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Trust in Scientists, Risk Perception, Conspiratorial Beliefs, and Unrealistic Optimism: A Network Approach to Investigating the Psychological Underpinnings of COVID-19 Vaccination Intentions

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Supplementary Materials: Data [see Index of Supplementary Materials]

Abstract

Using a network approach, we addressed in two studies interrelations among potential antecedents of vaccine intentions, related to both COVID-19 risk perception and epistemic beliefs (i.e., trust in scientists and conspiracy beliefs). In Study 1 and 2, we assessed a US (N = 994) and an international sample (N = 902) during spring and summer 2020. The network analysis reveals a complex interplay of factors where trust in scientists, the closest predictor of vaccine intention, is associated with conspiracy beliefs and danger perception. Furthermore, we found evidence for unrealistic optimism, with participants perceiving the risk of getting infected with COVID-19 as lower compared to the risk they attributed to other people. However, this bias was not associated with vaccine intention. Study 2 corroborated these results. The results call for a global change in the narrative which should highlight the epistemic authority of science in order to build a stronger trust in the scientific community. However, tackling trust in scientists needs a wider field of persuasion that includes conspiracy beliefs and risk perception factors.

Keywords

COVID-19, optimism, pessimism, unrealistic optimism bias, risk perception, vaccination hesitancy, cognitive illusions, positive illusions, conspiracy, coronavirus, trust in science

Highlights

- Vaccinations represent the key strategy to tackle pandemics, as vaccines can help to prevent infection, reduce the severity of COVID-19 symptoms, hospitalizations and deaths.
- Vaccine-compliance is required, and a substantial proportion of people are hesitant to get vaccinated in general.
- We tested four key factors that may allow predicting people's decision to get a COVID-19 vaccine: risk perception, unrealistic optimism, trust in scientists, and belief in conspiracy.
- Trust in scientists is the factor most strongly associated with vaccine intention. People have an unrealistic optimism bias about getting infected with COVID-19, but this bias is not associated with vaccination intention.

In the current COVID-19 crisis, vaccines represent the key strategy to tackle pandemics as they can help to prevent further spread of the disease and therefore collectively protect the population. Moreover, even when vaccines cannot prevent coronavirus infections, they represent a helpful tool to reduce the severity of COVID-19 symptoms, hospitalizations, and deaths (European Centre for Disease Prevention and Control, 2021).

However, vaccine-compliance is required, and psychological research indicates that a substantial proportion of people are hesitant in getting vaccinated in general (de Figueiredo et al., 2016), and specifically against COVID-19 (Barello et al., 2020; Ikhaq et al., 2020). To make the current vaccine strategy successful, one needs to understand the factors that predict individuals' vaccine intentions to envisage the most effective communication strategy. In this paper, we test four key factors that may allow predicting people's decision to get a COVID-19 vaccine: people's risk perception, unrealistic optimism, trust in scientists, and belief in conspiracy. Moreover, we employed a network analytical approach, which allows us to assess the gestalt in which the intention to get vaccinated is embedded, identifying the most distal and proximal underpinnings and their interconnections.

Risk Perception and Unrealistic Optimism

Several health-specific behavioral theories, such as the Health Belief Model (Rosenstock, 1974), the Protection Motivation Theory (Rogers, 1975), and the Extended Parallel Process Model (Witte, 1992), predict that the anticipated likelihood and the perceived severity of health-specific harms (e.g., likelihood to get infected by coronavirus and the danger

of being infected by the virus) shape health-related intentions and behaviors. This prediction is well supported in the scientific literature, and several studies reported that these concepts are associated with health-promoting intentions and behaviors, including changing unhealthy habits, maintaining protective behaviors, and initiating protective actions (Brewer et al., 2007; Dillard et al., 2012; Floyd et al., 2000; Jones et al., 2015).

Furthermore, it is important to highlight that individuals' perception of risks usually does not match objective risks. Research on unrealistic optimism has shown that most people expect negative events to be more likely for others than themselves, and vice versa for positive outcomes (Weinstein, 1980, 1983). Although unrealistic optimism helps people to cope with potentially threatening experiences (Taylor & Brown, 1988) and protects their wellbeing by holding fears in check (Hoorens, 1995; Klein & Weinstein, 1997), the flip side is that unrealistic optimism can be maladaptive in life-threatening situations as being shielded from fears reduces the intention to engage in health-promoting behaviors (Dillard et al., 2009; Weinstein, 1983). Currently, little is known about the role of unrealistic optimism in relation to attitudes toward COVID-19 vaccines although scholars have explicitly called for empirical research investigating this relation (Bottemanne et al., 2020).

Trust in Scientists

Usually, specialist knowledge and skills are required to understand how a vaccine is developed, and research data cannot be naively interpreted with respect to the safety and efficacy of vaccines. This complexity creates an imbalance of power between experts (e.g., healthcare professionals, scientists) and non-experts (patients). Vaccine decisions are therefore taken in a context where laypersons have to trust several actors who retain exclusive access to the available evidence. In other words, trusting vaccine experts means that individuals accept their vulnerable position and assume that someone else has the competence and the intention to take care of complex decisions, like the implementation of vaccine policies, the definition of vaccine dosage, and so forth. Scientists are particularly relevant in the context of COVID-19 vaccination, as they are in the first line of the development of vaccines, and assessment of vaccine safety both pre- and post-approval (Avorn & Kesselheim, 2020). Due to this, it is reasonable to assume that trust in scientists is the key building block of a positive attitude towards the process of vaccination.

Accordingly, past research suggests that trust is positively linked to vaccine intentions in different contexts (Cooper et al., 2017; Dohle et al., 2020; Larson et al., 2018; Marlow et al., 2007; Palamenghi et al., 2020; Van Der Weerd et al., 2011).

Belief in Conspiracy

Conspiratorial beliefs are defined as beliefs about a number of actors who join together in secret agreement and try to achieve a hidden goal, which is perceived as unlawful

or malevolent (Zonis & Joseph, 1994). According to previous research, conspiracy beliefs question scientists' legitimacy, shift authority from experts (i.e., doctors, scientists) to non-experts (i.e., patients; Kata, 2012) and are negatively correlated with trust in general vaccination (Jolley & Douglas, 2014, 2017; Salvador Casara et al., 2019), and specifically with the intention to get vaccinated against COVID-19 (Bertin et al., 2020).

Network Analysis Approach

As reported, previous research has already shown that risk perception, unrealistic optimism, trust in scientists, and conspiracy beliefs play an important role in the current COVID-19 pandemic. However, to the best of our knowledge, these factors are usually tested independently and are not always used to predict vaccine intentions within an integrative model. To fill this gap and to test which of these factors contributes to vaccine intentions most strongly, we conducted two studies in which we applied network analyses. We propose that a network analysis can serve as an innovative tool for unpacking the associations among drivers of COVID-19 vaccine intention and further our understanding of the attitudes toward vaccination as an interconnected belief system (Lange et al., 2020).

In our studies, nodes are the measured factors potentially relevant to vaccine intentions. Using an undirected network approach, we a) avoided assuming that these factors are independent of each other and b) are able to explore their interrelations.

In the context of our studies, this allows exploration of which factors are more strongly linked to vaccine intention and which nodes are more promising as a target for interventions and persuasion attempts (e.g., communication of vaccination policies) (Nudelman et al., 2019).

Present Research

Our major goal was to assess which of the most studied factors are the most strongly associated with COVID-19 vaccine intentions. Moreover, we wanted to enlarge the list of such factors investigating the so far neglected unrealistic optimism and test whether this bias impacts vaccine-related intentions. In particular, our second goal was to test whether unrealistic optimism (a) is present in the perception of the likelihood of being infected by coronavirus, (b) is present in the perceived likelihood of being already immune to the virus, and (c) predicts vaccine intentions.

In Study 1, using an undirected network model, we tested the strength of associations among the perceived likelihood of being infected with coronavirus, trust in scientists, conspiracy beliefs, and vaccine intention in a large U.S. sample. Moreover, we tested the presence of unrealistic optimism bias related to the likelihood of being infected and its predictive value on vaccination intention.

Study 2 aimed to replicate the findings obtained in Study 1: a) in a more culturally diverse sample involving several different countries, and b) during a time when COVID-19 had been already present for weeks/months. Besides corroborating the previously reported effects, we expanded the network by including the perception of COVID-19 danger and the perceived likelihood of already being immune to the virus. Moreover, we further explored the presence of unrealistic optimism in both assessments of being at risk and of already being immune.

Study 1

In Study 1, we assessed the network gestalt of four factors that may predict intentions to vaccinate against COVID-19: risk perception, unrealistic optimism bias, trust in scientists, and belief in conspiracy theories. We tested which of the above factors best explains individuals' willingness to get vaccinated against COVID-19.

Method

Participants

One thousand participants within the United States (515 women, 485 men; age ranging from 18 to 82, M = 45.33, SD = 15.95) were recruited for an online study via Prolific.com. Six participants (4 women, 2 men, M_{age} = 26.17, SD_{age} = 7.78) were excluded from the analyses due to lack of answers to the first question and/or a survey completion time below 10 seconds (which we treated as a proxy of lack of attention). The final sample consisted of 994 participants (511 women, 483 men, M_{age} = 45.45, SD_{age} = 15.92), ranging from 18 to 82. The data was collected from 05/07/2020 to 05/08/2020. The results from a post-hoc sensitivity power analysis, conducted with the software GPower (Erdfelder et al., 1996) revealed that with a sample of N = 994, α = .05, and β = .90 we are able to detect a minimum effect of Cohen's d = .10 for matched pairs t-test.

Questionnaire

Each question was displayed separately via Qualtrics. Respondents indicated their gender and age after answering the last survey question.
We asked participants to rate their agreement on 9-point rating scales to assess their:

- *Vaccine intention (*"Are you going to take a shot once the COVID-19 vaccine is available on the market?"), (1 = definitely no; 9 = definitely yes).
- *Trust in scientists (*"In the coronavirus (COVID-19) case, can we rely on the results of research conducted by scientists?"), (1 = definitely no; 9 = definitely yes).
- *Conspiracy beliefs* ("I believe that some secret powers (e.g., countries, big corporations) are responsible for coronavirus/COVID-19?"), (1 = definitely no; 9 = definitely yes).

- *Perceived likelihood of self-infection* ("How likely is it that you will become infected with coronavirus (COVID-19)?", 1 = absolutely impossible; 9 = quite certain).
- *Perceived likelihood of other-infection* ("How likely is it that your fellow countrymen will become infected with coronavirus (COVID-19)?"), 1 = absolutely impossible; 9 = quite certain).

In order to obtain a measure of the perceived likelihood of infection, we computed the mean of these two items.

In order to assess the unrealistic optimism bias, we computed the difference between estimating the likelihood of getting infected with the virus for "fellow countrymen" and "myself". Moreover, we created another variable by categorizing participants into three groups: pessimistic (negative indicator value), optimistic (positive indicator value), or neutral (indicator equal to 0).

Results

Unrealistic Optimism: Prevalence and Impact on Vaccine Intentions

We used the software R (R Team, 2013) in order to compute the following statistical tests. Respondents judged the likelihood of future coronavirus infection to be higher for their compatriots (M = 5.35, SD = 2.05), than for themselves (M = 4.29, SD = 1.89), $t(993)$ = 15.49, $p < .001$, d = .49.

Similar results were achieved using the categorical variable. A total of 57.7% (N = 574) of participants were optimists (i.e., they assessed it as more likely that their compatriots would be infected than themselves), 26.5% (N = 263) were neutral, and 15.8% (N = 157) were pessimists, $\chi^2(2) = 283.55$; $p < .001$. In other words, the results show that most of our participants believed to be more protected from COVID-19 in comparison with others.

Unrealistic optimism bias was not associated with vaccine intention (Pearson r = -.03, p = .29).

Network Analysis

In order to test which of the assessed factors best explains the intention to get vaccinated against COVID-19, an undirected network model was computed. The EBICglasso procedure (EBIC; Epskamp, 2016) was applied, using the software JASP (Love et al., 2019) in order to estimate the network model. The EBIC tuning parameter was set to 0.5. This procedure estimates networks based on partial correlations and it involves the GLASSO regularization technique (based on the true network structure and sample size) aiming to control spurious correlations (Epskamp, 2016; Friedman et al., 2008; Tibshirani, 2011) and shrink small coefficients to zero (Costantini et al., 2015; Epskamp & Fried, 2018). As an outcome of this procedure, the network shows the regularized partial correlation among each pair of nodes after controlling the effect of the rest of the nodes in the network (Figure 1). Moreover, in order to check edge-weight accuracy, we estimated

Network stability using the bootnet package (Epskamp et al., 2018). Specifically, we used a nonparametric bootstrap (with 1000 iterations) to estimate the 95% confidence interval of each edge. The results, as reported in Table 1, Figure 1, and Figure 2, showed that edge-weight accuracy was good for almost all associations. In fact, from the estimated relationships, only the association between the perceived likelihood of infection and trust in scientists included 0 within the 95% confidence interval, indicating that the link between these two variables was not robust. Vaccine intention was positively associated with trust in scientists, and negatively associated with conspiracy beliefs. The perceived likelihood of infection was associated with trust in scientists, but it was not associated with conspiracy beliefs. However, the perceived likelihood of infection was associated with vaccine intention.

Figure 1

Empirical Network Model

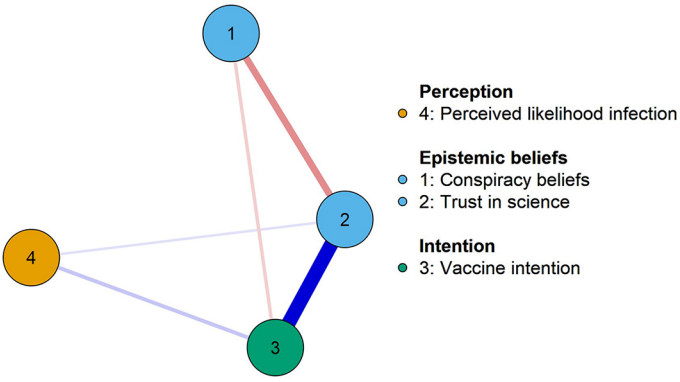


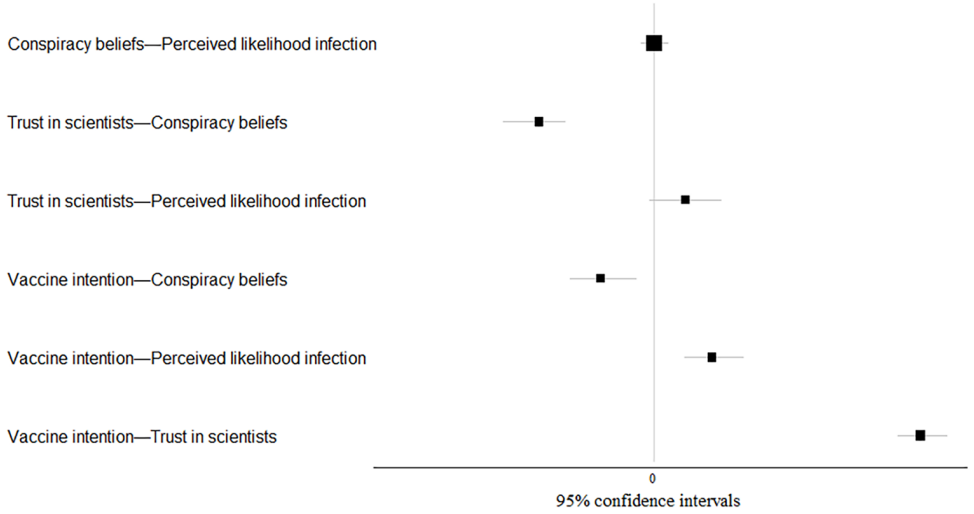
Table 1

Edge List With Estimated Weight, Standard Deviation, and Confidence Intervals

Edge	Sample	Bootstrap Mean	*SD*	*LL*	*UL*
Conspiracy beliefs—Perceived likelihood infection	0.00	0.00	0.01	-0.03	0.03
Trust in scientists—Conspiracy beliefs	-0.27	-0.26	0.03	-0.34	-0.20
Trust in scientists—Perceived likelihood infection	0.07	0.07	0.04	-0.01	0.15
Vaccine intention—Conspiracy beliefs	-0.12	-0.12	0.04	-0.19	-0.04
Vaccine intention—Perceived likelihood infection	0.13	0.13	0.03	0.07	0.20
Vaccine intention—Trust in scientists	0.60	0.60	0.03	0.55	0.66

Figure 2

95% Confidence Intervals of the Bootstrapped Edges



Note. Each node represents an attribute associated with the behavioral intention target. The edges represent the relationship among attributes. The thicker the edge, the greater the relationship between attributes.

Discussion

Study 1 provides initial insights into the degree to which different factors are associated with vaccine intentions. First, we found evidence for the existence of unrealistic optimism related to COVID-19. That is, people tend to believe that the likelihood to get infected with coronavirus is higher for other people than for themselves. Second, network analyses demonstrate that vaccination intentions are positively related to trust in scientists as well as to the perceived likelihood of infections, and negatively related to conspiracy beliefs. The presence of unrealistic optimism was not associated with the degree of vaccination intention. Trust in scientists was the closest predictor of vaccine intentions and was weakly positively associated with the perceived likelihood of infection. Given the association between trust in scientists and conspiracy beliefs, we may conclude that communication tackling both elements may be the most effective.

Study 2

In Study 1, the sample was limited to participants recruited from the United States. In order to overcome this limit, in Study 2, we aimed to replicate the results obtained in Study 1 in a more diverse sample of several countries that had different experiences with COVID-19.

Despite a more diverse sample, we modified the method to some extent. First, we assessed perceived danger. In Study 1, we focused only on the perceived susceptibility to coronavirus. However, in the health-related decision-making literature (Brewer et al., 2007), the perceived danger (severity) of disease also represents a relevant driver for health-promoting behaviors.

Second, as an additional measure of unrealistic optimism, in Study 2, we expanded the investigation of participants' risk assessment to their social network by investigating perceived risks at three social distances: the self, a friend/neighbor and fellow countrymen.

Finally, as Study 2 was conducted while COVID-19 was already a pervasive reality, we measured participants' perceived belief of being immune to COVID-19. This new variable tackles two goals: First, we were interested to which degree the belief of being immune reduces vaccine intentions. Second, we aimed at studying whether the belief about one's immunity is based on unrealistic optimism, meaning that individuals believe that they are more likely to be immune to COVID-19 than other individuals. Again, this assessment was evaluated at three social distances: the self, a friend/neighbor, and a fellow countryman.

Method

Participants

Participants were recruited via social media postings (with participants coming from Canada, France, Germany, India, Italy, New Zealand, Spain, Switzerland, and the United States), via Amazon's Mechanical Turk (participants from the United States), and mailing lists of university students (participants from Poland, Italy, and Germany). Overall, we recruited 1016 participants (see Supplementary Materials for subsamples' descriptive statistics). 114 were excluded from the analysis due to lack of answers (which we treated as a proxy of lack of attention) or a declaration of a positive COVID-19 test result. The final sample consisted of 902 participants (567 women, 328 men, 6 non-binary, 1 missing) with an age ranging from 18 to 76 (M = 34, SD = 11.68). The reason for collecting data across nations was to enhance generalizability and to ensure that conclusions were not limited to one particular socio-political circumstance. Nation level differences were not analyzed as the number of nations is too small to draw meaningful cross-national comparisons, and any such comparisons would be difficult or even problematic to interpret.

Measures

Participants answered the same questions as in Study 1 rating their agreement on 11-point rating scales assessing Vaccine intention, Trust in scientists, Conspiracy beliefs, Perceived likelihood of self-infection, and Perceived likelihood of other-infection. In addition, we also measured:

- *Perceived severity of the infection* ("How safe or dangerous is SARS-CoV-2/COVID-19 in your opinion?", 1 = very safe; 11 = extremely dangerous).
- *Perceived likelihood of friend-infection ("*How likely is it that your average friend, or your average neighbor, will become infected with coronavirus (SARS-CoV-2/COVID-19?)", 1 = absolutely impossible; 11 = quite certain).
- *Perceived likelihood of self-immunity* ("How likely is it that you were infected with SARS-CoV-2/COVID-19 at some point in the past, and therefore you have developed immunity or resistance to coronavirus infection?", 1 = absolutely impossible; 11 = quite certain).
- *Perceived likelihood of friend-immunity* ("How likely is that your average friend, your average neighbor was infected with SARS-CoV-2/COVID-19 at some point in the past, and therefore s/he has developed immunity or resistance to coronavirus infection?", 1 = absolutely impossible; 11 = quite certain).
- *Perceived likelihood of other-immunity* ("How likely is it that your fellow countryman will become infected with coronavirus (COVID-19?)", 1 = absolutely impossible; 11 = quite certain).

In order to obtain a measure of the general perceived likelihood of infection, we computed the mean between the three items of *Perceived likelihood of infection*. To compute a score for unrealistic optimism, we computed the mean in estimating the likelihood of getting infected with the virus for "a fellow countryman" and "friend/neighbor and then subtracted this value from the score to the question of getting infected "myself".

In order to obtain a measure of a general immunity belief, we averaged the answers to all three questions. In order to assess the unrealistic optimism bias toward immunity, we computed the mean in estimating immunity to the virus for another person and friend and then subtracted this value from the score of the answer to immunity for the self.

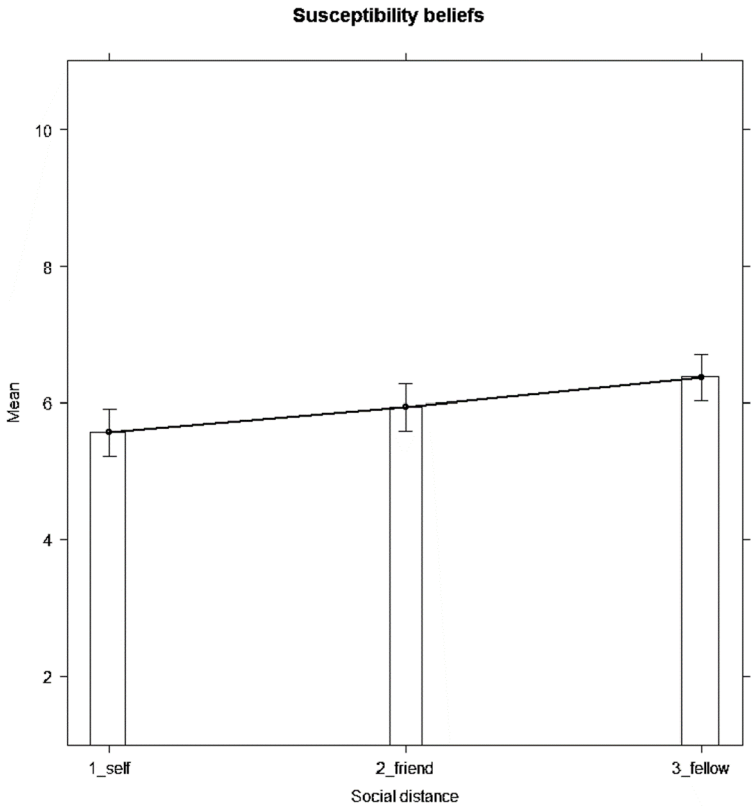
Results

Unrealistic Optimism Bias: Prevalence and Impact on Vaccine Intentions

Perceived Susceptibility — In order to test unrealistic optimism across different countries, we performed a mixed effects linear regression model, using the software R and the package *lmertest* (Kuznetsova et al., 2015), with social distance (self vs. friend vs. fellow countryman) as a fixed effect, and with participants' Id as random effects on the intercepts and country as random effects on the slopes. Participants' responses were nested within participants' Id which were nested within countries. Participants estimated that both a close friend ($\beta = .37$, $SE = .06$, $p < .001$) and a fellow countryman ($\beta = .80$, $SE = .13$, $p = .007$) were more likely to get infected in the future in comparison to themselves (intercept = 5.61, $SE = .14$; marginal $R^2 = .02$; conditional $R^2 = .75$; see Figure 3).

Figure 3

Susceptibility Belief Levels per Social Distance



Similar results were achieved using the categorical variable, $\chi^2(2) = 171.51$; $p < .001$: A total of 51.4% ($N = 464$) of participants were optimists (i.e., they assessed that it was more likely that others would be infected than themselves) and 32.7% ($N = 295$) were neutral—that is, they estimated the likelihood of infection for themselves and others as equally high. 15.9% ($N = 143$) were pessimists, i.e., they assessed that it was more likely that they themselves would be infected than their compatriots.

The association between unrealistic optimism related to perceived risk to COVID-19 and vaccine intention was not statistically significant (Pearsons $r = -.03$, $p = .24$).

Immunity Beliefs — In order to investigate the unrealistic optimism bias in terms of immunity beliefs, we performed a multilevel linear regression with social distance (self vs. friend vs. fellow countryman) as a fixed effect, and with participants' Id as random effects on the intercepts and country as random effects on the slopes. Participants'

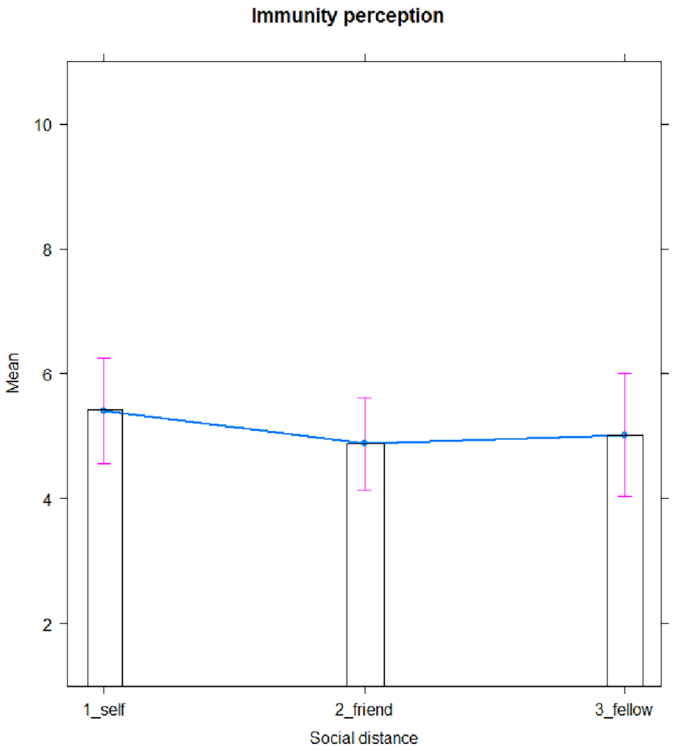
responses were nested within participants' Id which were nested within countries. Participants' estimations did not differ when the target was a close friend (β = -.53, *SE* = .07, $p < .49$) or a fellow countryman (β = -.39, *SE* = .09, $p < .67$) in comparison to themselves (intercept = 5.41, *SE* = .43; marginal $R^2 = .01$; conditional $R^2 = .79$ see Figure 4).

Different results were achieved using the categorical variable, $\chi^2(2) = 67.16$; $p < .001$. A total of 43.8% ($N = 395$) of participants were pessimists (i.e., they assessed that it was more likely that others would be immune than themselves) and 34.6% ($N = 312$) were neutral—that is, they estimated the likelihood of immunity for themselves and others as equally high. 21.6% ($N = 195$) were optimists, i.e., they assessed that it was more likely that they themselves would be immune than others.

The association between unrealistic optimism related to perceived immunity to COVID-19 and vaccine intention was not statistically significant (Pearsons $r = -.06$, $p = .07$).

Figure 4

Immunity Beliefs per Social Distance



Network Analysis

In order to assess the best predictor of vaccine intention, an undirected network model was estimated using the same procedure as in Study 1.

As reported in Table 2, Figure 5 and Figure 6, the edge-weight accuracy was good for almost all associations. Importantly, the association between the perceived likelihood of infection and conspiracy beliefs, and the association between the perceived likelihood of infection and vaccine intention included 0 within the 95% confidence interval, meaning that the estimated associations between these variables was not robust. The results showed that vaccine intention is positively associated with trust in scientists and perceived danger of COVID-19, and negatively associated with conspiracy beliefs. No association was found between vaccine intention and immunity beliefs. Furthermore, trust in scientists was positively associated with both perceived likelihood and danger of infection, and it was negatively associated with conspiracy beliefs. Finally, immunity beliefs were positively associated with conspiracy beliefs and perceived likelihood of infection.

Table 2

Edge List With Estimated Weight, Standard Deviation, and Confidence Intervals

Edge	Sample	Bootstrap Mean	*SD*	*LL*	*UL*
Conspiracy beliefs—Trust in scientists	-0.26	-0.26	0.03	-0.32	-0.19
Conspiracy beliefs—Vaccine intention	-0.10	-0.09	0.05	-0.21	0.00
Immunity beliefs—Conspiracy beliefs	0.24	0.24	0.03	0.17	0.30
Immunity beliefs—Trust in scientists	0.00	0.00	0.01	-0.03	0.03
Immunity beliefs—Vaccine intention	0.00	-0.01	0.02	-0.04	0.04
Perceived danger infection—Conspiracy beliefs	-0.13	-0.13	0.04	-0.21	-0.05
Perceived danger infection—Immunity beliefs	0.00	0.00	0.02	-0.03	0.03
Perceived danger infection—Perceived likelihood infection	0.26	0.27	0.03	0.19	0.33
Perceived danger infection—Trust in scientists	0.14	0.14	0.04	0.06	0.22
Perceived danger infection—Vaccine intention	0.18	0.18	0.03	0.12	0.25
Perceived likelihood infection—Conspiracy beliefs	0.00	0.03	0.04	-0.09	0.09
Perceived likelihood infection—Immunity beliefs	0.39	0.39	0.03	0.33	0.45
Perceived likelihood infection—Trust in scientists	0.17	0.17	0.03	0.10	0.24
Perceived likelihood infection—Vaccine intention	0.09	0.08	0.05	-0.01	0.19
Trust in scientists—Vaccine intention	0.31	0.31	0.03	0.24	0.37

Figure 5

Empirical Network Model

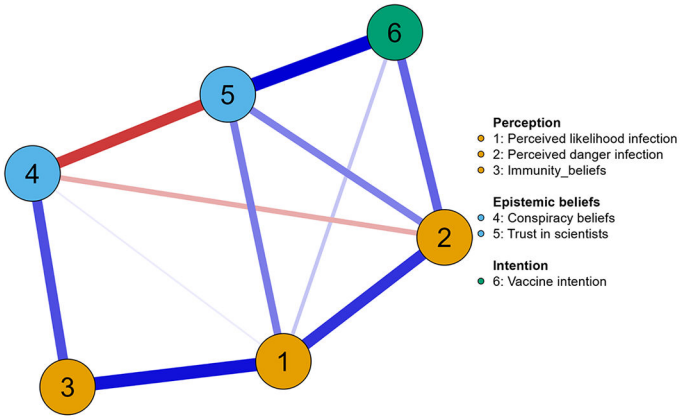
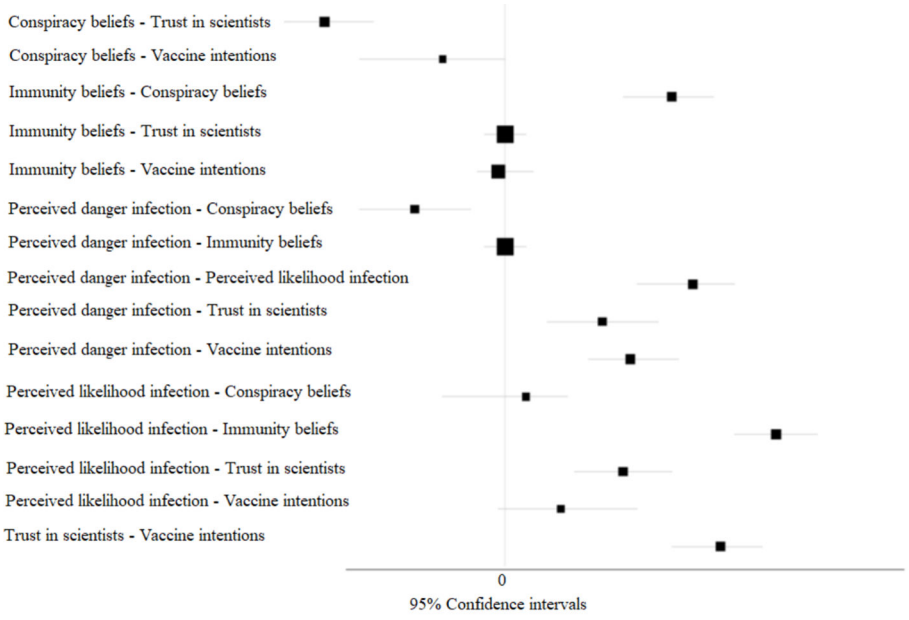


Figure 6

Bootstrapped Edges Confidence Intervals



Note. Each node represents an attribute associated with the behavioral intention target. The edges represent the relationship among attributes. The thicker the edge, the greater the relationship between attributes.

Discussion

Study 2 produced important insights about unrealistic optimism and potential drivers of vaccination intention. The unrealistic optimism found in Study 1 was here replicated, as respondents tended to estimate their likelihood of *future* coronavirus infection as lower than that of others. Moreover, going one step further than Study 1, our results indicate that this bias is present in relation to both referent groups. That is, participants judged their likelihood to get infected with COVID-19 as smaller than both the likelihood of friends and of fellow countrymen. However, findings were less clear when the respondents had to evaluate the likelihood of past infections. Indeed, taking into account the mean scores, respondents did not tend to estimate their likelihood of *past* coronavirus infection (and the associated likelihood of present immunity to the virus) as being higher than that of others. Differently, the majority of participants perceived that others were more likely to already be infected by the coronavirus. This finding can be interpreted in different ways. On the one hand, one could interpret it as a pessimistic bias, because participants assigned the most desirable outcome (i.e., immunity to the virus) to others compared to themselves. On the other hand, it can be interpreted as unrealistic optimism, because the question of being immune was coupled with the notion that immunity can only be achieved by being infected in the past. As unrealistically optimistic participants perceive the likelihood of getting infected as very low, they might have concluded that they cannot be immune. As both explanations are plausible, this result calls for future investigations.

Furthermore, our network analyses replicated the pattern of Study 1 by demonstrating that trust in scientists is the variable with a stronger association with vaccine intention. Moreover, trust in scientists was linked to all the other variables except the perceived likelihood of immunity to COVID-19.

An additional analysis indicates that among the measured risk perception factors (perceived COVID infection likelihood, danger, and immunity) it is the perceived danger of COVID-19 that is more strongly related to vaccine intention, whereas, in line with Study 1, perceived likelihood was only weakly and unreliably linked to it. In addition, perceived likelihood of immunity was not directly linked to vaccine intention.

General Discussion

The results of our studies showed that trust in scientists is most strongly associated with vaccine intention and is, therefore, a promising factor for communication campaigns aimed at promoting vaccination.

Besides trust in scientists, the perceived danger of the disease is associated with the intention to get vaccinated too. This suggests that when promoting vaccines in public speaking, one could highlight the danger of the pandemic for society. This suggestion

is in line with the "fear appeal" concept (Maloney et al., 2011), which refers to the role of fear in enhancing protective behaviors like vaccination. Based on this model, it is assumed that the threat generated by the fear of getting COVID-19 creates psychological stress and increases individuals' willingness to engage in health-promoting behaviors, such as getting vaccinated. The network approach used in our studies provides relevant insights that are not limited to the prediction of vaccine intention but further highlight the interplay among variables. Specifically, both in Study 1 and 2, conspiracy beliefs appeared weakly linked to vaccine intention but the network models revealed that conspiracy beliefs were negatively associated with both trust in scientists and perceived danger of COVID-19, two variables that have a strong connection with vaccine intention. Therefore, under a connectionist model of attitudes (Dalege et al., 2016), the final evaluative reaction toward an object is the result of the interplay of several interconnected elements. Because of cognitive consistency needs, it would be particularly hard to change the final attitude addressing only one of its related evaluative elements, especially when it is strongly related to other relevant evaluative reactions. Based on this perspective, trust in scientists is the closer attitude related to vaccine intention. However, it is plausible that tackling trust in scientists needs a wider field of persuasion that includes conspiracy beliefs and risk perception factors. Promoting transparency and inoculating against conspiracy theories (Jolley & Douglas, 2017) may prevent people from distrusting scientists and minimize the impact of COVID-19, in order to reach the final outcome of promoting vaccine intention. Similarly, the detected network allows the interrelation among the components of COVID-19 risk perception to be identified. Even if perceived immunity and perceived susceptibility do not appear to have a direct predictive value on vaccine intention, these evaluative reactions are still linked, and therefore may influence the perceived danger of COVID-19. Their interconnections suggest that a social marketing campaign should take into account all the components of risk perception.

Limitations and Future Directions

Despite these implications, it is important to highlight some limitations of our studies. Even if the network analysis provided interesting insights about vaccine intention's drivers and their interrelation, it is important to note that the correlational design of our studies does not allow causal inferences to be derived. Nevertheless, by using two large samples and by replicating our key findings, we were able to provide robust evidence of relevant associations. Thus, based on the correlational character of our studies, the results can be seen as a promising starting point for future experimental studies and intervention pilots.

The exploration of risk perceptions allowed us to detect the presence of unrealistic optimism bias related to susceptibility (due to future infections) and immunity to COVID-19. In Study 1 and Study 2, we found that people have an unrealistic optimism bias as they perceived the risk of getting infected with COVID-19 as lower than for others.

It is worth noting that in this study we focused only on psychological constructs, whereas sociodemographic information like education and socio-economic status were not taken into account. Education is related to both trust in scientists and conspiracy beliefs (Nadelson et al., 2014; van Prooijen, 2017), although other research found that support for these beliefs can be prompted not only by a lack of education, but also by motivated reasoning (Kraft et al., 2015; Miller et al., 2016) and psychological needs. Moreover, a meta-analysis conducted by Larson and colleagues (2014) highlighted that it is still unclear whether sociodemographic factors, such as education and socio-economic status, are associated with vaccine coverage, whereas psychological factors, such as trust in scientists and perception of disease severity, appear to be more robust predictors of vaccine coverage across studies.

Conclusion

Vaccines against COVID-19 will most likely be the fundamental force that ends the COVID-19 pandemic. However, the discovery of safe and effective vaccines is only one (although important) part of the fight against the pandemic. As a substantial number of people are hesitant regarding vaccines, understanding the psychological factors associated with vaccine compliance is another important element. In two studies, we demonstrated that individuals' risk perception of the virus plays an important role in the intention to get vaccinated, and it is the building of trust in scientists that represents the most promising driver of vaccine intentions. Communication campaigns promoting COVID-19 vaccines, and vaccines in general, may implement this finding to reach a large number of people and thereby herd immunity.

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Data Availability: The data for Study 1 and Study 2 are freely available (Salvador Casara et al., 2022).

Supplementary Materials

For this article, the following Supplementary Materials are available (for access see Index of Supplementary Materials below):

Index of Supplementary Materials

Salvador Casara, B. G., Martinez-Conde, S., Dolinski, D., Suitner, C., Genschow, O., Muniak, P., & Kulesza, W. (2022). *Supplementary materials to "Trust in scientists, risk perception, conspiratorial beliefs, and unrealistic optimism: A network approach to investigating the psychological underpinnings of COVID-19 vaccination intentions"* [Codebook and Data for Study 1 and Study 2]. PsychOpen GOLD. https://doi.org/10.23668/psycharchives.8244

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