true when the government is communicating. There were no significant main or interaction effects of intolerance of uncertainty on *trust in the number, trust in the information* or *trust in the source*. Thus, no evidence was found for the third hypothesis that people scoring high on intolerance of uncertainty in comparison to people who are scoring low on intolerance of uncertainty trust the message less.

Explorative Analysis

As explorative, additional analysis the association of psychological distress and action intentions (likeliness to recommend a booster shot, wear a facemask and adhere to social distancing rules) with IU, were investigated. As shown in Table 1 psychological distress and IU correlate moderately (r= .47; $p < 0.01$). In other words, people who are less tolerant of uncertainty have experienced more psychological distress in the last two weeks than people who are more tolerant of uncertainty. This seems to be in line with previous findings (Khubchandani et al., 2021; Taha et al., 2013; Reizer et al., 2021). A small correlation between action intentions and IU was found (r= .17, $p< 0.05$). This implies people who are

more intolerant of uncertainty are more likely to recommend a booster shot, wear a facemask and adhere to social distancing rules.

Discussion

The COVID-19 pandemic created uncertainty around the world. In particular, the importance of communicating scientific uncertainty became apparent. Building upon the work of Van der Bles et al. (2020), the current research seeks to clarify the effects of communicating uncertainty on trust in the scientific information. And adding the investigation of the effect of different sources and intolerance of uncertainty. This was examined by manipulating uncertainty associated with and the source of scientific information in a between-participants design. Verbal and numerical uncertainty was either present or not, the same scientific information was presented by the government or by scientists, and participants were split into two groups based on their scores on intolerance against uncertainty (IU). However, other than expected, in the present research none of these variables reliably affected trust in numbers, the information, or the sources.

Theoretical implications

Why did the present research not provide any reliable evidence that people were affected by communicating uncertainty? While the participants did perceive uncertainty in line with the manipulations, they nonetheless did not trust the uncertain message less than the certain message. In general, people struggle with the psychological feeling of uncertainty about future events (Bar-Anan et al., 2009; Hillen et al., 2017). In the context of current research, scientific uncertainty did not affect people's trust. In particular, in the context of COVID-19, it could be that people were getting used to the uncertainty that surrounded the pandemic and thus could be less affected by it. The whole world was involved in the pandemic so accompanied by scientific uncertainty, most likely people became more aware and used to the uncertainties in science itself. In fact, the present research showed the trend

that trust was higher when uncertainty was communicated by scientists. This could indicate that increased openness and transparency about scientific uncertainty could also re-establish public trust in science (Van der Linden & Löfstedt, 2019). Although no reliable significant evidence was found in the present data, this trend was not observed before and could be of interest for further research.

While the present research is closely built on the study by Van der Bles et al. (2020), different results were found. As will be discussed below, this could be due to several reasons. One of those is that the topics of the information given differed. While the present research was about the effectiveness of the booster shot against the coronavirus, the study by Van der Bles et al. (2020) used topics such as the number of tigers currently in India, UK unemployment rates and the increase in the global average surface temperature. The context of the booster shot and COVID-19 potentially has different effects because everyone is (or at least was when the data were collected) currently affected by the pandemic. As mentioned before people may have gotten more used to the uncertainty of the communicated information, thus a topic that is not chronically salient and in the news as COVID-19 could provide more similar reactions. Another difference in studies was that the present study was interested in differences between sources (government vs. scientists) while the study from Van der Bles et al. (2020) did not specify different sources as it was mentioned to be an "official report".

No differences between sources were found for trustworthiness. It could be that during the pandemic scientists and the government are blended and seen as an entity because both sources bring out information about COVID-19 to the public while also working together. For example, a study by Algan et al. (2021) did large-scale surveys in 12 countries on trust in scientists and the government during the COVID-19 pandemic. They argue that the level of trust in scientists was an important determinant for adhering to the corona measures, whereas

the trust in the government was not. They also argue that the perceived independence of scientists is a critical component. When trust in the government was low during the outbreak, trust in scientists was also low. This suggests that initial distrust could have also strengthened distrust in scientists. However, in the Netherlands trust in institutions like the government or health institutions is in the Netherlands quite high. This also implies that there might be no difference in trust between those sources. Moreover, research showed that trust in the government and science increased with lockdown measures in the Netherlands (Oude Groeninger et al., 2021). Future research could also investigate whether people see the government and scientists as a whole or as separate sources.

Another difference between the studies is that the present study does not make a distinction between verbal and numerical uncertainty, while the study of Van der Bles et al. (2021) does. Van der Bles and colleagues discovered a small reduction in trust, particularly for explicit verbal uncertainty. And a small effect for numerical uncertainty. Although almost similar results compared to the present study, we found no evidence whatsoever for the combination of verbal and numerical uncertainty.

Intolerance of Uncertainty

The present study found no effect of communicating uncertainty and intolerance of uncertainty on trust. People scoring high on IU did not have less trust in the scientific information that was given to them in comparison to people scoring low on IU. Intolerance of uncertainty has mostly been seen as a feature of emotional disorders like generalized anxiety disorder, obsessive-compulsive disorder and major depressive disorder (Gentes & Ruscio, 2011). Although IU has been researched in non-clinical populations, more research was done in clinical populations (McEnvoy et al., 2019; Reizer et al., 2021). In the non-clinical context of the current study, people scoring high on IU seem to react stronger to uncertainty than people scoring low on IU. The present research did not find these effects so it could be the

case that reactions towards scientific uncertainty can be different. In other words, people might react differently to uncertainty in a scientific context. A small correlation was found between IU and action intentions, such as social distancing and wearing facemasks. It could be that people scoring high on IU use these action intentions as preventative measures to lessen the stress and worry they may experience from uncertainty (Bavolar et al., 2021). However, other research has shown that ambiguity was seen as threatening and led to inaction and avoidance (Dugas et al, 2005; Heydayati et al., 2003). Accordingly, for future research it could be of interest to investigate these relations further.

Limitations

The current research tried to shed light on the effects of communicating uncertainty during COVID-19, but this research was certainly not free of some limitations. First, alle measures were self-reported. Moreover, due to social distancing and caution because of the coronavirus, participants answered online which could have impact on their responses. Furthermore, it could lead to response biases. The participant can potentially disengage with the topic because the topic was extensively debated during that time and not have full attention anymore. In addition to this, another limitation is the time frame of the study (December 2021). At that time, the booster shot was a much-discussed topic, and the first campaigns were launched to get a booster shot. People possibly read and heard a lot about this topic and informed themselves. Therefore, it could be people were less affected by the information presented in the survey because they were already familiar with scientific and political discussions about the booster shot during that period and were accustomed to the uncertainty present so the pandemic itself could have been of influence. Hence, more research on communicating uncertainty and the role of the source and the recipient's intolerance for uncertainty is needed.

The sample's external validity is another limitation of the current study. In total 78,1%

of the participants obtained or were pursuing a HBO bachelor or higher, as highest educational qualification, which implies that the sample was highly educated. This could mean they are more acquainted with scientific information and the uncertainties that come with it. Possibly people with lower educational backgrounds are less trusting of this type of information simply because they do not have the scientific knowledge and understanding. Adding to this, the present research focuses on the Dutch population. Based on the differences in trust between countries (Algan et al., 2021) it could be of interest to investigate the effects in different countries. A more representative sample is desired for future research.

Conclusion

Notwithstanding the above-mentioned limitations, the present study gives some further insight into the roles of communicating uncertainty and communication sources on trust in the scientific information. The current research shows that communicating uncertainty may not decrease trust in the message, despite the source. Moreover, there was some tentative evidence that scientists' communication of uncertainty may be more trusted than government communication of the same information. This trend has not yet been established and future research could examine this further. Furthermore, uncertain scientific information did not lead to less trust in the message for people less tolerant of uncertainty, as expected.

These results help to inform communicators on how the public reacts to uncertainty in a scientific context. This taps into the ongoing question of maintaining public trust while communicating transparently and honestly. Importantly, people did not seem to have been affected by communicating scientific uncertainty, irrespective of the communicating source. Although further research is needed to provide more evidence, the present research may provide some guidance for scientists, the government and policymakers. It seems they can communicate what is certain but also what is uncertain.

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Appendix A

Conditions (Dutch version[1])

Government, No Uncertainty

[1]These are the manipulations seen by participants of this research, which are in Dutch. The English translation and format can be provided on request.

Scientists, No Uncertainty

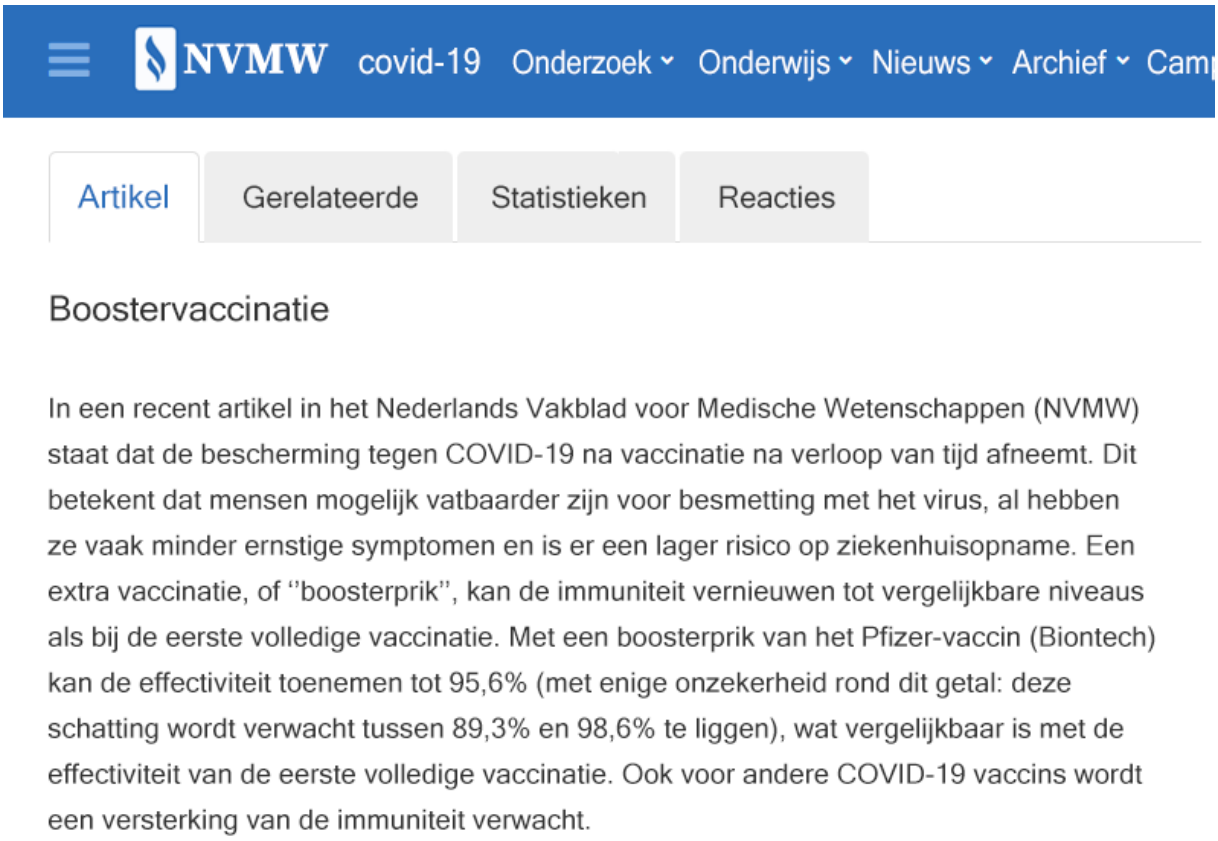
Home › Onderwerpen › Vaccinatie tegen het coronavirus ›

Boostervaccinatie

In een recent rapport van het Ministerie van Volksgezondheid staat dat de bescherming die vaccinatie biedt tegen COVID-19 na verloop van tijd afneemt. Dit betekent dat mensen mogelijk vatbaarder zijn voor besmetting met het virus, al hebben ze vaak minder ernstige symptomen en is er een lager risico op ziekenhuisopname. Een extra vaccinatie, of ''boosterprik'', kan de immuniteit vernieuwen tot vergelijkbare niveaus als bij de eerste volledige vaccinatie.

> Met een boosterprik van het Pfizer-vaccin (Biontech) kan de effectiviteit toenemen tot 95,6% (met enige onzekerheid rond dit getal: deze schatting wordt verwacht tussen 89,3% en 98,6% te liggen), wat vergelijkbaar is met de effectiviteit van de eerste volledige vaccinatie. Ook voor andere COVID-19 vaccins wordt een versterking van de immuniteit verwacht.

Scientists, Uncertainty



Appendix B

Intolerance of Uncertainty Scale (IUS-12, Carleton et al., 2007)

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 paralyzes 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.