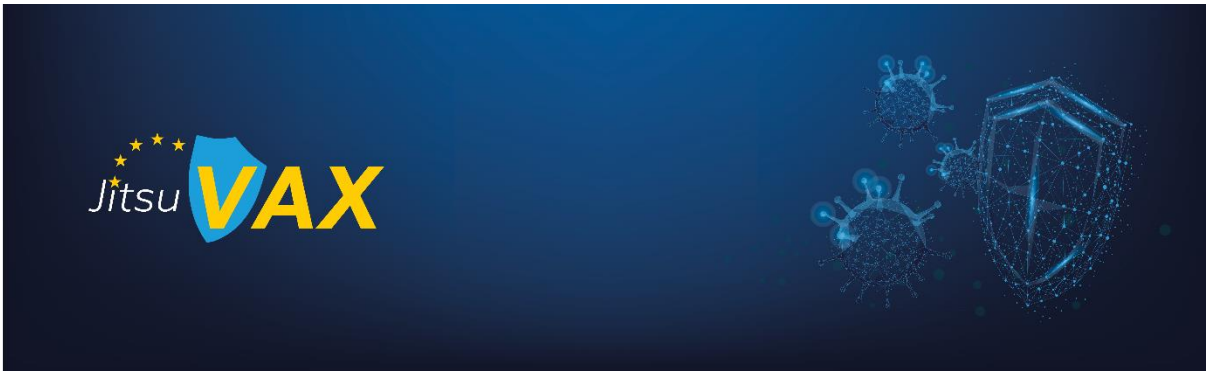

JITSUVAX:
Jiu-Jitsu with Misinformation in the Age of Covid

Report on Experiments to develop empathetic refutational interview

November 2022

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Contents

Summary

This document reports on the methods and results of a series of psychological studies and experiments to develop the empathetic refutational interview (ERI).

Scope and purpose of this document

This document reports on the methods and results of a series of psychological studies and experiments with the public to develop the empathetic refutational interview, which is a proposed tool to train Health Care Professionals (HCPs) to have more productive conversations about vaccination with patients. This document covers a validation study and three randomised experiments conducted over four stages to investigate how much the public endorse anti-vaccination arguments and how they respond to four proposed steps of the empathetic refutational interview. This document does not include information related to HCPs learning to use these steps, which will be described in D2.3 'Report on effects of refutational training' (to be submitted in month 24).

Project overview

Vaccine hesitancy—the delay or refusal of vaccination without medical indication—has been cited as a serious threat to global health by the World Health Organization (WHO), attributing it to misinformation on the internet (World Health Organization, 2019a). The WHO has also identified HCPs as the most trusted influencers of vaccination decisions (World Health Organization, 2019b).

JITSUVAX will leverage those insights to turn toxic misinformation into a potential asset based on two premises:

1. The best way to acquire knowledge and to combat misperceptions is by employing misinformation itself, either in weakened doses as a cognitive 'vaccine', or through thorough analysis of misinformation during 'refutational learning'.
2. HCPs form the critical link between vaccination policies and vaccine uptake.

The principal objective of JITSUVAX is to leverage misinformation about vaccinations into an opportunity by training HCPs through inoculation and refutational learning, thereby neutralizing misinformation among HCPs and enabling them to communicate more effectively with patients. We will disseminate and leverage our new knowledge for global impact through the team's contacts and previous collaborations with WHO and UNICEF.

Background

HCPs play a prominent role in their patients' (or caregivers') vaccination decisions (Betsch et al., 2016; Betsch, Böhm, & Chapman, 2015). Direct recommendations from HCPs can improve vaccination uptake (Brewer, Chapman, Rothman, Leask, & Kempe, 2017; Opel et al., 2013, 2015). In part, this is because HCPs should be trusted to put their patients' interests first (Alaszewski, 2010; Hall, Dugan, Zheng, & Mishra, 2001), since maintaining trust is known to improve patient outcomes (Birkhäuer et al., 2017). Overall, trusted communication from a HCP can be highly effective at dealing with patients' concerns and encouraging them to be vaccinated (Paterson et al., 2016).

However, communicating about vaccines to patients can be challenging. To be effective, HCPs must know how to reassure patients whose concerns may result from exposure to a wide range of anti-vaccination arguments, ranging from disproportionate concerns, the use of fallacious logic, and misinformation (Hughes et al., 2021; Jacobson, Targonski, & Poland, 2007). These arguments, which

are now spread rapidly on the Internet (Johnson et al., 2020), may seed doubts about specific aspects of vaccination, influencing individuals' vaccination decisions (Amanda S. Bradshaw, Shelton, Wollney, Treise, & Auguste, 2021; Amanda S. Bradshaw et al., 2020; Loomba, Figueiredo, Piatek, Graaf, & Larson, 2021; Peretti-Watel et al., 2020; Roozenbeek, Linden, & Nygren, 2020; Smith & Graham, 2019) and having detrimental impact on immunisation programmes (Garett & Young, 2021; Pierri et al., 2022; Wilson & Wiysonge, 2020). Countering misconceptions about vaccines is crucial to ensure patients make informed decisions with factual information. Indeed experimental studies have shown that debunking misinformation can successfully correct misconceptions and increase vaccine acceptance (Okuno, Arai, Suzuki, & Kikkawa, 2022; Schmid & Betsch, 2019, 2022; Yousuf et al., 2021).

For HCPs, attempting to counter each of the flawed anti-vaccination arguments that proliferate on the Internet is already a difficult task in itself. On top of this, anti-vaccination arguments often target cognitive systems used in intuitive judgements and motivated reasoning, which can make it harder to combat with statistics, facts, and logic (Okuhara, Ishikawa, Okada, Ueno, & Kiuchi, 2020). For example, opposition to vaccines that stems from social and cultural factors rather than a failure to understand the science of vaccination will not be satisfactorily countered with scientific evidence (Lander & Ragusa, 2020). Individuals can also be motivated to reject or misinterpret scientific evidence if it is in conflict with their personal interests and beliefs (Lewandowsky, Gignac, & Oberauer, 2013; Lewandowsky & Oberauer, 2016) or if it threatens their worldview or political affiliations—as observed with the greater likelihood to reject COVID-19 vaccination among Republicans compared to Democrats in the U.S. (Albrecht, 2022; Motta, 2021). Notably, attempting to correct misinformed beliefs that support people's worldview can backfire, resulting in people increasing their support for the misinformed belief (Nyhan, Reifler, Richey, & Freed, 2014; Pluviano, Watt, Ragazzini, & Sala, 2019; Pluviano, Watt, & Sala, 2017), so HCPs may worry that it will impact on trusted relationships with patients (Loftus, Sahm, & Fleming, 2021).

Effective rebuttal of anti-vaccination arguments therefore requires an approach that goes beyond addressing flaws in individual arguments and considers the 'attitude roots' of opposition to vaccines (Hornsey, 2020; Larson & Broniatowski, 2021). While an individual may express their resistance to vaccination as a specific argument, there are underlying psychological attributes that motivate their hesitance, such as personality, values, or emotions (Hornsey & Fielding, 2017). For example, an attitude rooted in a tendency to believe in conspiracy theories (i.e., 'conspiracist ideation') may manifest in the argument that one should reject vaccinations because they are part of a secret plot to control the population, whereas an attitude rooted in one's libertarian worldview may manifest in the argument that one should reject vaccinations because they are a political tool for regulatory control.

Understanding the attitude root of an individual's resistance to vaccines could allow a HCP to align their message with their patient's motivation for holding their position and avoid triggering their motivation to reject the pro-vaccination message (Hornsey & Fielding, 2017; Hornsey, Harris, & Fielding, 2018). This class of intervention is described as 'jiu-jitsu' persuasion (Hornsey & Fielding, 2017), named after the martial art that uses the opponents' force against them, rather than attempting to fight the opponent head-on. There is promising evidence that jiu-jitsu persuasion can be effective at correcting misinformed beliefs (see Table 1 for examples). In the context of HCPs' interactions with patients, jiu-jitsu persuasion could also be helpful as it takes into account patients' beliefs, increasing the likelihood of successful communication compared to if the HCP only provides practical and logistical information (Kaufman et al., 2018). Critically, a HCP can align themselves and their messages with their patients' motivations to reject vaccination without endorsing the misinformed argument(s) itself, reducing potential dissonance in HCPs' own beliefs and their response to the patient.

Table 1. Examples of 'jiu-jitsu' interventions

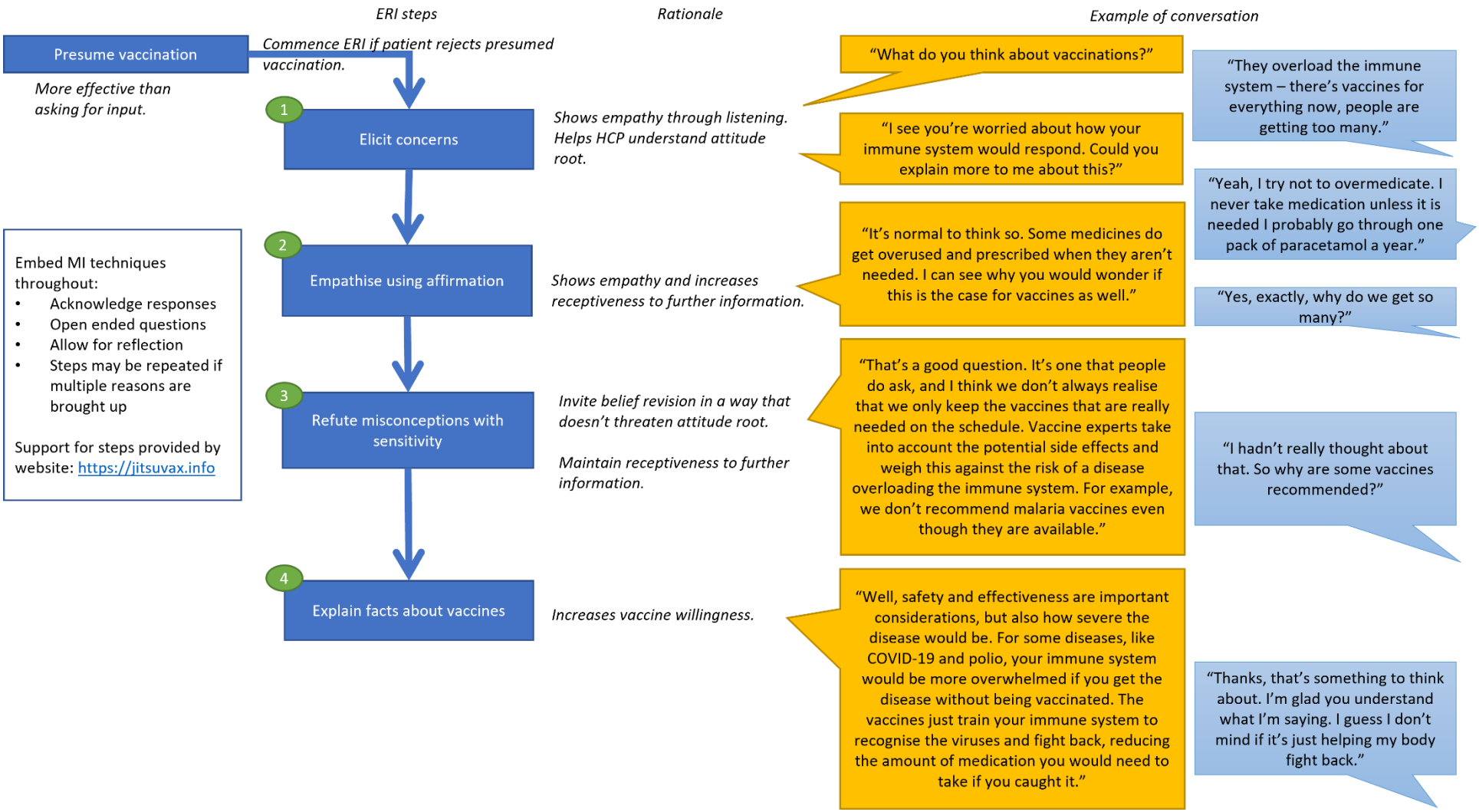
Intervention	Description	Examples of successful outcomes
Challenging meta-cognitions	Invites individual to explore their own rationale for holding their attitude or position on an issue.	Fisher and Keil (2014); Fernbach, Rogers, Fox, and Sloman (2013)
Refutational learning	Engages individual in belief revision process by pairing a misconception with a correction that replaces the misconception with the correct fact.	Schroeder and Kucera (2022) (meta-analysis)
Psychological inoculation	Warns the individual about misinformation, including tactics used to spread misinformation, to build their defences against it in the future.	Lewandowsky and Linden (2021); Ecker et al. (2022); van der Linden (2022)

How can jiu-jitsu persuasion best be operationalised in the context of a HCP's interaction with a hesitant patient? To maximise success, it is important to draw from communicative best practice in healthcare settings. In particular, motivational interviewing, a patient-centred and empathetic approach that works with patients' motivations for change (or at least their willingness to explore their motivations) (Miller & Rollnick, 2013), has been found to improve vaccination uptake among hesitant new parents (Gagneur et al., 2018) and adolescents (Dempsey & O'Leary, 2018). The motivational interviewing advises HCPs to avoid their reflex to immediately rebut patients' 'false' opinions and instead listen, show empathy, and explore and understand the patient's own motivations. The interview should then proceed to encourage and support self-efficacy in the patient's decisions. These communication elements can support jiu-jitsu persuasion, as it allows the HCP to first understand the attitude root of resistance to vaccination, then build trust through empathy, which should counter the sense of threat to the attitude root and increase receptivity to further information. The HCP can further use the motivational interviewing technique to guide the patient towards replacing their misconception with an attitude-consistent correction and receiving facts about vaccination.

Overall, combining jiu-jitsu persuasion with motivational interviewing could make a potent tool to improve vaccine confidence, with the goal being that the patient becomes receptive to, is provided with, and takes on board the facts they need to make an evidence-informed decision rather than one based on misconceptions. In this report, we present five experiments that test the efficacy this combined intervention, which we term the 'Empathetic Refutational Interview' (ERI). Our experiments provide evidence, in the context of vaccination, that show how using jiu-jitsu persuasion with the empathetic style of motivational interviewing, could guide people towards belief revision and lowering vaccine hesitancy through four steps that integrate theory and research on correcting misinformed beliefs and communicating about vaccines.

We still advise that HCPs begin conversations by presenting vaccinations as the presumptive, default option ('Let's administer your vaccinations today.'), which has been repeatedly shown to be more effective than starting the conversation with a non-presumptive approach ('Shall we talk about having your vaccinations today?'; Brewer et al., 2017; Opel et al., 2013, 2015). However, in cases where the patient does not accept the default—as is likely to be the case if misinformed beliefs are influencing their decision—the HCP can use the ERI as a tool to guide the subsequent conversation. Figure 1 summarises the steps of the ERI. We explain each step below, accompanied by a brief review of why the step is expected to be beneficial.

Figure 1. Steps of the Empathetic Refutational Interview (ERI).



Step 1: Elicit concerns

The interview commences with an invitation for the patient to share their thoughts about vaccination, based on the elicitation and active listening approach in motivational interviewing (Miller & Rollnick, 2013). The HCP is encouraged to listen and reflect on the underlying motivations, or 'attitude roots' (Fasce et al., in revision; Hornsey, 2020), that may be driving the patient's concerns about vaccination.

Part of this could involve asking patients to explain in more detail the reasons underlying their position, both as a signal of empathy and to engage the patient in a process of reflection about their own cognitions. It is common for people who hold anti-vaccination attitudes to be overconfident in their knowledge about the subject matter (Motta, Callaghan, & Sylvester, 2018). This 'meta-cognition' may lead them to believe their anti-vaccination position is right or justified and resist correction (Tormala & Rucker, 2007).

We thus expected that targeting overconfidence in the basis of the anti-vaccination position by asking people to explain their position would subsequently reduce their confidence in how well they understand their position (Fernbach et al., 2013) and how justifiable that position is (Fisher & Keil, 2014), thereby leading to less extreme attitudes about the issue (Fernbach et al., 2013).

Beyond the potential benefits of tempering overconfidence, the HCP needs a conversation opener with their patient that provides context for the rest of the interview. Eliciting concerns will also achieve this goal of helping to understand a patient's attitude roots better.

Step 2: Affirmation

Having encouraged patients to recalibrate their confidence in their anti-vaccination position, the second step in the ERI is to display empathy for the patient's position. Empathy is a multifaceted component that requires emotional intelligence on the part of the communicator, crucially to understand or imagine how the other person feels (Jeffrey, 2016).

One way to show empathy in an exchange is to offer an affirmation about the concerns of one's interlocuter, as advocated, for example, in motivational interviewing techniques (Gagneur, 2020). Here, understanding the patient's reasons and the roots of those is helpful, because it is possible to affirm the root of an attitude without agreeing with the specifics of an argument. For example, a HCP can agree that a patient has a legitimate worry that medications are overprescribed (since this is true in known cases) without agreeing that *vaccinations* are overused. Acknowledging the (partial) truth in their argument may help build receptivity for the HCP to continue the conversation and maintain trust that the HCP is looking out for the patient's interests, even if the HCP subsequently seeks to correct the patient's misconceptions.

We therefore hypothesised that a doctor providing an affirmation would generate these beneficial effects on receptiveness and trust compared to one who did not affirm their patient.

Step 3: Correct misconceptions with sensitivity

After establishing rapport through the first two steps, the third step is to refute the flawed anti-vaccination argument. Explaining why a misconception is wrong and replacing it with the correct fact is more effective at revising people's incorrect scientific beliefs than simply telling them the correct fact (Schroeder & Kucera, 2022), including in the context of vaccination (Okuno et al., 2022; Schmid & Betsch, 2019, 2022).

However, the HCP must resist the temptation to directly confront the misconception and leave this step for later in the interview as the earlier steps are essential to ensure the refutation is not perceived as a threat, for example to one's worldview, which might otherwise produce reactance

(i.e., one's resistance to others imposing their will on them; Helfers & Ebersbach, 2022; Nyhan et al., 2014). Steps 1 and 2 show that the HCP cares, which can build trust between parties even if they hold opposing positions about an issue (Zlatev, 2019). The correction in Step 3 should therefore build on this foundation and deliver the correction in a sensitive manner that aligns the facts and evidence with the patient's attitude root—thereby embedding empathy for the patient within it.

We hypothesised that refutations would help temper people's anti-vaccination positions and a sensitive refutation, paired with an affirmation, would do so more while also increase receptivity and trust relative to direct, non-affirmative refutations.

Step 4: Provide factual information

The final step in the ERI is to provide the patient with relevant vaccination information. Studies have repeatedly shown that providing information about vaccines is preferable to no information (e.g., Horne, Powell, Hummel, & Holyoak, 2015; Betsch, Böhm, Korn, & Holtmann, 2017). There are various types of information that HCPs can communicated, that have previously been successful at tackling vaccine hesitancy. Emphasising the risks children faced from measles lowered parental vaccine hesitancy compared to a control without vaccine information (Horne et al., 2015). Explaining the concept of herd immunity and how high vaccine uptake achieves the social and individual benefits of herd immunity increased vaccination intentions compared to a no-information control, especially when the explanation was accompanied by an interactive display about herd immunity (Betsch et al., 2017). Explaining about herd immunity with the interactive display was also effective at countering reactance to mandates (Sprengholz & Betsch, 2020).

From past work, it was not fully clear whether one type of information is better than another. Freeman et al. (2021) compared a number of text-based information conditions that elaborated on different facts about COVID-19 vaccination compared with a basic statement about safety and efficacy; they found that overall, vaccine hesitancy scores did not differ significantly across the information conditions. However, for strongly hesitant participants, telling them about how the vaccine would help avoid disruption to their life was most successful relative to the control statement, and also better than providing all types of information together. Strikingly, statistics evidencing the severity of the disease did no better than the control, nor did information about collective benefits (although this was focused on minimising societal disruption by staying healthy and controlling spread, rather than explaining the mechanisms of herd immunity).

We therefore expected that presenting participants with facts about vaccination, particularly those targeted at explaining the benefits of vaccination for herd immunity and the risks of the disease, would help raise vaccine willingness. Our experiments found that in fact, all types of vaccination facts appeared just as effective, and we consistently found increased vaccine willingness among participants who received these—whereas we did not find any change in vaccine willingness when we did not show participants these facts.

Altogether, the series of experiments presented here build on previous research that offered support for the different components of the interview. We tested some components that had never been operationalised as an intervention (e.g., pairing refutations with affirmation). Other components we investigated for the first time in the context of vaccination (e.g., explanations for one's position), or replicated using different formats that might be useful in the context of a patient consultation (e.g., using posters and leaflets instead of text information). In independent experiments for different steps, we isolated the key effects each intervention in the ERI should target. We then combined the interventions to test their potency when delivered as a holistic package. This research therefore offers a novel proof of concept that the ERI can be a successful tool to support positive HCP-patient conversations about vaccination.

Overview of methods and materials

Ethics and scientific best practice

Before data collection, each study was approved by the University of Bristol School of Psychological Science Ethics committee and the study methods and planned analyses pre-registered. Pre-registrations are all documented on the Open Science Framework (OSF). Experimental materials, data and the code used to derive the reported analyses will be openly shared on JITSUVAX's OSF project repository (https://osf.io/7jgs3/) when manuscript(s) are submitted for peer review. Prior to publication, they can be accessed at the following view-only links:

Experiment 1a: https://osf.io/y9rj6/?view_only=79deb460f122400dae1c35865cbb2c44
Experiment 1b: https://osf.io/vb6q9/?view_only=8d959b8f6c6c4c12807a71073e9a8508
Experiment 1c: https://osf.io/7crx4/?view_only=51549f8396e245dfae798722ed2ec504
Experiments 2-3: https://osf.io/azgv2/?view_only=e06a33ec459d40438e803585f00d6d37

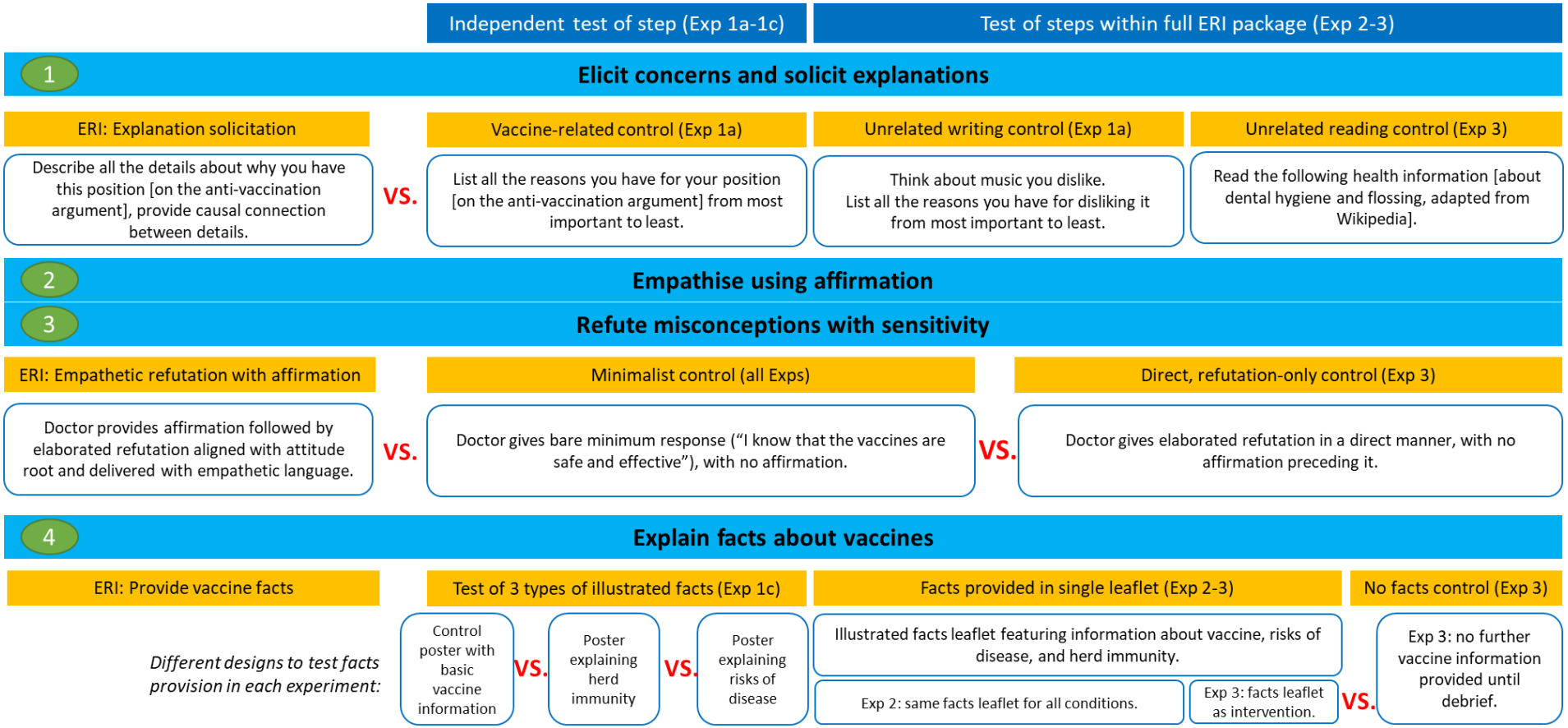
Participants

For each experiment, we collected data from participants using the online recruitment platform Prolific, which is committed to establishing ethical minimum payments for participants and has been shown to yield higher quality data compared to rival panel services (Peer, Brandimarte, Samat, & Acquisti, 2017). Prolific also allows researchers to recruit participants with various characteristics, such as political affiliations, vaccination status, and vaccine opinions. This allowed us to target our sampling to achieve a balance of gender, political leaning, and vaccine opinions by targeting similar proportions of each or focus on certain groups (e.g., unvaccinated individuals) where appropriate for the study. Participants were paid through Prolific at a rate of £9/hr (pro-rated to the length of the study). An exception was in Experiment 1c, where an additional subsample of volunteer participants was recruited among a student population.

Design

The experiments were designed to test the steps advocated in the ERI, first independently (Experiments 1a-1c; corresponding to Experiments 1-4 planned in the original JITSUVAX proposal) and then as a complete package (Experiments 2-3; corresponding to Experiments 5-6 planned in the original JITSUVAX proposal). Each experiment employed the critical ERI component against an active control condition in which participants completed a comparable task. Figure 2 gives an overview of the critical tests in each component, mapped to the ERI stages identified in Figure 1.

Figure 2. Overview of experimental interventions to test the ERI.



Note. Red 'vs.' denotes where there were comparisons between different conditions in a single experiment.

Anti-vaccination arguments

In all experiments (except Experiment 1c), participants were given anti-vaccination arguments and/or their refutations to rate. The ratings included how much they supported the arguments (or refutations), how much they thought they understood the arguments, how well they thought they could justify the arguments, and how compelling the arguments were. The ratings were made on 7-point Likert scales (e.g., 'What is your level of support for this argument?' 1: strongly against – 7: strongly in favour).

We used prototypical arguments drawn from the Taxonomy of Anti-Vaccination Arguments (Deliverable 2.1). In a pre-test (reported in full in the Appendix), we solicited endorsement ratings of these arguments from 1,250 UK participants on Prolific. We selected the 30 top-rated arguments as a starting pool from which to draw for the experiments reported here.

Vaccine willingness measures

Across the experiments, we used a range of measures targeted at measuring determinants of vaccine behaviour. We presented the original forms of all measures to participants in the experiments. These original forms included items with both polarities (e.g., 'COVID-19 is not so serious that I should get vaccinated' indicates a reluctance to be vaccinated, whereas 'The COVID-19 vaccines are safe' indicates a willingness to be vaccinated). For consistency, we recoded all responses to items such that they reflected participants' overall levels of vaccine willingness in the figures that we present in this report.

Experiments 1a-1c: Testing the individual components of the ERI

Soliciting explanations or listing reasons for vaccine opposition

In Experiment 1a, we addressed the solicitation step of the ERI independently. Building on past work, we hypothesised that soliciting explanations would reduce support for the position and re-calibrate participants' self-perceived understanding and ability to justify their position compared to an active control condition where participants were also asked why they supported the anti-vaccination position, but to just list reasons for it.

Methods

Participants

We collected data from 226 UK participants who had not had a COVID-19 vaccine (identified using a Prolific screener question). This sample size was determined based on achieving 90% power (at α = 0.05) to detect a between-subjects main effect of size partial eta-square = 0.034 (as was found in previous research; Fernbach et al., 2013). Participants were 54% female (45% male, 1% other identity or did not state), aged 19-74 years (M = 36.24 years, SD = 12.23), and political leanings were normally distributed across the political spectrum (skewness = -0.18, kurtosis = 0.33).

Materials and procedure

Participants first completed the Confidence, Complacency, and Collective subscales of the 5C determinants of vaccine behaviour (Betsch et al., 2018; Confidence: α = 0.87, Complacency: α = 0.72, Collective: α = 0.63[1]).

Participants then rated their level of support for 10 anti-vaccination arguments (randomly chosen from the overall pool of 30 arguments). We then took the top three most supported arguments for

[1] Because the collective responsibility subscale had less-than-satisfactory reliability (< 0.70), we checked whether the analyses would change using a two-item composite rather than a three-item (dropping the item that resulted in reliability of α = 0.75 on both subscales). Using either composite measure did not change the outcome of any of the analyses.

each participant[2], and participants rated how well they understood these and how well they thought they could justify their level of support for them. Each rating was made on a 7-point Likert scale (1: not at all, 7: completely).

Participants were then randomised to either the control (n = 115) or experimental condition (n = 111)[3]. In the control, for each of the three chosen arguments, participants were asked to list the reasons they had for supporting the argument. In the experimental condition, for each of the three arguments, participants were asked to explain the causal mechanisms leading them to support the argument. Participants gave their answers in free text.

After listing or explaining their position, participants completed the argument ratings for the three arguments and three 5C subscales again (Confidence: α = 0.86, Complacency: α = 0.85, Collective: α = 0.66). Finally, participants provided socio-demographic information.

Results

Effects of soliciting explanations on anti-vaccination argument ratings

We ran mixed Analyses of Variances (ANOVAs) on each of the argument ratings: support, understanding, and perceived ability to justify one's position, with experimental condition (control or experimental) as a between-subjects factor and timing of the rating (pre or post intervention) as a within-subjects factor. Overall, ratings of arguments decreased post-intervention compared to pre-intervention (see Figure 3). In both experimental conditions, participants supported and reported understanding the arguments significantly less post-intervention (support: M_{diff} = -0.31, SD = 0.80, 95% CI = -0.42, -0.21, F(1, 224) = 34.62, p < .001, η^2_P = 0.13; understanding: M_{diff} = -0.21, SD = 0.78, 95% CI = -0.31, -0.11, F(1, 224) = 16.97, p < .001, η^2_P = 0.07). This did not interact significantly with the condition (support: F(1,224) = 0.82, p = .367, η^2_P < 0.01; understanding: F(1, 224) = 1.75, p = .187, η^2_P = 0.01). Participants rated themselves less able to justify their position post-intervention in the experimental condition, but not the control condition (interaction effect: F(1, 224) = 5.42, p = .021, η^2_P = 0.02; $M_{diff, control}$ = 0.03, SD = 0.79, 95% CI = -0.12, 0.17; $M_{diff, experimental}$ = -0.26, SD = 1.01, 95% CI = -0.45, -0.06).

Effects of soliciting explanations on vaccine willingness hesitancy

Mixed ANOVAs on each of the 5C subscales (confidence, complacency, and collective) found no significant changes in vaccine willingness on these measures pre- and post-intervention (Confidence: F(1, 224) = 2.83, p = .094, η^2_P = 0.01; Complacency: F(1, 224) = 2.15, p = .144, η^2_P = 0.01; Collective: F(1, 224) < 0.01, p = .979, η^2_P = 0.01). Experimental condition had no significant effects (Confidence: F(1, 224) = 0.28, p = .598, η^2_P = < 0.01; Complacency: F(1, 224) = 1.46, p = .228, η^2_P < 0.01; Collective: F(1, 224) < 0.01, p = .953, η^2_P < 0.01).

Overall effects

Overall, Experiment 1a found that asking participants about why they support anti-vaccination arguments (whether by explaining or listing them) reduced support for the argument and perceived understanding of the argument, but only asking participants to explain their reasons lowered confidence in justifying their support. However, although participants may have supported the arguments less, this did not carry over into shifting their levels of vaccine willingness.

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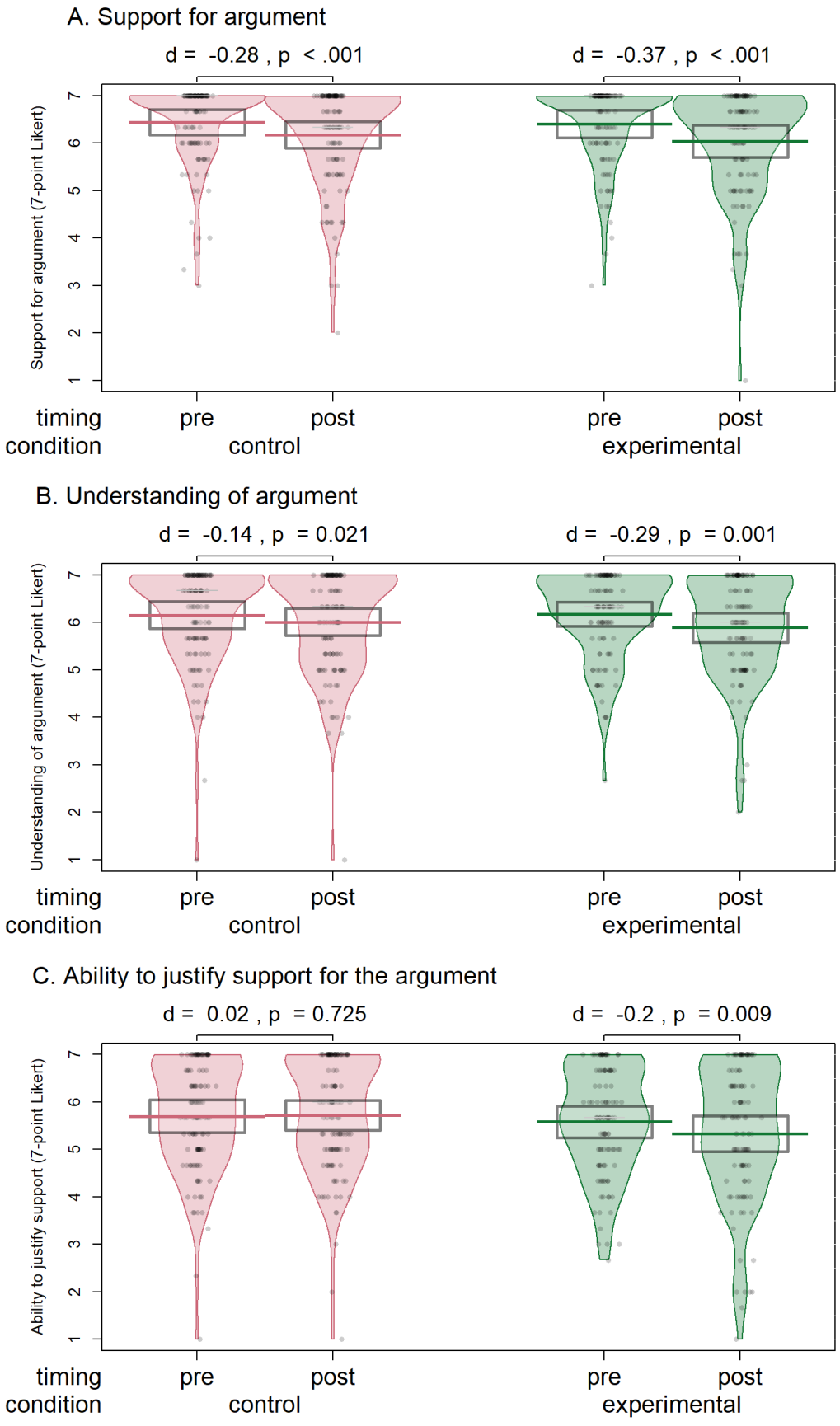
[2] Only 4 participants expressed no endorsement of any of the anti-vaccination arguments (their top 3 responses were at the midpoint of the scale). Excluding these participants did not change any of the results.

[3] Five more participants in the experimental compared to control group did not finish the study. However, this different in drop-out rate was not significant, χ^2(df = 1) = 0.73, p = .392.

Figure 3.

Changes in support, understanding, and perceived ability to justify one's endorsement in the control (left) and experimental (right) conditions in Experiment 1a.



Experiment 1b: Reading an empathetic refutation

In Experiment 1b, we tested the affirmation and refutation components of the ERI together as a single empathetic refutation. We hypothesised that participants reading a scenario where a patient received an empathetic refutation would perceive this refutation more favourably, and the empathetic refutation would also reduce support for the anti-vaccination argument and increase vaccine willingness compared to an active control where the anti-vaccination argument received minimal refutation.

Methods

Participants

We collected data from 1100 UK participants (51% female, 48% male, 1% other identity; age range 18-85 years, *M* = 40.52, *SD* = 13.38, 88% White), using quota sampling from the general population to achieve a reasonable distribution of opinions about the COVID-19 vaccine (our sample included 36% with negative opinions, 21% positive, 42% neutral or not stated). This sample size would achieve 90% power (at α = 0.05) to detect a between-subjects main effect in the planned comparison for the main DVs, when including 9 covariates in the model, assuming a small effect size (*d* = 0.2, *f* = 0.1). Participants' political leanings were normally distributed across the political spectrum, skewness = -0.02, kurtosis = -0.52).

Materials and procedure

Participants first completed four sets of questions in random order: the 5C subscales for Complacency (α = 0.78, M = 3.22, SD = 1.4) and Confidence (α = 0.9, M = 4.43, SD = 1.7; Betsch et al., 2018), the 6-item Cognitive Reflection Test (mean score = 3.12, SD = 1.93; Primi, Morsanyi, Chiesi, Donati, & Hamilton, 2016), the Health Literacy Scale (α = 0.76, M = 4.4, SD = 0.62; Haun et al., 2009), and the Patient Trust in Medical Profession subscale (α = 0.89, M = 2.95, SD = 0.83; Dugan, Trachtenberg, & Hall, 2005).

Participants then saw an anti-vaccination argument, which was selected randomly from a set of 24 arguments. This was a subset of the 30 arguments used in Experiment 1a, but instead of taking the most highly-rated arguments from the pre-test, we selected only those that had received between 60-75% of the maximum rating in the pre-test. This was to ensure that arguments fell within a range that would avoid floor or ceiling effects. This subset of 24 arguments covered 10 different attitude roots. Participants rated how much they (i) supported the argument; (ii) found the argument compelling; (iii) thought they would be able to justify the position in the argument (irrespective of how much they supported it). These ratings were given on a 7-point Likert scale (1: not at all, 7: completely). These ratings provided a baseline measure of anti-vaccination argument ratings.

Participants were then randomised into the control (*n* = 521) or experimental condition (*n*= 579)[4], where they were presented with a different randomly chosen argument from the set. This time, the argument was shown as part of a simulated online forum discussion between a regular forum user ('Tom') who was against vaccines and a medical professional ('Dr Jones', a General Practitioner). In the control condition, Dr Jones refuted Tom's argument by simply saying 'I know that the recommended vaccines are safe and effective' and nothing else. In the experimental condition, Dr Jones refuted Tom's argument by providing an empathetic refutation targeted at showing empathy for Tom's position and correcting the misconception.

[4] Thirteen more participants in the control compared to the experimental group did not finish the study, which was a significant drop-out rate between the two conditions, $\chi^2(df = 1) = 5.82$, $p = .016$. However, this is unlikely to have affected the experiment as we found no significant differences between conditions in terms of participants' baseline support of an anti-vaccination argument, $t(1075) = -0.38$, $p = .705$.

For example, in the experimental condition, one argument was as follows (the full set of empathetic refutations can be found in Appendix):

> Tom [user] posted:
> Guys, we shouldn't be getting vaccinated. The authorities are lying and covering up important information about vaccines.
>
> Dr Jones [GP] posted:
> It's true that there are situations where we aren't told the whole truth about things. So it's important that we're open to any evidence that would indicate that this might be the case. But in this case, independent experts are giving evidence about the safety of vaccines, and they are not under the government's control. In addition, all side effects from vaccines are reported and kept track of through public reporting sites that are open to anyone. If safety concerns are raised after the vaccines have been approved for broader use, agencies take them very seriously and may even pause administering a vaccine, as we saw in 2021 with the AstraZeneca vaccine against COVID-19.

Participants first completed ratings of their support for Tom's position, how compelling Tom's position was, and how much they could justify Tom's position, as they had with the previous argument. Following that, they completed the same ratings for Dr Jones's position.

After reading and rating the forum discussion, participants completed the two 5C subscales again (Complacency: α = 0.81, M = 3.17, SD = 1.43; Confidence: α = 0.91, M = 4.38, SD = 1.68). Finally, they provided socio-demographic information.

Results

Effects of empathetic refutation on receptiveness to doctor

On average, participants rated the doctors' refutation higher than the forum user's anti-vaccination argument (support: d = 0.65, compelling: d = 0.64, ability to justify: d = 0.62, all p's < .001). Compared to participants in the control condition, participants in the experimental condition supported the doctor's refutation more (M_{diff} = 0.70, d = 0.41 [95% CI: 0.29, 0.53]), found it more compelling (M_{diff} = 1.46, d = 0.92 [95% CI: 0.79.1.05]), and felt themselves more able to justify the refutation (M_{diff} = 0.62, d = 0.4 [95% CI: 0.28, 0.52]). This intervention effect remained significant when controlling for participants' baseline ratings for the first anti-vaccination argument in a multiple linear regression model (support: β = 0.21, p < .001, compelling: β = 0.43, p < .001, ability to justify: β = 0.19, p < .001).

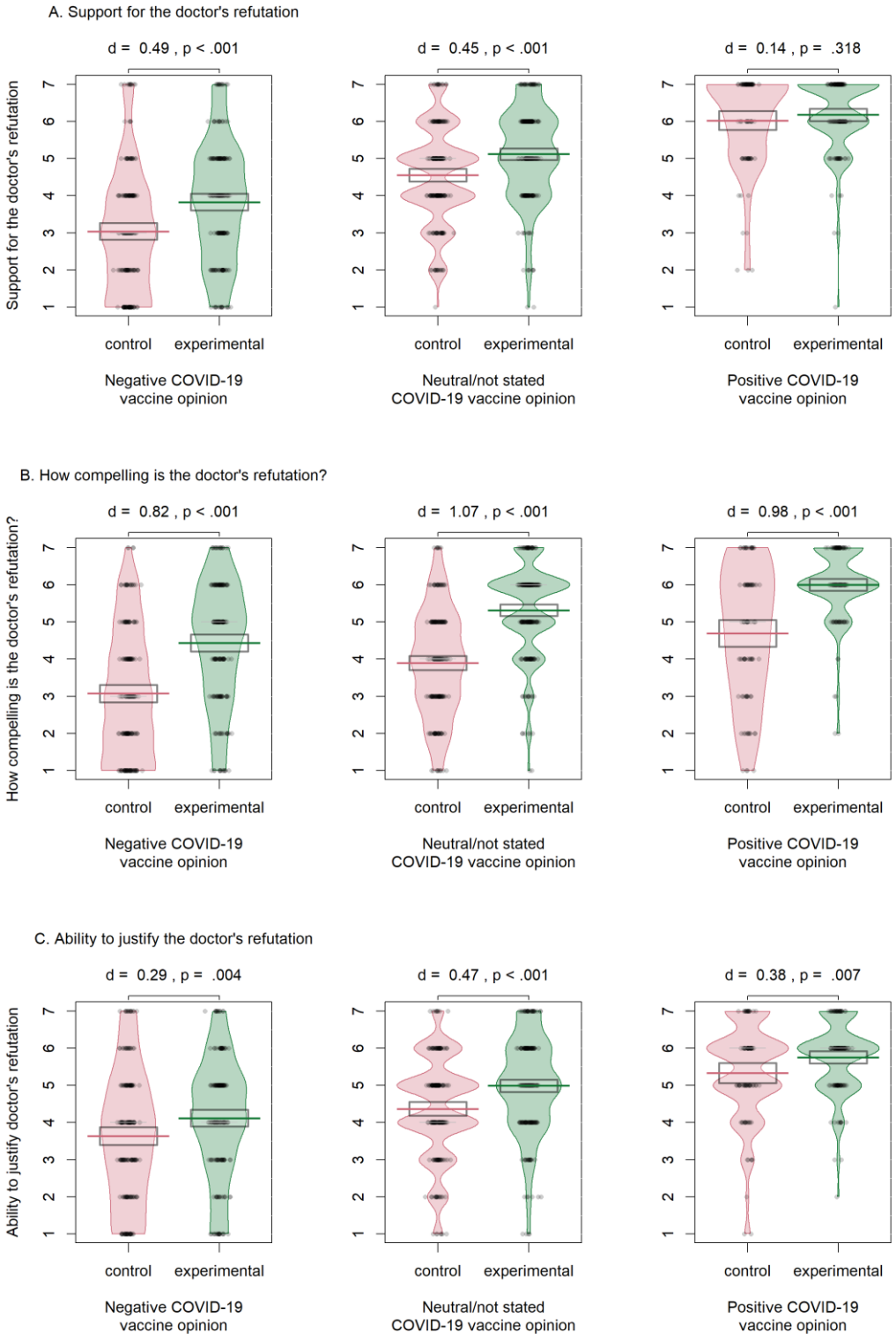
The intervention effect on participants' ratings of the doctor's refutation remained significant after controlling for trust, cognitive reflection, and health literacy (support: β = 0.19, p < .001, compelling: β = 0.41, p < .001, ability to justify: β = 0.18, p < .001). These secondary analyses showed that trust in the medical profession was a significant predictor of participants' support for the refutation and how compelling they found it (support: β = 0.18, p < .001, compelling: β = 0.28, p < .001) but not their perceived ability to justify the refutation, β = 0.01, p = .649. None of the other covariates had significant effects in these analyses.

To further assess the interplay between existing attitudes and support for the doctor's refutation, we conducted another exploratory subgroup analysis based on participants' opinions of the COVID-19 vaccine, as we had in our sample three different opinion groups: positive, negative, or neutral/not stated. Participants with positive opinions showed the highest support for the refutation, followed by those who were neutral, and finally those with negative opinions (see Figure 4). A between-subjects ANCOVA including this factor and its interaction with experimental condition (while controlling for baseline argument support and trust as covariates) found a significant interaction, $F(2, 1092) = 3.76$, $p = .024$, $\eta^2_P = 0.01$. Follow-up tests showed that the intervention

produced larger effects for those with less positive opinions of the COVID-19 vaccine (negative: $t(399) = 4.87$, $p < .001$, $d = 0.49$; neutral/not stated: $t(454) = 4.84$, $p < .001$, $d = 0.45$; positive: $t(173) = 1.00$, $p = .318$, $d = 0.14$).

Figure 4.

Support for the doctor's refutation in the control and experimental conditions in Experiment 1b, by participants' attitude towards the COVID-19 vaccines.



Effects of empathetic refutation on anti-vaccination argument ratings

All of participants' ratings for the anti-vaccination argument in the forum discussion were lower than their baseline ratings (support: d = -0.36, compelling: d = -0.51, ability to justify: d = -0.37, all p's < .001), suggesting that overall, encountering an anti-vaccination argument that is being refuted—even minimally—by a medical professional, produces lower support for the argument than encountering it unchallenged.

Controlling for baseline ratings, we did not find a significant effect on ratings of the anti-vaccination argument between conditions (see Figure 5); support: β < 0.01, p = .979, compelling: β = -0.03, p = .281, ability to justify: β < -0.01, p = .854. This was still the case when we added trust in the medical profession, cognitive reflection, and health literacy as covariates. Participants with lower trust rated the anti-vaccination argument higher on all measures (support: β = -0.22, p < .001, compelling: β = -0.18, p < .001, ability to justify: β = -0.17, p < .001). Participants with lower CRT scores also rated the anti-vaccination argument higher (support: β = -0.08, p = .002, compelling: β = -0.11, p < .001, ability to justify: β = -0.05, p = .050).

Effects of empathetic refutation on the relationship between trust and support ratings

Because of the significant interactions between participants' trust in the medical profession and the experimental condition, we followed up with an exploratory multiple linear regression on how trust affected support for the doctor's refutation and for the anti-vaccination argument in each experimental condition.

In the control condition, trust had a stronger effect on support for the doctor's refutation (β = 0.42) compared to the experimental condition (β = 0.28). This appeared to be due to less trustful participants supporting the refutation more, as opposed to more trustful participants supporting the refutation less (see Figure 6). Trust also had a stronger effect on support for the anti-vaccination arguments in the control condition (β = -0.29) compared to the experimental condition (β = -0.16), but this seemed to affect both ends of the trust scale. The less trustful participants showed a larger drop in support for the anti-vaccination argument in the experimental condition than the control, but the more trustful participants also had a smaller drop in support in the experimental compared to the control condition.

Effects of empathetic refutation on vaccine willingness measures

Mixed ANOVAs on the Confidence and Complacency subscales found that compared to baseline, participants were more vaccine-willing (less complacent) but also less vaccine-willing (less confident), but these effects were very small (Complacency: M_{diff} = -0.05, F(1, 1098) = 7.25, p = .007, η^2_P < 0.01, Confidence M_{diff} = -0.05, F(1, 1098) = 9.59, p = .002, η^2_P = 0.01). The intervention had no significant effects nor interactions (Complacency: F(1, 1098) = 0.07, p = .796, F(1, 1098) = 1.26, p = .263; Confidence: F(1, 1098) = 3.53, p = .061, F(1, 1098) = 1.23, p = .268 for the main and interaction effects respectively).

Overall effects

Overall, Experiment 1b found that an empathetic refutation (compared to the minimal control) was more supported and perceived as more compelling and justifiable, particularly for those whose levels of trust in the medical profession are lower and who have less positive views about vaccination. Having a doctor oppose an anti-vaccination argument appeared to help reduce support for anti-vaccination arguments, but this was also contingent on trust. Those with lower trust displayed a greater reduction in anti-vaccination argument support in the empathetic refutation condition than the control. However, this intervention still did not produce any changes in vaccine willingness.

Figure 5.

Change in support for the anti-vaccination argument in the control and experimental conditions in Experiment 1b, by participants' attitude towards the COVID-19 vaccines.

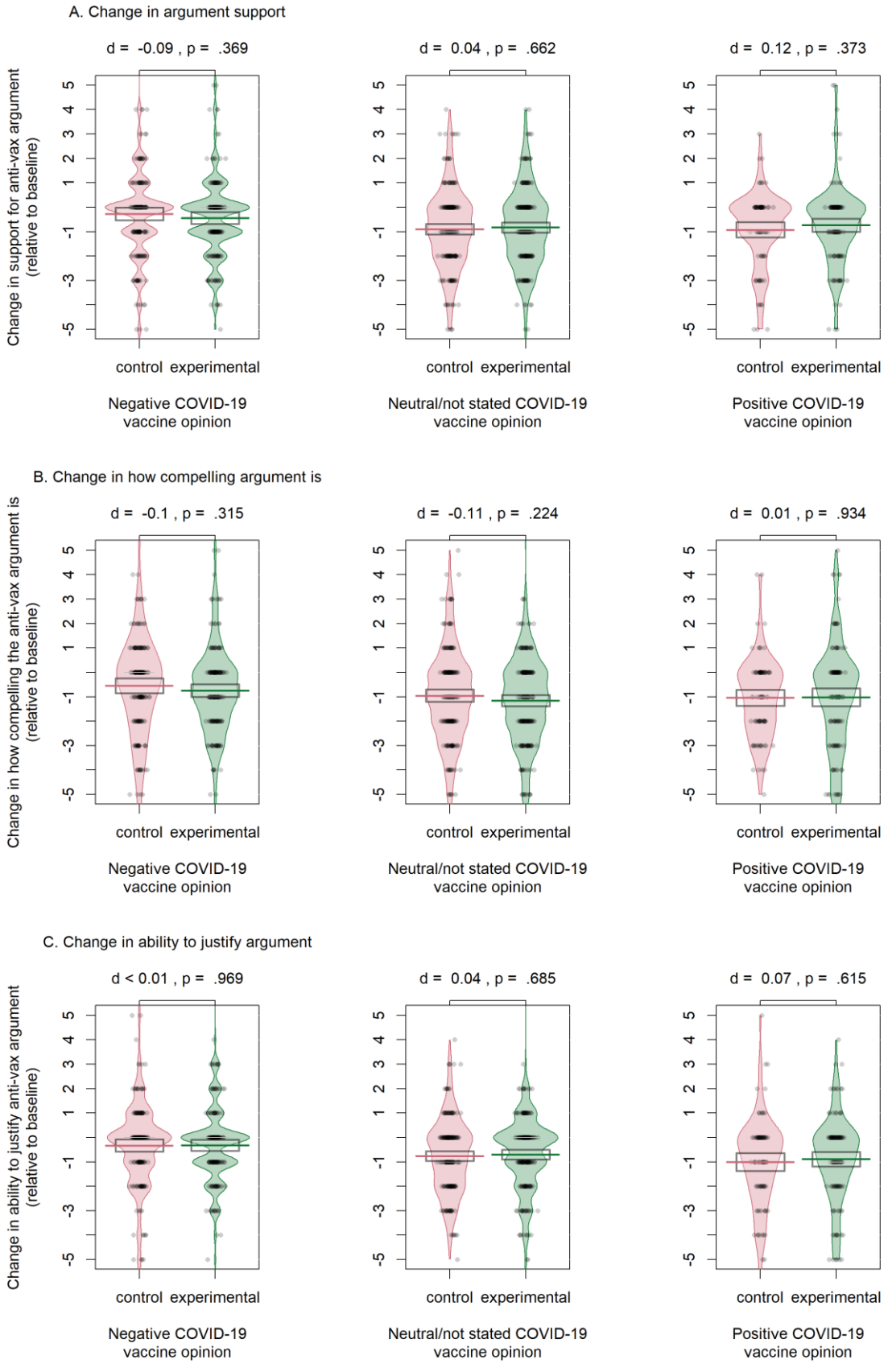
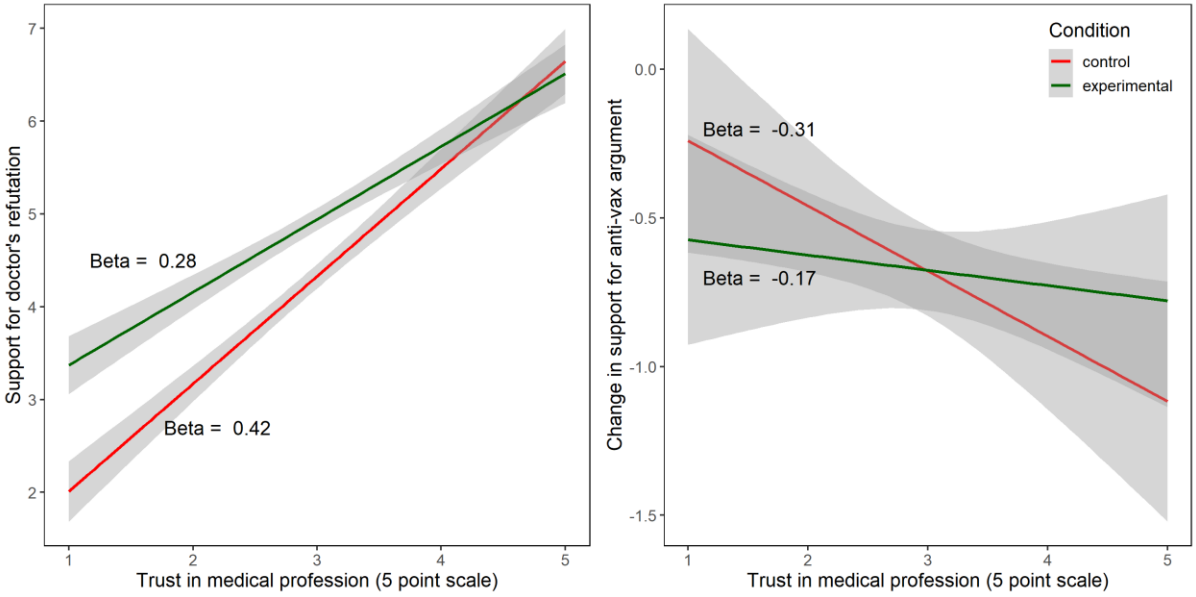


Figure 6.

Differential effects of trust on support for the doctor's refutation (left panel) and change in support for the anti-vaccination argument (right panel) in the control and experimental conditions in Experiment 1b.



Experiment 1c: Comparing risk redirection, herd immunity against general factual information

In Experiment 1c, we assessed the effectiveness of providing vaccination facts, namely information about disease risks and herd immunity. Because previous research had shown that illustrations could be effective in engaging people, we designed illustrated formats of vaccine information. We hypothesised that providing disease risk information and herd immunity benefits would be more effective at reducing vaccine hesitancy compared to a control condition that only covered basic factual information about vaccines.

Methods

Participants

In addition to a sample of participants on Prolific (n = 215), our participants also included a convenience sample of 45 University students, who participated for course credit, and 77 volunteers recruited via snowball sampling. Participants were aged 18-73 years (M = 35.23, SD = 13.32), 56% female (42% male, 1% identified otherwise), 71% White (23% Asian/Asian British, 6% other ethnicities); 61% had completed a Bachelor's degree. The total sample size (n = 337[5]) offered 90% power to detect a small-to-medium main effect (f = 0.17), and a small interaction effect (f = 0.10) in a mixed ANOVA.

[5] Sixty-four participants started but did not complete the study. There was no evidence that the drop-out rate was significantly different among conditions, $\chi^2(df = 2) = 0.96$, p = .617. Sixty-two failed a pre-registered attention check and were excluded from the analytical sample. These participants had generally higher hesitancy levels than the analytical sample. Including these participants to the sample did not change the pattern of results, but the change in the Calculation and Collective measures became non-significant.

Materials and procedure

Participants first completed five vaccine willingness measures: a 10-item Vaccine Hesitancy Scale (VHS: Shapiro et al., 2018; α = 0.92), and the Confidence (α = 0.84), Complacency (α = 0.65[6]), Calculation (α = 0.70), and Collective (α = 0.77) 5C subscales, each composed of 3 items. The VHS was measured on a 5-point Likert scale and the 5C subscales on a 7-point Likert, each anchored at 'strongly disagree' (1) and 'strongly agree' (5 or 7 respectively).

Participants were then randomly assigned to view one of three different vaccine facts posters: (i) a control poster including only basic facts about vaccines (*n* = 112); (ii) a poster explaining the risks of COVID-19 (*n* = 111), or; (iii) a poster explaining herd immunity and its benefits (*n*= 112). All posters were matched in terms of design and length, and included a visual illustration of relevant statistics (for the control poster: percentage of people who had received the vaccines; for the risk poster: percentage of vaccinated and unvaccinated people who had died from COVID-19; for the herd immunity poster: proportion of people who would get COVID-19 in a population with low vs. high vaccination coverage). See the Appendix for the exact design of these posters.

To prevent participants from skipping past the posters, a 30-second timer was set to ensure they spent at least this amount of time reading. Participants completed a one-item multiple choice question about what the poster contained as an attention check after viewing the posters, as an exclusion criterion for participants who had not paid attention.

Participants then responded to the VHS and 5C subscale measures again (VHS: α = 0.93; Confidence: α = 0.87; Complacency: α = 0.70; Calculation: α = 0.84; Collective: α = 0.82), and an additional question asking if they were willing to receive a COVID-19 booster vaccine if it was recommended annually. This question was measured on a 5-point Likert scale (1: not at all willing; 5: very willing). Finally, participants completed socio-demographic information.

Results

Effects of vaccine facts posters on vaccine hesitancy

On each of the vaccine hesitancy measures, we conducted mixed ANOVAs with timing of the measure (pre- and post-test) as a within-subjects factor and poster condition as a between-subjects factor.

Overall, participants significantly increased their vaccine willingness after reading the posters, with significant main effects of timing in all analyses with pre- and post-scores; VHS: $F(1, 334) = 9.21$, $p = .003$, $\eta_p^2 = 0.03$; Confidence: $F(1, 334) = 27.39$, $p < .001$, $\eta_p^2 = 0.08$; Complacency: $F(1, 334) = 14.54$, $p < .001$, $\eta_p^2 = 0.04$; Calculation: $F(1, 334) = 7.53$, $p = .006$, $\eta_p^2 = 0.02$; Collective: $F(1, 334) = 4.09$, $p = .044$, $\eta_p^2 = 0.01$.

However, although the effect sizes for the changes in vaccine willingness varied across conditions (see Figure 7), we did not find the hypothesised interaction effects that would indicate the poster conditions differentially affected this change, interaction effects for: VHS, $F(2, 334) = 0.57$, $p = .567$; Confidence, $F(2, 334) = 0.72$, $p = .489$; Complacency, $F(2, 334) = 0.34$, $p = .711$; Calculation, $F(2, 334) = 0.74$, $p = .480$; Collective, $F(2, 334) = 0.12$, $p = .886$.

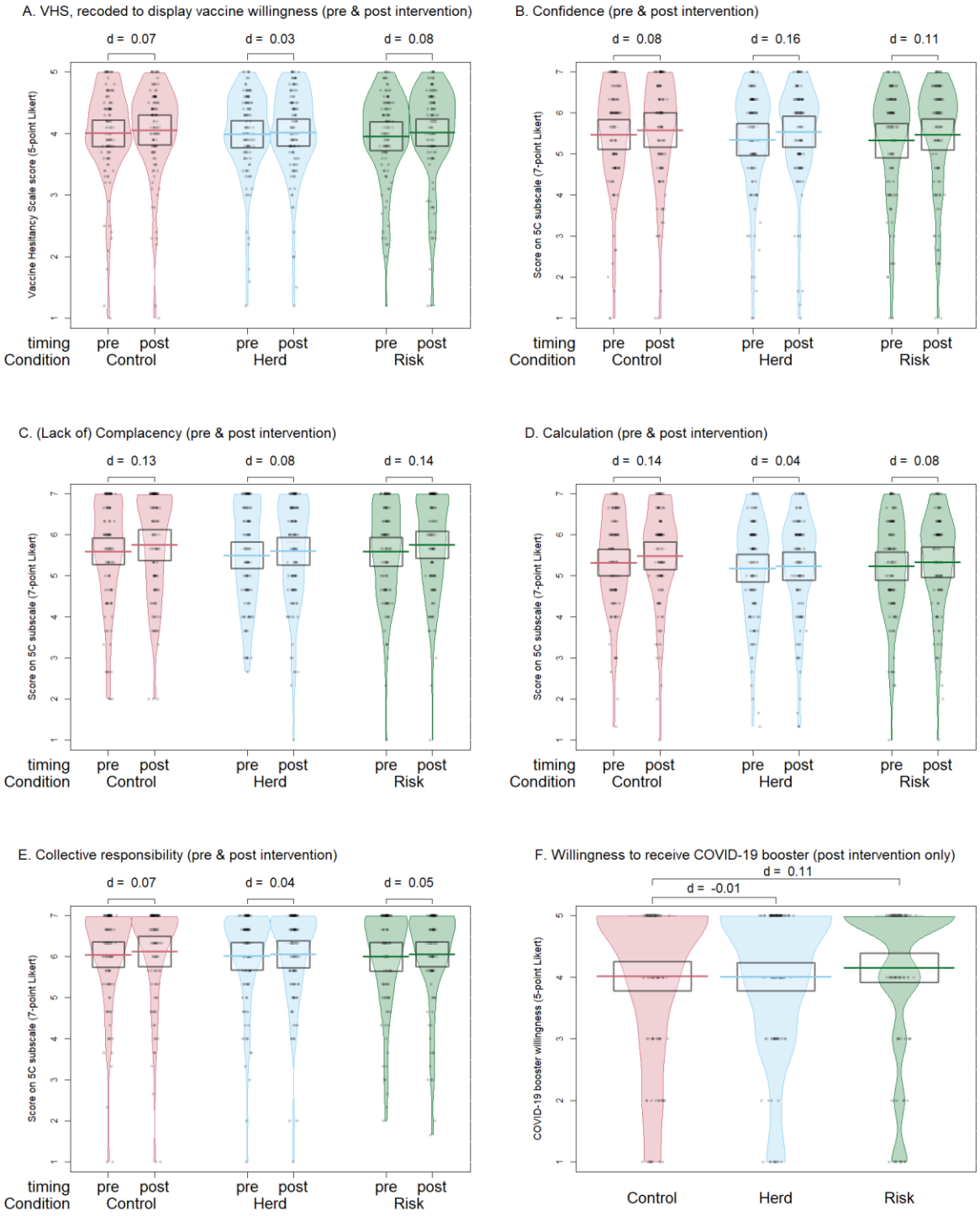
Willingness to receive the booster vaccine was significantly correlated with less vaccine hesitancy except in the case of calculation (VHS: $r = -0.69$, $p < .001$; Confidence: $r = 0.66$, $p < .001$; Complacency: $r = -0.51$, $p < .001$; Calculation: $r = -0.10$, $p = .082$; Collective: $r = 0.60$, $p < .001$).

[6] Because the complacency subscale had less-than-satisfactory reliability (< 0.70), we checked whether the analyses would change using a two-item composite rather than a three-item (dropping the item that resulted in reliability of α < 0.70 on both subscales). Using either composite measure did not change the outcome of any of the analyses.

However, a one-way ANOVA on participants' willingness to receive a COVID-19 booster vaccine also found no main effect of the poster condition, $F(2, 334) = 0.46$, $p = .629$, $\eta_p^2 < 0.01$.

Figure 7.

Increases in vaccine willingness for the 3 poster conditions in Experiment 1c.



Discussion

Experiments 1a-1c tested the components of the ERI in separate steps. These experiments confirmed that each step of the proposed ERI best tackles a different component when it comes to increasing vaccine willingness. Experiment 1a found that soliciting explanations influenced meta-

cognitive evaluations of one's argument support: participants lowered their confidence in justifying their supported argument as compared to when they just listed reasons (although participants' support and perceived understanding decreased in both conditions). Experiment 1b found that (empathetically) refuting misconceptions influenced receptivity to the doctor, especially for those who had negative vaccination opinions and lower trust in the medical profession. Finally, Experiment 1c found that the provision of facts to participants, regardless of the type, increased vaccine willingness. The type of facts shown did not significantly change willingness as measured by the various scales, nor willingness to receive a COVID-19 booster vaccine after reading the facts.

In our next experiments, we aimed to replicate our findings and assess the different components of the ERI in combination with each other.

Experiment 2: Testing the full ERI against a single control condition

In Experiment 2, we put together each of the elements tested in Experiments 1a-1c into a combined intervention. We hypothesised that this ERI intervention would be more effective compared to a control in each of the areas targeted by the different ERI steps. We expected explanation solicitation to lower anti-vaccination argument support, understanding, and confidence in justifying one's support. We expected the empathetic refutation to increase support for refutations and the perception that they were compelling, and that it would increase participants' trust in the doctor providing the refutation and openness to hear more information relative to a control refutation. Finally, we expected that vaccine willingness would increase more after the full ERI, and that the full ERI would also further reduce support for arguments.

Methods

Participants

We collected data from 519 UK participants who had not had a COVID-19 vaccine (identified using a Prolific screener question). This sample size was determined based on achieving 90% power (at α = 0.05) to detect an interaction effect of size η^2_P = 0.02 (calculated based on Experiments 1a-1c) in a 2 (within) x 2 (between) design. Participants were 66% female (33% male, 1% other identity or did not state), aged 18-76 years (*M* = 34.27 years, *SD* = 10.37), and political leanings were normally distributed across the political spectrum (skewness = -0.05, kurtosis = 0.73).

Materials and procedure

Participants first completed the Confidence, Complacency, and Collective 5C subscales (Confidence: α = 0.88, Complacency: α = 0.71, Collective: α = 0.66[7]), and one question on their willingness to receive a COVID-19 booster vaccine if it was recommended. They also completed the Trust in the Medical Profession scale (α = 0.85) from Experiment 1b. The order of presentation of these items were randomised.

Participants then followed the argument rating procedure in Experiment 1a, except that we reduced the number of arguments to rate in the first step to 6, and they were selected from a smaller pool (*n* = 22) that only included arguments with refutations designed for Experiment 1b that could be inserted reasonably into a consultation excerpt in the next step.

[7] Because the collective responsibility subscale had less-than-satisfactory reliability (< 0.70), we checked whether the analyses would change using a two-item composite rather than a three-item (dropping the item that would result in a reliability of α > 0.70 on both subscales). Using either composite measure did not change the outcome of any of the analyses.

Participants were then randomised to either the control (n = 263) or experimental condition (n = 256)[8]. For the experimental condition, we retained the explanation condition from Experiment 1a, as this had produced a consistent effect on all three argument rating measures. However, we reduced the number of arguments participants explained to two, to shorten the time spent on this component. In the control condition, participants were asked to think about a type of music they disliked and write a detailed explanation of why they disliked it. Participants completed the argument ratings (support, understanding, ability to justify) after writing their explanations.

We then replicated the refutation step from Experiment 1b, only this time participants were shown an excerpt of a consultation between Tom and Dr Jones, and Dr Jones refuted two arguments instead of one, and these were no longer randomly chosen, but the two arguments that participants supported the most. The control and experimental conditions in this step were identical to Experiment 1b (with a minimal response vs. an empathetic refutation from Dr Jones accompanying each of the two arguments from Tom, presented in random order). Participants completed the support and 'how compelling' rating for Dr Jones's refutation. We then extended the scenario by providing a short text in which Dr Jones offered more information to Tom in either an empathetic (experimental) or direct (control) way. Participants indicated how open they would be to receiving this information if they were in Tom's position (on a 7-point scale, 1: not at all, 7: completely) and then rated Dr Jones on the Trust in a Doctor scale (Dugan et al., 2005; α = 0.88).

Participants in both conditions then saw an illustrated page with facts about vaccines, which included both facts about COVID-19 disease risks and the benefits of herd immunity. They completed a multiple-choice attention check question to assess how well they had taken in the information.

Overall, the control condition differed from the experimental condition only in the first two steps of the ERI. Thus, overall, the control condition received two active control elements (an unrelated writing exercise and the minimal response from Experiment 1b) but the same provision of facts as the experimental condition. This meant that effectively, the ERI was compared against a facts-only control.

Finally, participants rated their support for the two arguments used throughout the experiment and completed the three 5C measures (Confidence: α = 0.90, Complacency: α = 0.77, Collective: α = 0.70) and booster vaccine willingness question again, and providing socio-demographic information.

Results

Effects of soliciting explanations on anti-vaccination argument ratings

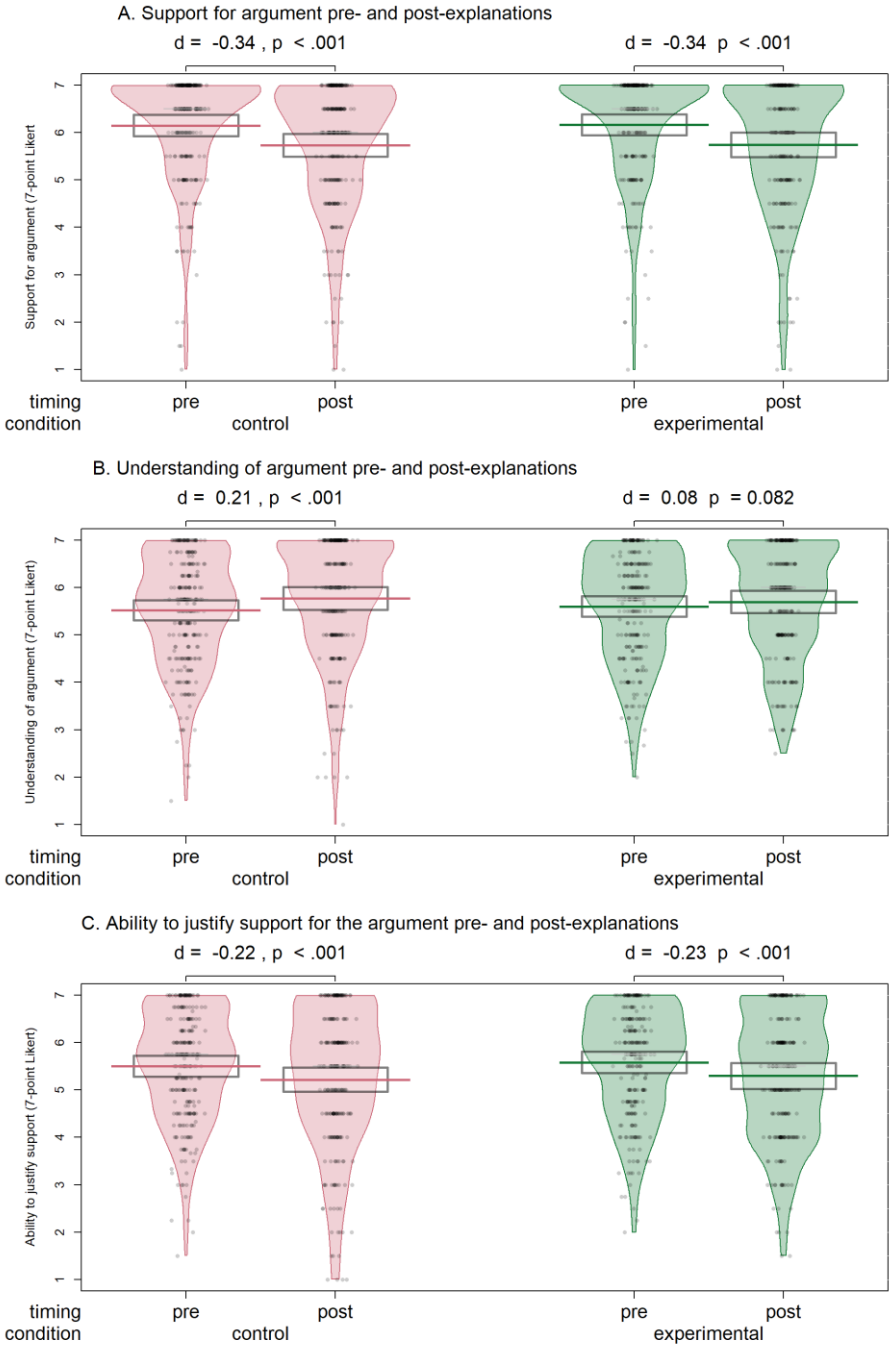
A mixed ANOVA analysing the effect of condition, timing of measure, and their interaction on each argument rating found that support for the argument and ability to justify support for it decreased significantly overall (see Figure 8), $F(1, 517) = 118.55$, $p < .001$, $\eta^2_P = 0.19$ (support); $F(1, 517) = 23.49$, $p < .001$, $\eta^2_P = 0.04$ (ability to justify), while understanding of the argument increased significantly, $F(1, 517) = 54.33$, $p < .001$, $\eta^2_P = 0.10$. However, we did not find the expected interactions with the experimental condition that would indicate that these ratings decreased more in the experimental than the control conditions. The interactions for support and justification ability were non-significant, $F(1, 517) = 0.02$, $p = .883$, $\eta^2_P < 0.01$ (support); $F(1, 517) < 0.01$, $p = .990$, $\eta^2_P < 0.01$ (ability to justify). The significant interaction for understanding showed that the increase in understanding was mainly driven by the control condition, $F(1, 517) = 4.59$, $p = .033$, $\eta^2_P = 0.01$, as pairwise

[8] Seven more participants in the experimental compared to control group did not finish the study. However, this different in drop-out rate was not significant, $\chi^2(df = 1) = 1.04$, $p = .307$.

comparisons showed that the change in understanding was significant only in the control but not the experimental condition.

Figure 8.

Ratings of anti-vaccination arguments pre- and post- writing explanations in the control and experimental conditions in Experiment 2.



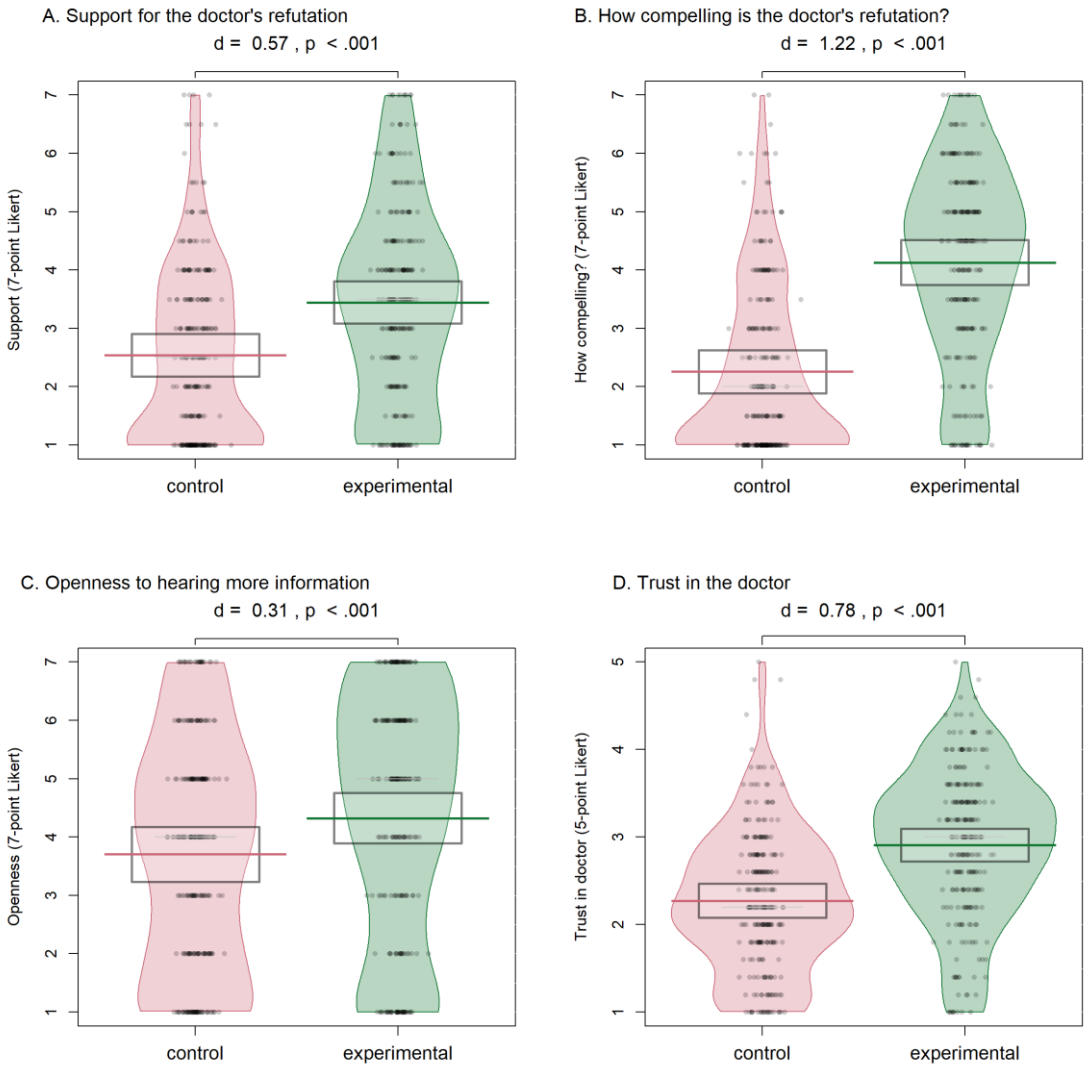
Effects of empathetic refutation on receptivity to doctor

For each of the four measures related to the doctor and their refutation, we ran a linear regression model comparing the two conditions as a between-subjects factor and controlling for baseline (pre-test) support for the anti-vaccination argument and trust in the medical profession. As shown in Figure 9, the empathetic refutation was highly successful: participants supported it more, found it more compelling, were more open to receiving information after it, and trusted the doctor giving it

more, with the experimental effect being significant in all four models, β = 0.26, $p < .001$ (support); β = 0.51, $p < .001$ (compelling), β = 0.15, $p < .001$ (openness), β = 0.35, $p < .001$ (trust).

Figure 9.

Ratings of the doctor and refutation in the control and experimental conditions in Experiment 2.



Overall effects of ERI on vaccine willingness and anti-vaccination argument support

We ran a mixed ANOVA analysing the effect of condition, timing of measure, and their interaction for each of the vaccine willingness measures. As shown in the top two panels of Figure 10, vaccine willingness across all measures increased significantly between the start and end of the experiment, $F(1, 517) = 44.02$, $p < .001$, $\eta^2_P = 0.08$ (confidence); $F(1, 517) = 35.56$, $p < .001$, $\eta^2_P = 0.06$ (complacency); $F(1, 517) = 70.84$, $p < .001$, $\eta^2_P = 0.12$ (collective); $F(1, 517) = 11.16$, $p < .001$, $\eta^2_P = 0.02$ (booster willingness). There were no significant interactions with condition, $F(1, 517) = 2.48$, $p = .116$, $\eta^2_P = 0.01$ (confidence); $F(1, 517) = 0.60$, $p = .439$, $\eta^2_P < 0.01$ (complacency); $F(1, 517) = 0.71$, $p = .400$, $\eta^2_P < 0.01$ (collective); $F(1, 517) = 2.62$, $p = .106$, $\eta^2_P = 0.01$ (booster willingness). However, we observed that the effect sizes for the vaccine hesitancy reduction were consistently larger in the experimental conditions. We thus ran an exploratory analysis on a combined variable that averaged the four vaccine willingness measures into a single composite measure, to see if the individual effects we observed might be additive (see bottom panel of Figure 10). In this analysis, the increase in vaccine willingness remained significant, $F(1, 517) = 104.79$, $p < .001$, $\eta^2_P = 0.17$. In addition, the

increase in vaccine willingness was indeed greater in the experimental than control condition, with a significant interaction effect, $F(1, 517) = 3.98$, $p = .046$, $\eta^2_P = 0.01$.

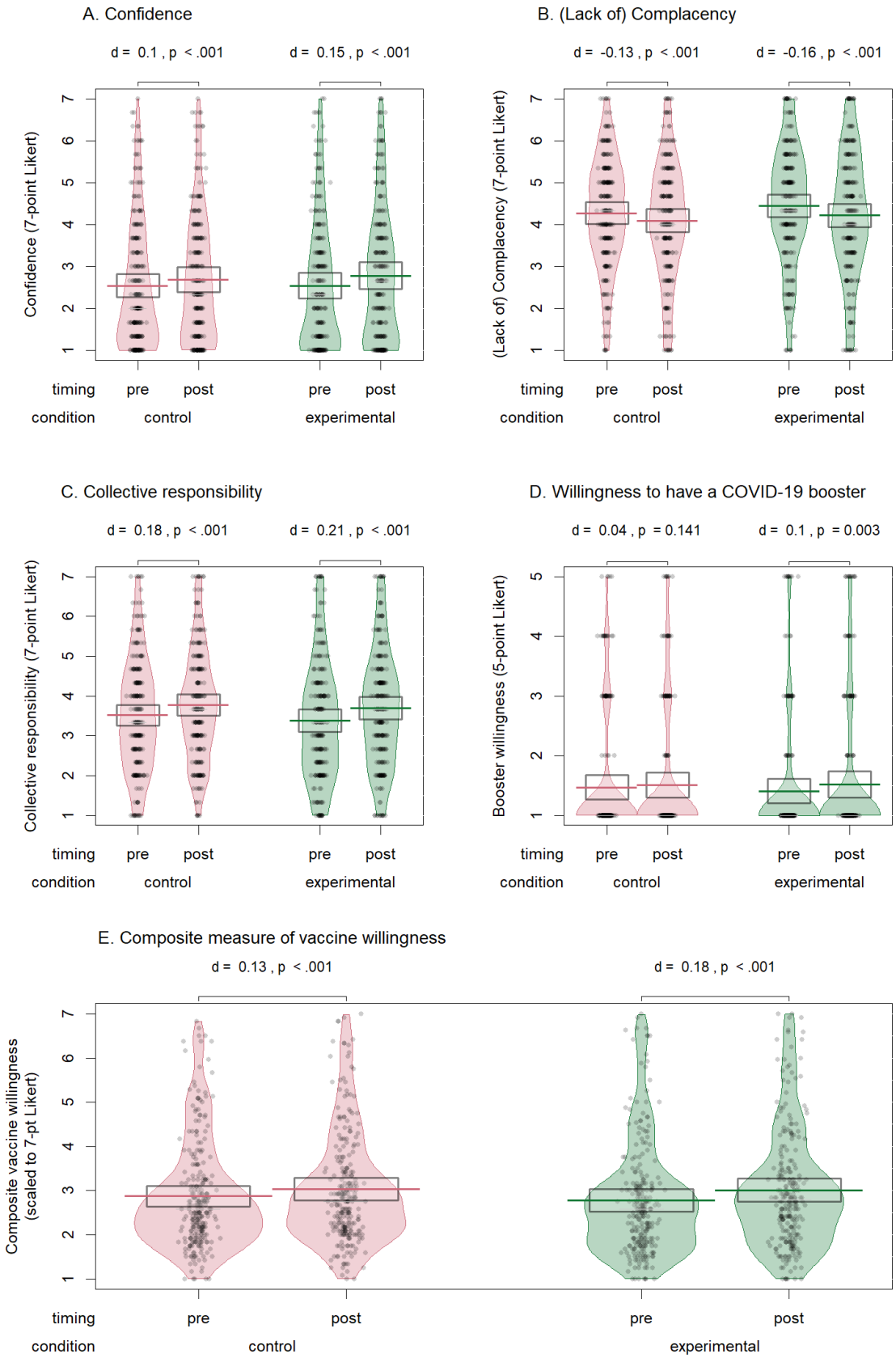
We also ran a mixed ANOVA comparing further change in anti-vaccination argument support between when this measure was taken post-explanation and at the end of the experiment. Support for the anti-vaccination argument significantly decreased over the second part of the experiment (after the doctor's refutation and the vaccination facts), $F(1, 517) = 22.95$, $p < .001$, $\eta^2_P = 0.04$. However, the decrease in support did not differ between conditions, as there was no significant interaction, $F(1, 517) = 0.02$, $p = .902$, $\eta^2_P < 0.01$.

Discussion

Overall, Experiment 2 produced positive changes in vaccine willingness and receptivity to the doctor and their refutation, but had some limitations. While argument support also decreased throughout this experiment, it did so in both conditions, and we did not replicate the interaction effect found in Experiment 1a (where participants in Experiment 1a tempered their perceived ability to justify the argument in the experimental but not the control condition). We replicated and extended the positive benefits of empathetic refutation on participants perceived the doctor, even in a case where the participants already highly supported the anti-vaccination argument the doctor was refuting. However, because we used a control that did not elaborate on its refutation, we cannot be certain that the empathetic, affirmative component was critical to producing the positive effects as opposed to simply giving a direct, factual refutation without being empathetic. Finally, the differential increase in vaccine willingness between conditions was also very small, and could potentially be attributed to participants in both conditions receiving the same vaccination facts. Therefore, we ran Experiment 3 to address these issues.

Figure 10.

Changes in vaccine willingness measures between beginning and end of experiment across control and experimental conditions in Experiment 2.



Experiment 3: Testing the full ERI against partial components

Experiment 3 again tested the combined ERI intervention, but against three different conditions: a control condition where the participant experienced minimal intervention overall, and two partial interventions where the participant experienced some parts of the ERI but not all.

Methods

Participants

We collected data from 700 participants in the US who held non-positive attitudes towards the COVID-19 vaccines (identified using a Prolific screener question). This sample size was determined based on achieving 90% power (at $\alpha = 0.05$) to detect the same interaction effect that Experiment 2 was powered for, while increasing the number of between subjects groups from 2 to 4.

We switched our sample to the US for three reasons. First, recruiting from a different country would allow us to increase the generalisability of our findings to other populations. Second, we had already sampled heavily from the pool of participants in the UK who held negative attitudes or were unvaccinated against COVID-19, limiting our ability to conduct further studies among this population. Third, there remains substantial opposition to COVID-19 vaccination in the US, where vaccination is a highly polarising topic (Bolsen & Palm, 2022) and vaccine hesitancy increased over time there, in contrast to the global pattern (including in JITSUVAX countries) where vaccine hesitancy decreased (Lazarus et al., 2022). Recruiting in the US thus increasing our likelihood to obtain sufficient numbers of participants with negative vaccination views.

Participants were 52% female (47% male, 1% other identity or did not state), aged 18-90 years (M = 40.03 years, SD = 12.97), and political leanings were normally distributed across the political spectrum (skewness = -0.12, kurtosis = -0.63).

Materials and procedure

Participants first completed in random order the Trust in Medical Profession scale ($\alpha = 0.88$) and the same vaccine willingness measures as in Experiment 2, except we adjusted the COVID-19 booster vaccine willingness question to a 7-point instead of 5-point scale to facilitate creating a composite measure of vaccine willingness across the four variables ($\alpha = 0.91$).

We also used the same baseline argument rating procedure as Experiment 2, selecting each participant's top two supported arguments for further use.

Participants were then randomised to one of four conditions: control (n = 185), facts-only (n = 185), direct refutation (n = 164), or full ERI (n = 166)[9]. Table 2 summarises the differences in the four conditions by the different ERI steps. For the first step (soliciting explanations), participants either read a facts sheet about dental hygiene (control and facts-only conditions) or completed the explanation task used in Experiment 2 (direct refutation and full ERI conditions). We compared the explanation task to a reading control instead of one where participants produced texts so we could isolate the effect of writing an explanation. Participants completed post-intervention argument ratings after this step.

For the second step (refutation), participants either saw the consultation scenario in Experiment 2 with the minimal (control) refutations from Dr Jones (control and facts-only conditions), or the empathetic refutation (full ERI condition), or a third refutation condition where Dr Jones directly

[9] Significantly more participants in the groups with the explanation component did not finish the study (n = 47) compared to the groups that only read health facts in the first stage (n = 6), $\chi^2(df = 1) = 32.36$, $p < .001$. However, we did not find any significant differences in the pre-test characteristic (vaccine willingness, initial argument ratings) between the groups, nor between our final sample and those who dropped out.

refuted Tom's anti-vaccination argument using the same factual rebuttal but without any affirmative language. In the minimal (control) refutations, participants were asked to imagine that Dr Jones had offered more information. In the other two conditions, participants read Dr Jones giving this offer, which was done in the direct way for the direct refutation condition and the empathetic way for the empathetic refutation condition. Participants completed the same four ratings of Dr Jones and the refutations as in Experiment 2 ($\alpha = 0.89$ for the Trust in a Doctor scale).

For the third step (facts provision), participants in the control condition did not receive the information and proceeded directly to the end-of-experiment measures. Participants in the other three conditions all read the same illustrated page used in Experiment 2. We omitted the attention check question in this round as it had not been informative in Experiment 2.

Finally, participants completed the same end of experiment measures as Experiment 2: support ratings for arguments, vaccine willingness measures ($\alpha = 0.92$), and socio-demographic information.

Table 2.

Design of the four experimental conditions in Experiment 3.

Experimental condition	**Soliciting explanations**	**Empathetic refutation (consultation scenario)**	**Facts provision**
Control	Read health facts about dental hygiene (unrelated to vaccination).	Doctor responds minimally to each argument.	No facts provided until debrief.
Facts-only			Illustrated vaccination information leaflet with facts about herd immunity and disease risks.
Refutation-only	Write a detailed explanation of position on top 2 most supported anti-vaccination arguments.	Doctor refutes each argument in a direct manner (and without affirmation).	
Full ERI		Doctor delivers the empathetic refutation (with affirmation).	

Results

Effects of soliciting explanations on anti-vaccination argument support

A mixed ANOVA analysing the effect of condition, timing of measure, and their interaction on each argument rating found that support for the argument and ability to justify support for it decreased significantly overall (see Figure 11), $F(1, 698) = 102.55$, $p < .001$, $\eta^2_P = 0.13$ (support); $F(1, 698) = 65.66$, $p < .001$, $\eta^2_P = 0.09$ (ability to justify), while understanding of the argument increased significantly, $F(1, 698) = 44.06$, $p < .001$, $\eta^2_P = 0.06$. However, we did not find the expected interactions with the experimental condition that would indicate that these ratings decreased more in the experimental than the control conditions. The interactions for understanding and justification ability were non-significant, $F(1, 698) = 2.19$, $p = .139$, $\eta^2_P < 0.01$ (understanding); $F(1, 698) = 0.13$, $p = .720$, $\eta^2_P < 0.01$ (ability to justify). The significant interaction for support showed that while participants reduced argument support significantly in both conditions, they did so more in the control than the experimental condition, $F(1, 698) = 4.57$, $p = .033$, $\eta^2_P = 0.10$.

Effects of empathetic refutation on receptiveness to doctor

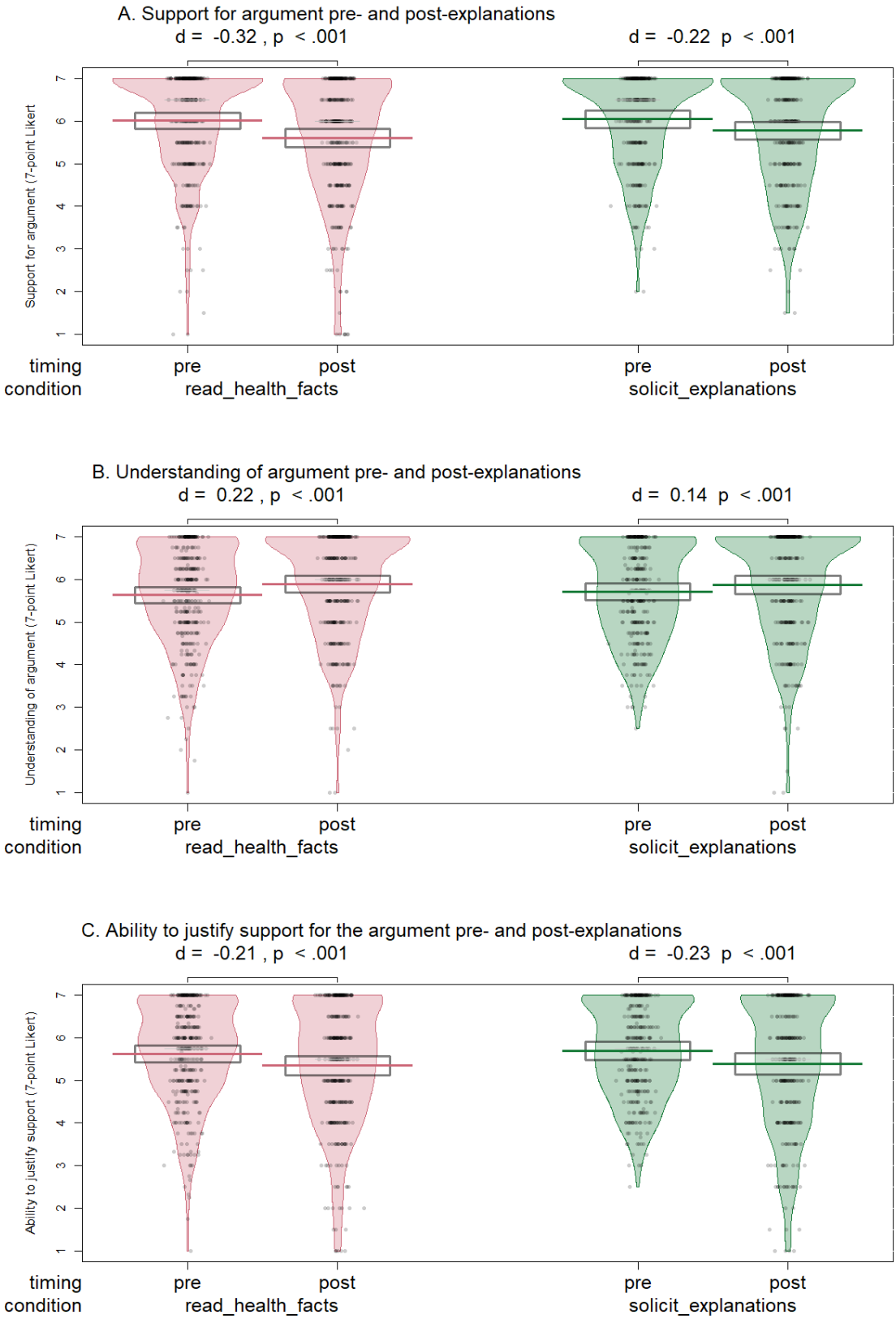
For each of the four measures related to the doctor and their refutation, we ran an analysis of covariance (ANCOVA) model with condition assignment ('minimal' control refutation vs. direct refutation vs. empathetic refutation) as a between-subjects factor and controlling for baseline (pre-test) support for the anti-vaccination argument and trust in the medical profession. We pre-

registered two follow-up contrasts, comparing between the minimal control response and both experimental ones (refutation-only and empathetic refutation), and between the refutation-only and empathetic refutation. As shown in Figure 12, the empathetic refutation had the best ratings on all measures. Compared to the control, the refutation-only and empathetic refutation combined gained more support (main effect: $F(2, 695) = 13.02$, $p < .001$; contrast: $t(696) = 4.44$, $p < .001$), was more compelling (main effect: $F(2, 695) = 55.41$, $p < .001$; contrast: $t(696 = 10.4$, $p < .001$), and resulted in higher trust for the doctor (main effect: $F(2, 695) = 27.63$, $p < .001$; contrast: $t(696) = 7.42$, $p < .001$). The main effect for openness to more information was not significant, $F(2, 695) = 1.00$, $p = .370$. Compared to the refutation-only condition, the empathetic refutation was significantly more supported, $t(695) = 2.48$, $p = .013$, but these conditions did not differ significantly on the other measures (compelling: $t(695) = 1.46$, $p = .144$; trust: $t(695) = 0.57$, $p = .570$; openness: $t(695) = 0.49$, $p = .627$).

Overall effects of ERI on vaccine hesitancy and anti-vaccination argument support

We ran a mixed ANCOVA analysing the effect of condition, timing of measure, and their interaction on the composite vaccine willingness measure. As shown in Figure 13, vaccine willingness increased significantly between the start and end of the experiment ($F(1, 696) = 36.20$, $p < .001$, $\eta^2_P = 0.05$), and there was a significant interaction between condition and timing ($F(3, 696) = 3.16$, $p = .024$, $\eta^2_P = 0.01$). Pre-registered follow-up contrasts comparing the control against all the other intervention conditions found that in the intervention conditions, vaccine willingness increased ($t(696) = 6.52$, $p < .001$) whereas it did not change significantly in the control ($t(696) = 0.66$, $p = .760$), difference in difference contrast: $t(696) = 2.79$, $p = .005$. Our other pre-registered contrasts comparing the different intervention conditions found no significant differences in the change in vaccine willingness between the control and facts-only and the two refutation conditions ($t(696) = 0.82$, $p = .415$), the facts-only and two refutation conditions ($t(696) = -0.94$, $p = .345$), or the refutation-only and empathetic refutation conditions ($t(696) = 0.81$, $p = .417$).

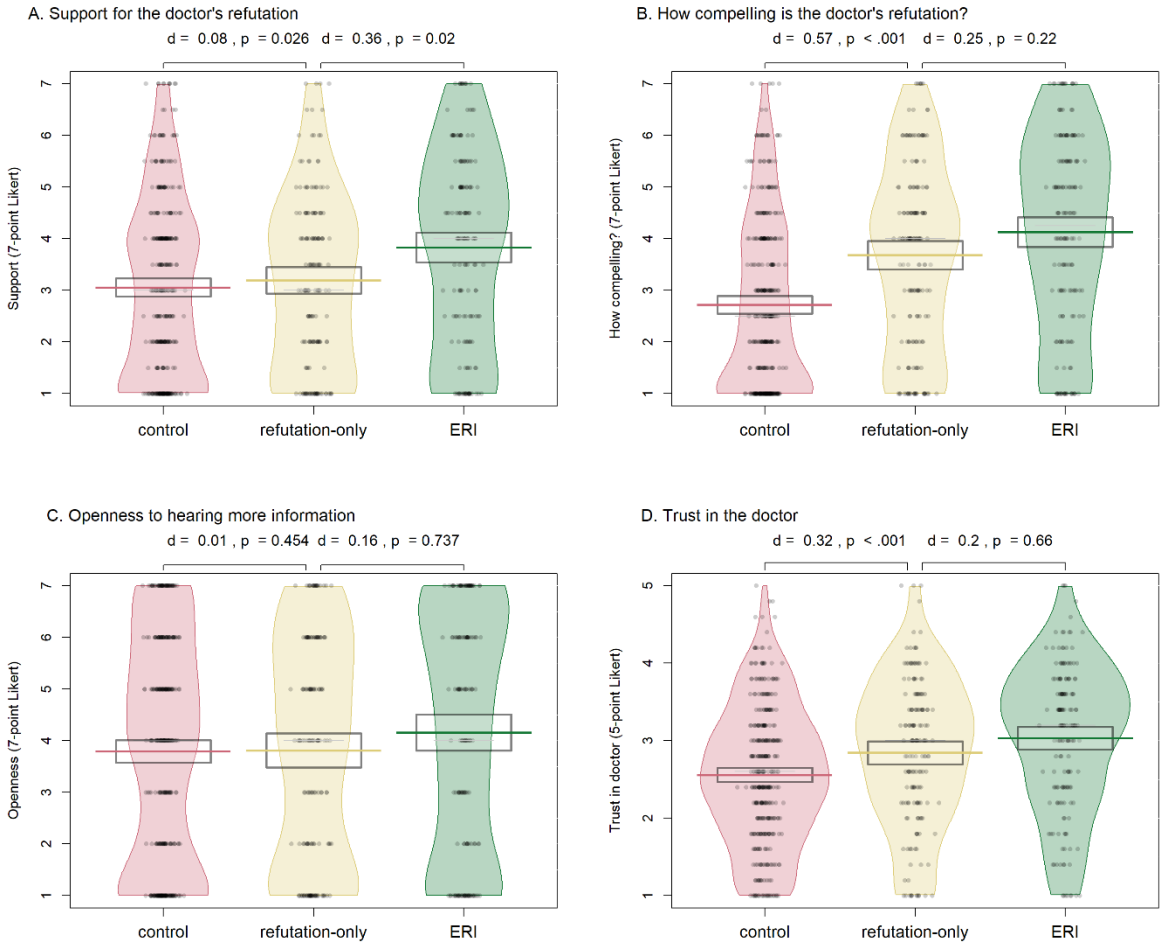
Figure 11. Ratings of anti-vaccination arguments pre- and post- the control (reading health facts) and experimental (writing explanations) conditions in Experiment 3.



Note. All overall changes between pre- and post-test are significant. Only the interaction for support of argument was significant.

Figure 12.

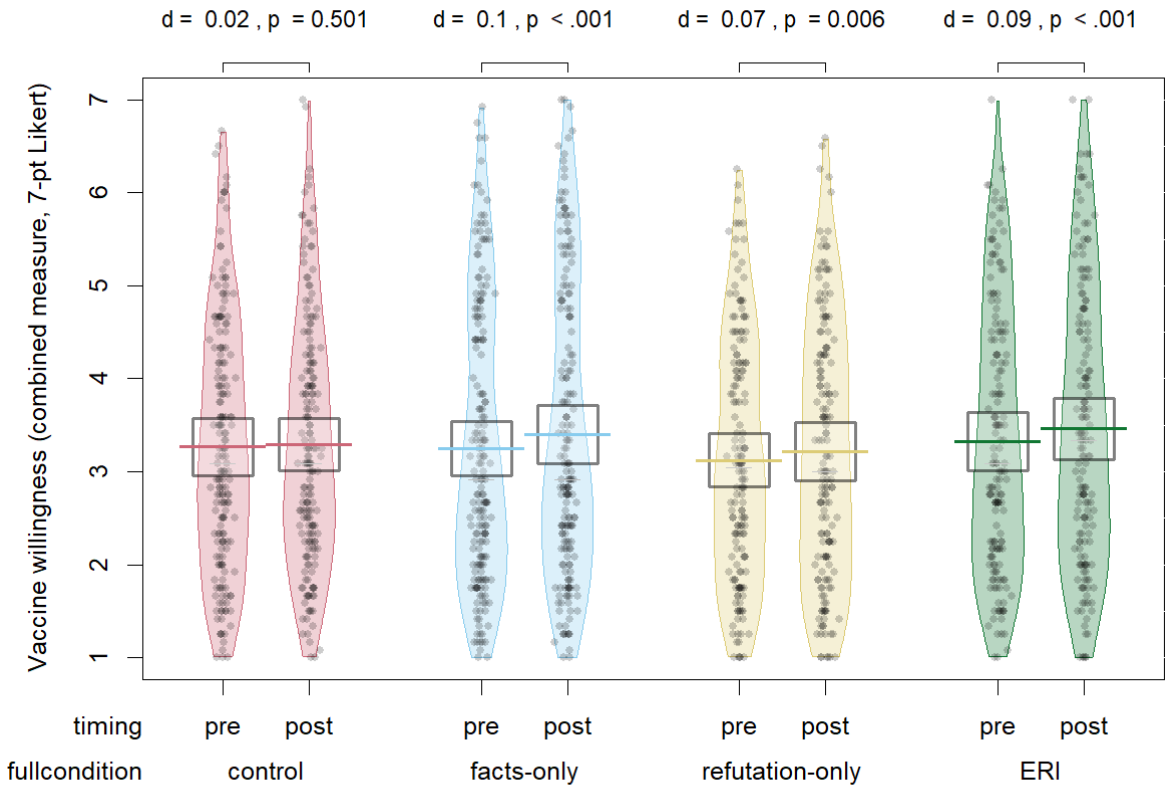
Ratings of the doctor and their refutation in the control, refutation-only, and empathetic refutation conditions in Experiment 3.



Note: Effect sizes are given as the standardised mean difference between ratings in different conditions. *p*-values shown on the plot were calculated in a linear regression controlling for baseline anti-vaccination argument support and trust in the medical profession.

Figure 13.

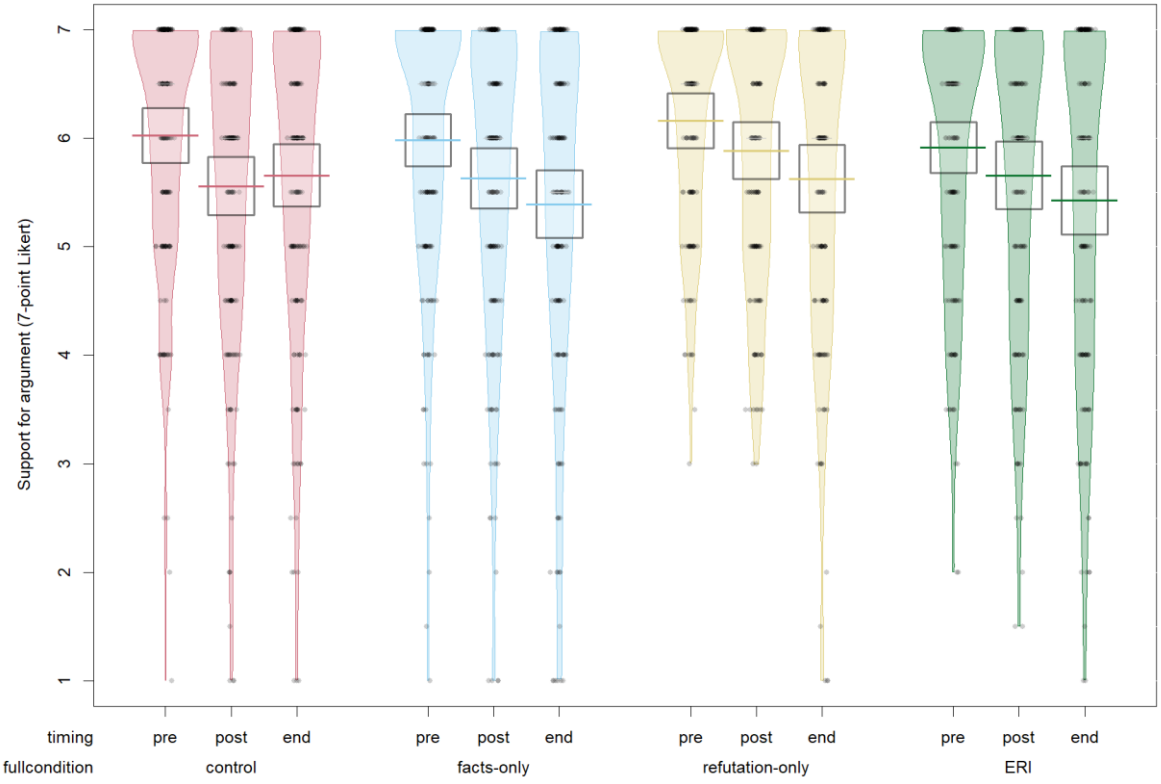
Changes in vaccine willingness between beginning and end of experiment across four conditions in Experiment 3.



We also ran a mixed ANCOVA comparing further change in anti-vaccination argument support between when this measure was taken post-explanation and at the end of the experiment. As shown in Figure 14, support for the anti-vaccination argument further decreased over the second part of the experiment (after the doctor's refutation and the vaccination facts), $F(1, 696) = 26.34$, $p < .001$, $\eta^2_P = 0.04$. Importantly, there was an interaction effect with condition, $F(3, 696) = 8.21$, $p < .001$, $\eta^2_P = 0.03$. Pre-registered follow-up contrasts showed that only the intervention conditions had a significant further drop in argument support ($t(696) = -6.81$, $p < .001$), while in the control, argument support rose, but not significantly ($t(696) = 1.69$, $p = .175$), difference in difference: $t(696) = -4.95$, $p < .001$. The change in argument support was also significantly smaller for the control and facts-only vs. the two refutation conditions, $t(696) = -2.87$, $p = .004$. However, this was most likely driven by the lack of effect in the control condition, since our other pre-registered contrasts comparing the intervention conditions among themselves found no significant differences in the change in argument support; facts-only vs. two refutation conditions: $t(696) = -0.08$, $p = .933$; refutation-only vs. empathetic refutation: $t(696) = 0.34$, $p = .733$.

Figure 14.

Anti-vaccination support at pre-test, after the first stage of the experiment, and at the end of the experiment in Experiment 3.



Discussion

Experiment 3 showed that the effects of the empathetic refutation interventions were generally positive, with participants showing increased vaccine willingness, lower support for anti-vaccination arguments, and greater support and trust for a doctor refuting an argument. These positive changes were heightened compared to the control, where no elements of the ERI were included, showing that even just having participants read the facts about vaccination has an impact on improving attitudes and reducing argument support. Of course, participants in our experiment were more likely to read these under lab conditions since they are requested to pay attention to all information presented, resulting in a larger effect of the facts-only condition than might be obtained by simply giving patients a leaflet to read. It is therefore also important to understand how receptive patients may feel to this information after interacting with their doctor. Here, we incrementally tested the effects of the affirmation and empathetic language, comparing this to a refutation without these components as well as to the same control in Experiments 1b and 2. Refutations of both types were clearly important, replicating findings from our previous experiments (although for openness to more information, the effects were smaller and did not reach significance in Experiment 3).

The inconsistent finding in this experiment, compared with the previous studies, remains the rating of the anti-vaccination arguments. We had expected, based on past work (Fernbach et al., 2013; Fisher & Keil, 2014), that explanations could temper people's support for and meta-cognitive confidence in their position. However, we did not consistently find evidence for this across the three experiments that tested this—suggesting that this strategy may not hold for entrenched vaccination perspectives. What was promising, however, is that there was no adverse effects of engaging participants in discussing their anti-vaccination perspectives. In all experiments, support for the

argument decreased from the pre-test component, which might mean that repeated questioning may in itself trigger meta-cognitive re-evaluations. Nonetheless, because asking patients about their reasons for not wanting a vaccination is a necessary precondition to affirming their concerns and refuting their misconceptions, it is good that this step does not produce a detrimental effect.

Additional Outputs

JITSUVAX researchers worked on additional outputs in tandem with the results mentioned in this document, including the production of a website (https://jitsuvax.info/) that is targeted at assisting HCPs in identifying attitude roots and providing content to conduct empathetic refutations. The content covers all 62 argument themes from 11 attitude roots identified in the JITSUVAX research (see also D2.1) and the affirmations and rebuttals developed for the materials in this report. This website will be used alongside with the results here to develop the empathetic refutational interview protocol and test it with HCPs in WP 3.

Next steps

Overall, the empirical research in this reports provides validation for which steps to retain in the ERI and why, summarised in Table 3. Nonetheless, the work has several limitations, largely borne out of the necessity to maintain a controlled experiment that could be scaled up to obtain sufficient numbers of participants. First, we presented anti-vaccination statements for participants to endorse to obtain baseline measures of these. While we pre-tested these statements extensively prior to the experiments in this report (results of the pre-test reported in the Appendix) to ensure we could reasonably expect them to be reasons participants would themselves hold, it is possible that participants endorsed statements highly upon reading them even if they would not spontaneously produce those statements (for example, in a consultation with a doctor). This may have predisposed participants more to change their views on these arguments. However, this limitation would only have lowered our power slightly to detect effects on argument support in the earlier part of the ERI protocol and should not affect other targets of the ERI. Second, we only tested the ERI steps in a non-interactive form, where participants generally read about the information or the interactions rather than listening or experiencing it themselves. This meant that we were not able to incorporate the proposed motivational interviewing components (such as active listening and asking open ended questions). However, although we do not ourselves provide evidence for the utility of these, the success of motivational interviewing in other work (e.g., Gagneur, 2020) suggests that delivering the ERI in a face-to-face interaction using these techniques could enhance the positive effects found in our current work. Finally, the scope of this work was addressing the public's (i.e., prospective patients') reactions to the ERI technique, so we have not investigated how HCPs themselves might perceive the ERI.

Two immediate follow-ups are planned to build on the work in this report and address its limitations. In WP2.3, we investigate HCPs' receptivity to the ERI method and whether they can learn aspects of it from reading text scenarios of interactions using it. In WP3, we assess the effectiveness of using the ERI as a package in real contexts between HCPs and patients.

Finally, it is important to note that although we have presented the ERI as a series of linear steps, it is plausible that a given individual may enter a consultation at a different stage of vaccine readiness where it may be more sensible to skip steps or re-order them. As an example, a patient may arrive with a specific question about their recommended vaccine, in which case providing the facts may be sufficient to reassure them. It is also highly plausible that patients may have several concerns and the HCP may go back and forth along the interview steps to address these. As such, the ERI is intended to give HCPs a suite of tools that may be used within a patient interaction.

Table 3.

Summary of outcomes from tests of each of the ERI components across all experiments.

	Independent test of components	**Test of full ERI (UK; Exp 2)**	**Test of full ERI (US; Exp 3)**	**Overall findings and recommendations**
Step 1: Solicit explanation	Experiment 1a (UK, *n* = 226) Against a related active control where participants wrote a list of reasons for their anti-vaccination argument position: • Argument support and perceived understanding decreased for both conditions. • Perceived ability to justify decreased only in explanation (not control) condition.	Against an unrelated active control where participants wrote a list of reasons for disliking a particular type of music: • Argument support and perceived ability to justify argument decreased in both conditions. • Perceived understanding of argument increased more in control than explanation condition.	Against an unrelated active control where participants read a page of health facts about dental hygiene: • Argument support and perceived ability to justify decreased in both conditions. • Argument support decreased more in the control than the explanation condition. • Perceived understanding of argument increased in both conditions.	Findings were inconsistent and did not replicate, giving poor evidence for the desired intervention effect of tempering argument support and challenging overconfidence. However, asking participants to explain themselves does not produce a backfire effect (i.e., increase argument support), thus it is still a viable first step for HCPs to use to better understand a patient's concerns and attitude roots.

	Independent test of components	Test of full ERI (UK; Exp 2)	Test of full ERI (US; Exp 3)	Overall findings and recommendations
Steps 2-3: Empathetic refutation	Experiment 1b (UK, *n* = 1100) Against a minimal response control: • Empathetic refutation received more support and was rated more compelling than control. • Argument support decreased in both conditions. • Intervention effects stronger among participants with non-positive vaccination opinions.	Against a minimal response control: • Empathetic refutation received more support and was rated more compelling than control. • Participants trusted the doctor more and were more open to receiving more information from the doctor delivering the empathetic refutation.	Against a minimal response control *and* a refutation-only comparison group: • Empathetic refutation received most support. • Both refutations performed better than the control. • Direction of these effects were in line with expectations (empathetic refutation always did better than the refutation-only condition, which did better than the control).	Overall evidence strongly supports that people respond better to the ERI with affirmation and empathy, though the effects may vary and be smaller in certain samples. This is a valid and important component to include in the ERI protocol.
Step 4: Providing facts	Experiment 1c (UK, *n* = 337) Testing 3 types of vaccination information posters: • Vaccine willingness increased for all types of information, no significant differences between types.	No active control, facts presented in both conditions. • Vaccine willingness increased for both conditions, no difference between conditions.	Against a control where no facts were shown: • Vaccine willingness increased in conditions where facts were presented, but not in the control.	Overall evidence strongly supports the benefits of giving people facts about vaccination, e.g., explaining herd immunity and the risks of the disease. These both work well and can be presented succinctly together and be effective.
Overall	-	Argument support decreased even more by end of experiment, in both conditions.	Argument support decreased even more by end of experiment only for conditions where participants read facts.	Even minimal engagement with patients can help to prevent anti-vaccination argument support returning to baseline higher levels. Partial delivery of some ERI components is preferable to not engaging at all.

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Appendix

Pre-test of anti-vaccination argument endorsements

The objective of the pre-test was to assess how much people endorsed arguments from 11 attitude roots (identified in D2.1) and whether their endorsements were associated with known psychological drivers of vaccine hesitancy that would be expected to relate to the attitude roots. This served as a psychological validation of the D2.1 Taxonomy as well as a test of whether prototypical arguments could be used as a measure of anti-vaccination belief strength in subsequent stages.

We recruited 1,250 participants (Sample 1: n = 660; Sample 2: n = 590) from the UK for the pre-test. For Sample 1, we pre-selected participants who had stated they either felt negatively or neutral towards the COVID-19 vaccine in a Prolific screener question. This was to ensure sufficient variability in responses to the anti-vaccination arguments to enable a factor analysis. For Sample 2, we aimed to assess a wider range of attitudes and psychological characteristics, so we did not applied this pre-selection filter. In both cases, we collected data in batches to ensure our sample included a balanced gender ratio and distribution of political leanings. At the end of each data gathering process, participants provided demographic information, including their age, gender, highest level of education completed, and where they rated themselves on the political spectrum (British Election Study, 2021; Imhoff et al., 2022). Participants in Sample 1 were 50% male, 49% female (1% did not identify with either gender), with ages ranging between 18-84 years (M = 38.36, SD = 12.13). Participants in Sample 2 were 49% male, 51% female, with ages ranging between 18-85 years (M = 43.10, SD = 14.12). In both samples, 48% had at least a Bachelor's degree, and there was normal distribution across political leanings on the 11-point scale (Sample 1: M = 5.74, SD = 2.33, skewness = 0.06, kurtosis = -0.37; Sample 2: M = 5.83, SD = 2.40, skewness < 0.01, kurtosis = -0.62).

In the first sample, participants indicated their level of agreement with 66 prototype anti-vaccination arguments crafted to reflected all themes identified in D2.1 across 11 attitude roots. Because the original taxonomy only identified 62 themes that were unevenly distributed across attitude roots, we added three and one arguments to the "perceived self-interest" and "reactance" roots, respectively, such that these two roots would not have disproportionately fewer arguments for analysis than the others. Participants provided their level of agreement on a 7-point Likert scale. The levels of skewness and kurtosis of most of the arguments assessed in Sample 1 were within the usual thresholds for normal distribution (+2/-2). Only 3 arguments (the second and fourth of religious concerns, and the second of reactance) exhibited a kurtosis slightly above the threshold (2.71, 2.12, and 2.47, respectively). These 66 arguments showed high internal consistency (α of the attitude roots ranging from 0.67 to 0.91; total α = 0.98).

We used a bi-factor analysis of argument endorsements in Sample 1 to identify the most indicative arguments for each attitude root in the taxonomy to use in Sample 2. For this, we selected the 3 arguments for each attitude root that displayed the highest factor loading, resulting in 33 anti-vaccination arguments (the list of selected arguments and their respective means can be found in Appendix), which participants responded to as in Sample 1. The parameters of skewness and kurtosis of almost all the 33 anti-vaccination arguments included in the second sample were within the thresholds of normality (+2/-2), except for the second and fourth arguments of religious concerns, which showed higher levels of kurtosis (3.55 and 2.17, respectively). The total α of the 33 anti-vaccination arguments was 0.98, with the internal consistency of the attitude roots ranging from 0.75 to 0.91.

In Sample 2, we also collected data on participants' responses to 13 validated measures of psychological constructs that were selected as external criteria that correspond to the 11 attitude

roots, as well as a general measure of vaccine hesitancy (the short version 5C scale; Betsch et al., 2018).

Conspiracy Mentality. Bruder, Haffke, Neave, Nouripanah, and Imhoff (2013)'s Conspiracy Mentality Questionnaire, 5 items measuring generic conspiracy beliefs.

General Distrust. Yamagishi (1988)'s Trust Scale, 8 items measuring general trust towards other people.

Pseudoscientific Beliefs. Fasce, Avendaño, and Adrián-Ventura (2021)'s short-form Pseudoscientific Belief Scale, 8 items measuring general unwarranted beliefs falsely presented as scientific.

Free Market Ideology. Lewandowsky et al. (2013)'s Free-market Endorsement Scale, 5 items measuring economic conservatism through the promotion of laissez-faire capitalism and private enterprise.

Traditionalism. Four items from the conventionalism factor of the Aggression-Submission-Conventionalism Scale (Dunwoody & Funke, 2016) that express traditionalism (as opposed to respect for social norms). While traditionalism is an anti-vaccination theme identified in Fasce et al. (in revision), following social norms and vaccine hesitancy are not expected to be positively associated as vaccinations are a social norm among the general British population. An exploratory factor analysis using maximum likelihood and promax rotation revealed that, indeed, both groups of items constitute subfactors of conventionalism. There was no significant association between respect for social norms and anti-vaccination arguments ($r = 0.03$, $p > 0.05$).

Populism. Three items with the highest factor loading on the Populist Attitudes Scale (Akkerman, Mudde, & Zaslove, 2013), defined as a political attitude with three core features: sovereignty of the people, opposition to the elite, and the Manichean division between 'good' and 'evil'.

Centrality of Religion. Huber and Huber (2012)'s Centrality of Religion Scale, 5 items measuring salience of religious meanings in personality.

Moral Absolutism. Peterson, Smith, Tannenbaum, and Shaw (2009)'s Moral Absolutism Scale, 6 items measuring desire for certainty in the moral domain. An additional measure of moral exporting was discarded due to poor internal consistency.

Trait Fear. 6 items with factor loadings > 0.70 from Kramer et al. (2020)'s Trait Fear Scale, measuring self-reported variations in fear and fearlessness.

Perceived Vaccination Risk. Following Betsch et al. (2018), We asked participants to rate the risk of 4 diseases (Covid-19, influenza, measles, and HPV) and the risk of their respective vaccines. To calculate the likelihood and magnitude of perceived risk of vaccination in comparison to that of vaccine-preventable diseases, we subtracted the risk of vaccines scores from the risk of disease scores.

Prosocial Behavioural Intentions. Baumsteiger and Siegel (2019)'s Prosocial Behavioral Intentions Scale, 4 items measuring participants' general prosociality in common situations.

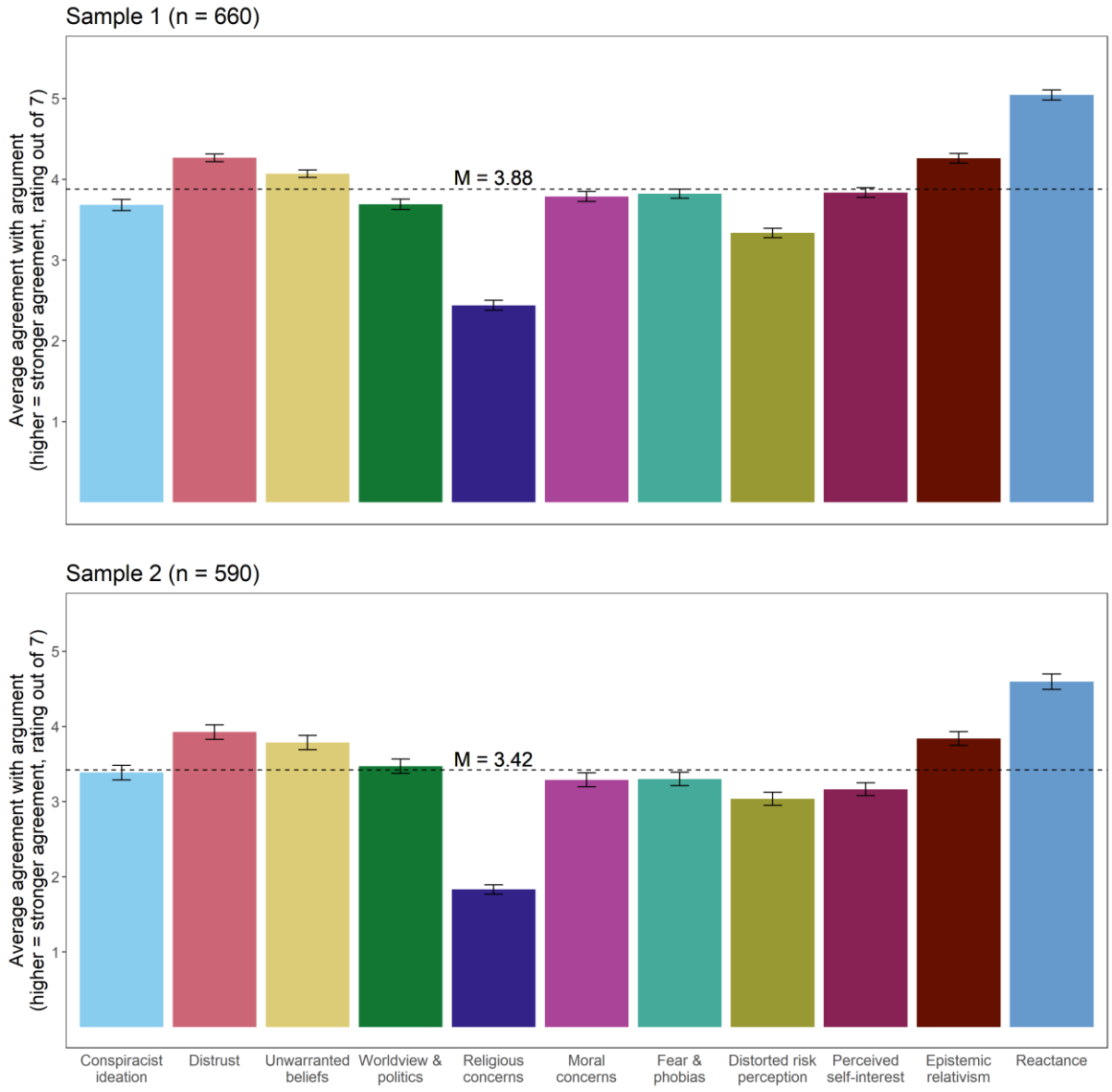
Alternative Epistemology. Garrett and Weeks (2017)'s Epistemic Beliefs Scale, 12 items with 3 sub-factors measuring epistemic beliefs. The first factor measures reliance on intuition for factual beliefs, the second reflects conviction that facts are politically constructed, and the third measures importance of consistency between empirical evidence and beliefs. The third factor was reversed to denote rejection of evidence and, subsequently, calculate a total score in alternative epistemology.

General Reactance. A condensed version of the Hong Psychological Reactance Scale (Hong & Faedda, 1996) used in Hornsey et al. (2018), with 5 items measuring motivation to reject consensus views as part of a nonconformist identity.

We found very similar patterns of argument endorsement between the two samples (see Figure A1). Agreement with arguments varied across attitude roots, although all were well-represented in the data.

Figure A1.

Participants' agreement with arguments from 11 attitude roots in two pre-test samples.



As shown in Table A1, 11 out of 13 of our measured psychological constructs in Sample 2 correlated significantly with endorsements of the target attitude root, endorsements of other arguments, and the 11-item short-form scale we constructed. These correlations were robust when controlling for age, gender, education, and political orientation. The directions and effect sizes of the correlations generally match those found in previous research regarding the relationship of those constructs to vaccine hesitancy.

We would also expect that greater endorsement of the arguments indicates stronger vaccine hesitancy and, therefore, average endorsement should correlate positively with the 5C subscales Constraints, Complacency, Calculation, Collective, as well as negatively with the Confidence subscale. This was indeed the case, as shown at the bottom of Table A1.

Table A1.

Correlations between argument endorsements and psychological constructs and vaccine hesitancy determinants.

Psychological construct	Argument endorsements	
	of target attitude root	of all arguments
Conspiracy mentality	0.60***	0.59***
General distrust	0.19***	0.20***
Pseudoscientific beliefs	0.47***	0.44***
Centrality of religion	0.33***	0.22***
Moral absolutism	0.13***	0.14***
Trait fear	0.07	0.09*
Prosocial behavioural intentions	0.01	0.04
Alternative epistemology	0.50***	0.55***
General reactance	0.22***	0.24***
Free market ideology	0.27***	0.30***
Traditionalism	0.17***	0.23***
Populism	0.45***	0.43***
Perceived vaccination risk	0.68***	0.68***
5C scale		
Confidence	-	-0.83***
Constraints	-	0.43***
Complacency	-	0.79***
Calculation	-	0.14***
Collective	-	0.71***

Empathetic (and direct) refutations in Experiment 1b, 2, and 3

Table A2 shows the refutations used by the doctor in the scenarios for Experiment 1b, 2, and 3 for each prototype argument. The empathetic refutation was used in all three experiments, and the direct refutation was only used in the refutation-only condition of Experiment 3. These were always tested against a control condition where the doctor's refutation was 'I know that the [recommended] vaccines are safe and effective.'

Table A2.

Empathetic and direct refutations to anti-vaccination arguments used in Experiments 1b, 2, and 3.

Attitude root	Prototype argument	Empathetic refutation	Direct refutation
Conspiracist ideation	The authorities are lying and covering up important information about vaccines.	It's true that there are situations where we aren't told the whole truth about things. So it's important that we're open to any evidence that would indicate that this might be the case. But in this case, independent experts are giving evidence about the safety of vaccines, and they are not under the government's control. In addition, all side effects from vaccines are reported and kept track of through public reporting sites that are open to anyone. If safety concerns are raised after the vaccines have been approved for broader use, agencies take them very seriously and may even pause administering a vaccine, as we saw in 2021 with the AstraZeneca vaccine against COVID-19.	That's not true. Independent experts are giving evidence about the safety of vaccines, and they are not under the government's control. In addition, all side effects from vaccines are reported and kept track of through public reporting sites that are open to anyone. If safety concerns are raised after the vaccines have been approved for broader use, agencies take them very seriously and may even pause administering a vaccine, as we saw in 2021 with the AstraZeneca vaccine against COVID-19.
Conspiracist ideation	Big Pharma is colluding with the medical authorities to profit from people getting vaccinated.	I get that it's important to scrutinise the actions of vaccine companies and those who work with them—focusing on profits can create conflicts of interest. But actually, health authorities are more interested in preventing diseases that cost the NHS [for US participants, "health system"] money. That's why they only recommend vaccines that were approved by independent regulators who take safety concerns very seriously, and will pause administering vaccines if needed—	That's not true. The health authorities are more interested in preventing diseases that cost the health system money. That's why they only recommend vaccines that were approved by independent regulators who take safety concerns very seriously, and will pause administering vaccines if needed—regardless of company profits. Basically, the recommended vaccines are safe and effective.

		regardless of company profits. So we can be confident that the recommended vaccines are safe and effective.	
Distrust	Research on vaccine safety is based on biased or incomplete data.	I can see why you wouldn't automatically trust the scientific studies behind the vaccines – sometimes data presented in reports can be biased. But there is actually a very thorough regulatory process that checks the safety and efficacy of vaccines, with checks for any bias in the research. Before approving vaccines, independent regulators review all the data from thousands of people in multiple rounds of testing, and they keep monitoring the millions of people who get vaccines after they are approved, which is how we know that vaccines are safe and effective.	That's not true. There is a very thorough regulatory process that checks the safety and efficacy of vaccines, with checks for any bias in the research. Before approving vaccines, independent regulators review all the data from thousands of people in multiple rounds of testing, and they keep monitoring the millions of people who get vaccines after they are approved. Basically, vaccines are safe and effective.
Distrust	Medical authorities are overreacting, with vaccines being recommended for every minor illness now.	I can see why you wouldn't automatically trust that vaccines are necessary. We definitely don't want to overuse any type of medicine. It's true that sometimes diseases can seem mild. But it's impossible to know ahead of time how you'll be affected by a disease. We select recommended vaccines because they give good protection against diseases that can have severe consequences. For example, vaccines have successfully reduced the severity of COVID-19 to the extent that a vaccinated person can now experience a mild infection, when before it may have been life-threatening for them.	That's not true. It's impossible to know ahead of time how one will be affected by a disease. The recommended vaccines are selected because they give good protection against diseases that can have severe consequences. For example, vaccines have successfully reduced the severity of COVID-19 to the extent that a vaccinated person can now experience a mild infection, when before it may have been life-threatening for them.
Distrust	Information from Big Pharma about vaccines is not to be trusted.	It's true that the pharmaceutical industry does make money with vaccines. Critically questioning the motives of industries is very important, because profit making activities sometimes involve a conflict of interest or other misleading information. But when it comes to vaccine information, we can look at what independent scientists say. For example, regulators have reviewed the data to make sure that vaccines are safe and effective, with very low risks of side effects before we get them. The data that	That's the wrong way to look at it. There's information about vaccines from independent scientists. For example, regulators have reviewed the data to make sure that vaccines are safe and effective, with very low risks of side effects before they are given to the public. The data that reports the safety as well as any side-effects of vaccines are public and open to anyone. Whenever any safety concerns are

		reports the safety as well as any side-effects of vaccines are public and open to anyone. Whenever any safety concerns are raised, regulators take them very seriously and may even pause administering a vaccine –as we saw in 2021 with the AstraZeneca vaccine against COVID-19.	raised, regulators take them very seriously and may even pause administering a vaccine –as we saw in 2021 with the AstraZeneca vaccine against COVID-19.
Distrust	Healthcare authorities, politicians, and governments are corrupt and profit from vaccinations.	I can see why you would worry about this. We definitely need to be alert and report signs of corruption when we find them. There was even a prominent case in the past where a doctor were paid to advocate against vaccines. But actually, most scientists and healthcare professionals who evaluate and recommend vaccines are not affiliated with any politicians, governments, or companies. We can even see advisory bodies deliberate in public nowadays, e.g., on YouTube—if we watch this, we actually see that their concerns are about the benefits to public health, and they only approve and recommend vaccines when they are convinced that vaccination is safe and effective.	That's not true. Most scientists and healthcare professionals who evaluate and recommend vaccines are not affiliated with any politicians, governments, or companies. Advisory bodies also deliberate in public nowadays, e.g., on YouTube—if you watched this, you would actually see that their concerns are about the benefits to public health, and they only approve and recommend vaccines when they are convinced that vaccination is safe and effective.
Distrust	There is not enough safety testing, and no one is liable if someone is harmed by the vaccine.	I can see why you would worry about whether vaccine companies are accountable. I too would want people to be responsible for safety to be held to account if things go wrong. Liability is a complex issue, and for diseases such as COVID-19, there were liability exemptions for all kinds of protective measures, not just vaccines. This doesn't mean that companies are exempt from their duty to ensure vaccines meet regulatory safety standards. They are always liable if they produce defective vaccines. Serious side effects from vaccination are extremely rare, and there are compensation schemes in place for these rare occasions. It's worth bearing in mind that if we catch a disease, like COVID-19, there most likely won't be anyone held responsible at all.	That's not true. There were liability exemptions for all kinds of COVID-19 protective measures, not just vaccines. This doesn't mean that companies are exempt from their duty to ensure vaccines meet regulatory safety standards. They are always liable if they produce defective vaccines. Serious side effects from vaccination are extremely rare, and there are compensation schemes in place for these rare occasions. No one will be held responsible if you catch a disease like COVID-19.

Distrust	People should do their own research and decide rather than following so-called “experts”.	It is important to be proactive and inform our medical decisions with the best evidence available. It’s good to look into things for ourselves, and it’s also important that we have reliable knowledge and good evidence. When we’re reading up about vaccines, we want to look for verified evidence and avoid sources that are trying to mislead us. Experts are trying to do that too by working in large groups so that they can overcome each other’s blind spots. That’s why we can rely on the independently verified evidence that vaccines are safe and effective at protecting against severe diseases.	That’s the wrong way to think about it. When reading up about vaccines, people should look for verified evidence and avoid misleading sources. Experts are trying to do that too by working in large groups so that they can overcome each other’s blind spots. That’s why people should rely on independently verified evidence that vaccines are safe and effective at protecting against severe diseases.
Unwarranted beliefs	People are being offered too many vaccines nowadays, and this will overload their immune systems.	It’s normal to have questions and doubts about medical treatments and wonder how our bodies will react. We definitely don’t want to overuse any type of medicine. But actually, vaccines work by strengthening the immune system and training it to recognise and fight against viruses. Without vaccines, our immune systems risk being overloaded by trying to fight off infection without this training. We know from data from millions of people that the recommended vaccines do this in a safe and effective way.	That’s not true. Vaccines work by strengthening the immune system and training it to recognise and fight against viruses. Without vaccines, the immune system would have to fight off infection without this training. There is data from millions of people showing that the recommended vaccines do this in a safe and effective way.
Unwarranted beliefs	Instead of vaccines, people should improve environmental factors like good hygiene, healthy lifestyles, and protective measures against the disease.	You are right that we should also take other protective measures. Good lifestyles, hygiene and personal responsibility are important components in the fight against diseases. They can help slow the spread and decrease the risks of disease. It’s great that you’re thinking about this. However, vaccines are not less important than other protective measures. They are still important to include in our healthy lifestyles on top of other health behaviours that we recommend. Vaccines train our bodies to fight off diseases and are the best way to train our immune systems to protect us against health threats before we are exposed to them. We can’t ever be sure we won’t be	That’s not true. Vaccines are not less important than other protective measures. They are important to include and they are recommended in healthcare because they train the body to fight off disease and are the best way to train the immune system to protect against health threats before being exposed to them. It’s not possible to be sure of not being exposed to diseases because no one is isolated from other people. Vaccinations deal specifically with disease.

		exposed to diseases because we're not isolated from other people and the role of vaccination is to deal specifically with disease.	
Unwarranted beliefs	Scientists are still debating the benefits of vaccination, and the science is not settled.	It's understandable to think that there are still controversies about vaccine science. Scientists do disagree during the research process and, sadly, they don't always communicate effectively when they have reached consensus on an issue, which can make it difficult to work out what are accepted scientific facts and what's still being debated. However, the science behind vaccinations is settled. There is now a strong and widespread medical consensus that the benefits of all recommended vaccines outweigh their risks. We can be confident that vaccines are safe and effective because over a hundred years of work has gone into showing this. Recent vaccines are based on this reliable previous knowledge and evidence from billions of people worldwide.	That's not true. The science behind vaccinations is settled. There is now a strong and widespread medical consensus that the benefits of all recommended vaccines outweigh their risks. Over a hundred years of work has gone into showing that vaccines are safe and effective. Recent vaccines are based on this reliable previous knowledge and evidence from billions of people worldwide.
Unwarranted beliefs	The disease will disappear on its own, following a natural cycle.	Some diseases do seem to disappear after time, or change in nature. The pathogens that cause diseases do evolve, and in some cases, they can evolve to be less harmful. There are many diseases that used to cause high fatality rates that are no longer a problem today. However, there is no guarantee that pathogens will evolve to become less severe. They could easily become more harmful, like the Delta variant of COVID-19 did. The more a virus like that gets to spread, the higher the likelihood that new variants will emerge, and the reason why diseases like measles went away is because enough people got vaccinated to prevent it from spreading. Vaccination is also the most safe and effective way to help the body build protection against the disease. The vaccine makes our bodies create antibodies without us having to go through the illness.	That's not true. There is no guarantee that pathogens will evolve to become less severe. They could easily become more harmful, like the Delta variant of COVID-19 did. The more a virus like that gets to spread, the higher the likelihood that new variants will emerge, and the reason why diseases like measles went away is because enough people got vaccinated to prevent it from spreading. and the reason why diseases like measles went away is because enough people got vaccinated to prevent it from spreading. The vaccine makes the body create antibodies without it having to go through the illness.
Worldview & politics	Politicians use vaccinations as	You make a good point that politicians say a lot of misleading things about vaccines. It makes sense for anyone to have doubts when	That's not true. Research that isn't influenced by politicians show that vaccines have

	strategies to boost their own political agendas at the expense of the common good.	vaccines are presented in such a politicised and uncertain way. This is a shame because it has made it harder to have confidence about the information we get. But we know from research that isn't influenced by politicians that vaccines have important health benefits for us. Billions of people all over the world have been vaccinated against several diseases, so scientists have been able to analyse this data. We find overwhelming evidence and agreement from scientists and medical professionals that vaccines are safe and effective.	important health benefits for us. Billions of people all over the world have been vaccinated against several diseases. Analysis of this data has found overwhelming evidence and agreement that vaccines are safe and effective.
Moral concerns	People should not accept vaccines that are produced using tissues from aborted foetuses.	It's important to uphold high ethical standards when developing medical treatments, and it's understandable to feel concerned about using cells that once came from foetal tissues in vaccine development. But it's not true that foetuses are aborted for vaccination. In fact, many vaccines don't involve foetal cells at all. For those that do, they use cells that were originally from embryos that were aborted decades ago, most in the sixties, due to other reasons. These cells can multiply but cannot grow into babies, so they are used for the testing and production of vaccines, and also many other routine drugs like ibuprofen and aspirin.	It's not true that foetuses are aborted for vaccination. In fact, many vaccines don't involve foetal cells at all. For those that do, they use cells that were originally from embryos that were aborted decades ago, most in the sixties, due to other reasons. These cells can multiply but cannot grow into babies, so they are used for the testing and production of vaccines, and also many other routine drugs like ibuprofen and aspirin.
Fear & phobias	I worry about experiencing side effects from the vaccine.	It's understandable to worry about side effects–it's quite common to experience mild side effects like fever and fatigue, and these can feel like inconveniences that we'd rather avoid. But these side effects are normal signs that your immune system is building protection, and they go away in a few days. However, not getting vaccinated means facing the risks of an infection with the disease. We need to compare those two risks to be able to make an optimal decision. Being unprotected against disease can have much worse consequences and become a much greater inconvenience.	There's no need to be worried about side effects. Side effects are normal signs that your immune system is building protection, and they go away in a few days. However, not getting vaccinated means facing the risks of an infection with the disease. You have to compare those two risks to be able to make an optimal decision. Being unprotected against disease can have much worse

			consequences and become a much greater inconvenience.
Perceived self-interest	People should look after their own health rather than put themselves or their child at risk to protect others.	It is understandable for our first priority to be ourselves and our families. It can be tempting to let others protect us with their vaccinations and to benefit from group immunity. Sometimes it is difficult to make decisions that seem like they are only going to benefit others. But by remaining unvaccinated we're also compromising our own health. And if more people choose not to vaccinate, we won't reach herd immunity and everyone will continue to be at risk. What really benefits you is to take advantage of your opportunity of being vaccinated. We know that vaccination is a safer and more reliable way of developing immunity against diseases than falling ill. Vaccination decreases your likelihood to experience severe symptoms.	That's the wrong way to look at it. By remaining unvaccinated you're compromising your own health. And if more people choose not to vaccinate, herd immunity won't be reached and everyone will continue to be at risk. What really benefits you is to be vaccinated. Vaccination is a safer and more reliable way of developing immunity against diseases than falling ill. Vaccination decreases the likelihood of experiencing severe symptoms.
Epistemic relativism	The vaccination movement does not respect alternative perspectives on health that are more comprehensive and holistic.	Of course, we all want to do the best for our health and consider all potentially beneficial alternatives. Modern science is relatively recent, and many pre-scientific ideas have also shown to have health benefits. However, science takes into account many different types of knowledge where they prove helpful. Vaccination is one piece of a health strategy that tackles a specific problem. Vaccines are the best way to train our immune systems to protect us against health threats before we are exposed to them. That's why we recommend vaccines as part of a comprehensive strategy, where their role is to deal specifically with disease.	That's not true. Science takes into account many different types of knowledge if they prove helpful. Vaccination tackles a specific problem as vaccines are the best way to train the immune systems to protect against health threats before being exposed to them. Vaccinations are recommended to deal specifically with disease.
Epistemic relativism	People are experts on their own bodies so they may legitimately conclude based on	It's true that doctors should consider personal preferences and experiences when they treat patients. Current medical practice is open to patients and their families actively participating in decision-making, which is important to achieve and maintain good health.	That's the wrong way to think about it. It's sensible to rely on expert sources. Such sources are the result of comprehensive and systematic information gathering. Gut feelings and intuition are easily affected by irrelevant or misleading

	their own reading that vaccination is not for them.	However, it's actually sensible to rely on expert sources when doing your own reading. Such sources are the result of comprehensive and systematic information gathering, while our gut feeling or intuition is easily affected by irrelevant or misleading information. Reliable information shows that vaccinations are the most effective way to protect people from diseases that once caused a lot of suffering and even deaths. Choosing not to vaccinate increases the risk that we might suffer a disease we could be protected against.	information. Reliable information shows that vaccinations are the most effective way to protect people from diseases that once caused a lot of suffering and even deaths. Choosing not to vaccinate increases the risk that you will suffer a disease you could be protected against
Reactance	Vaccination campaigns bully and harass people into getting a vaccine.	Public health campaigns can indeed come across the wrong way. They can be condescending and sound like they know better and of course that just makes us want to resist them. Sometimes people say things like campaigns are bullying and harassing people into getting vaccinated, but the objective of public health is to protect people. We can ignore the campaign and just look at the facts to make our own decisions. In the case of vaccines, we find overwhelming evidence and scientific agreement that they are safe and effective in protecting us from the impact of severe diseases like measles, whooping cough, and COVID-19. For example, vaccination successfully suppressed measles, a disease that used to cause more than 2.6 million deaths globally each year. We can look at this evidence independently and make a choice that protects ourselves.	That's not true. The objective of public health is to protect people. People should look at the facts. In the case of vaccines, there is overwhelming evidence and scientific agreement that they are safe and effective in protecting people from the impact of severe diseases like measles, whooping cough, and COVID-19. For example, vaccination successfully suppressed measles, a disease that used to cause more than 2.6 million deaths globally each year. The evidence shows that vaccines are a good choice to protect people.
Reactance	We need to resist an authoritarian state that is abusing its power and violating individual rights by telling us to get vaccinated.	It's good to be vigilant and defend our freedoms and rights and be aware if they are being infringed. We should definitely think about how civil rights are applied. When we ask people to get vaccinated, we're striking a balance between different people's rights. Each of us has the right to take our own risks with a disease, but when the spread of disease affects a lot of people, we don't have unlimited rights to infringe on other people's right to avoid disease. For example, we can't exercise our right to drink beer when driving because it would endanger others	That's the wrong way to think about it. Asking people to get vaccinated is striking a balance between different people. When the spread of disease affects a lot of people, you don't have the right to prevent someone from avoiding disease. For example, you can't drink beer when driving because it would endanger others on the road. There is evidence from millions of people that vaccines are safe and prevent severe diseases, which means fewer people needing

		on the road. We have evidence from millions of people that vaccines are safe and prevent severe diseases, which means fewer people needing medical attention. If we all get vaccinated and protect ourselves from severe illness, that helps the health service cope with patient numbers and helps uphold everyone's right to access healthcare when needed.	medical attention. If everyone gets vaccinated and protected from severe illness, that helps the health service cope with patient numbers so everyone can access healthcare when needed.
Reactance	People are getting vaccinated out of ignorance and fear, according to what the nanny state expects of them.	It's reasonable to worry that society becomes a place where people no longer freely discuss their concerns or think critically. But actually, people aren't just being ignorant or uncritical. Many people who get vaccinated also have concerns and ask their healthcare providers many questions. It's okay to talk about your concerns and make our decision based on the facts we know about vaccines. I would recommend it because data from millions of people show that vaccination is safe and effective at protecting against severe diseases.	That's not true. People aren't just being ignorant or uncritical. Many people who get vaccinated also have concerns and ask their healthcare providers many questions. You can talk about your concerns and decide to get vaccinated based on the facts about vaccines. Data from millions of people show that vaccination is safe and effective at protecting against severe diseases.
Reactance	Everyone has the right to contract a disease if they want to.	It's good to be vigilant and defend our freedoms and rights and be aware if they are being infringed. We should definitely think about how civil rights are applied. When we ask people to get vaccinated, we're striking a balance between different people's rights. Each of us has the right to take our own risks with a disease, but when the spread of disease affects a lot of people, we don't have unlimited rights to infringe on other people's right to avoid disease. For example, we can't exercise our right to drink beer when driving because it would endanger others on the road. We have evidence from millions of people that vaccines are safe and prevent severe diseases, which means fewer people needing medical attention. If we all get vaccinated and protect ourselves from severe illness, that helps the health service cope with patient numbers and helps uphold everyone's right to access healthcare when needed.	That's not true. Asking people to get vaccinated is striking a balance between different people. When the spread of disease affects a lot of people, you don't have the right to prevent someone from avoiding disease. For example, you can't drink beer when driving because it would endanger others on the road. There is evidence from millions of people that vaccines are safe and prevent severe diseases, which means fewer people needing medical attention. If everyone gets vaccinated and protected from severe illness, that helps the health service cope with patient numbers so everyone can access healthcare when needed.

Information posters in Experiment 1c, 2, and 3

Figures A2 and A3 show the information posters used in Experiment 1c, and Experiments 2 and 3, respectively.

Figure A2. Information posters depicting basic vaccine facts, herd immunity, and risks of COVID-19 used in the three poster conditions in Experiment 1c.

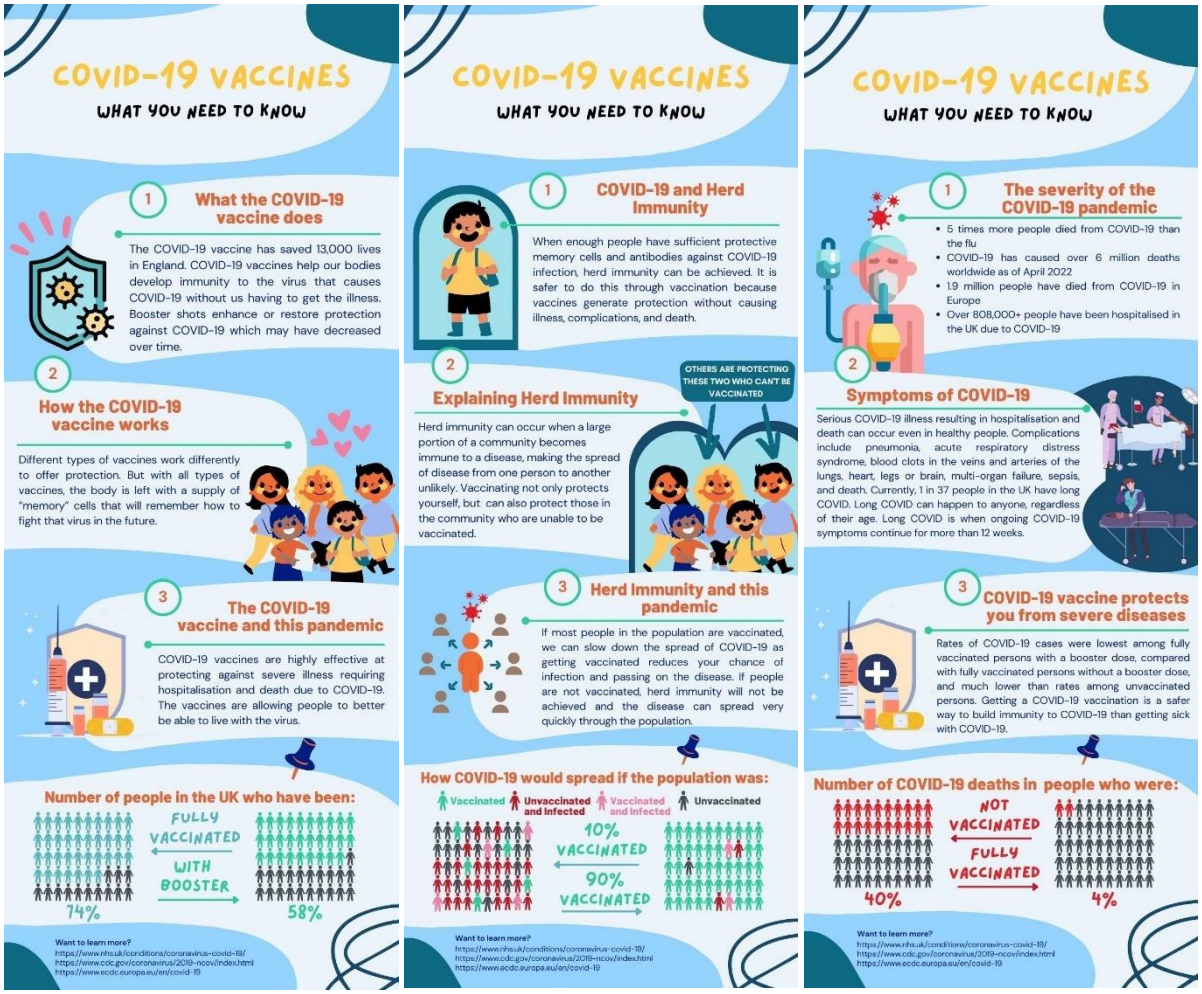


Figure A3. Information poster about vaccination used in Experiments 2 and 3.

Your guide to COVID-19 vaccination

Why do we offer COVID-19 vaccinations?

COVID-19 can have severe consequences:

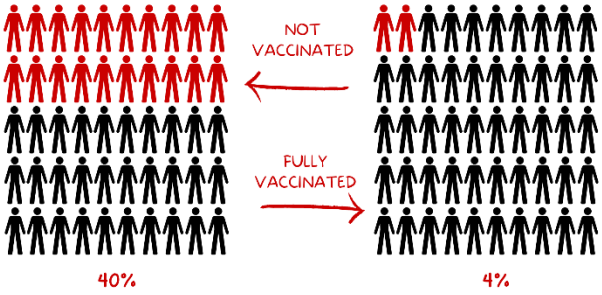
- COVID-19 has caused over 6 million deaths worldwide.
- Millions of people have been hospitalised due to COVID-19.
- Anyone who gets COVID-19 can become seriously ill or have long-term effects (long COVID).
- Serious complications can occur even in healthy people.

COVID-19 vaccines offer the best protection against COVID-19.

Research has shown the vaccines help:

- Reduce your risk of getting seriously ill or dying from COVID-19
- Reduce your risk of catching or spreading COVID-19
- Protect against COVID-19 variants

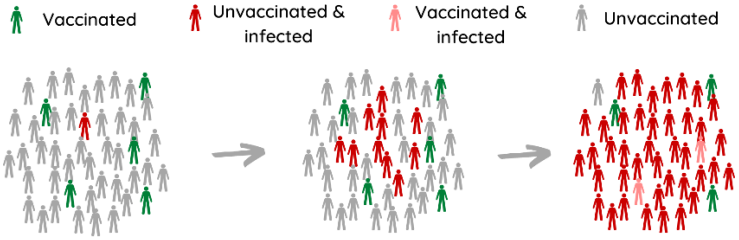
People who have not been vaccinated face a much higher risk of complications if they get COVID-19.



COVID-19 vaccines can contribute to herd immunity

- Herd immunity can occur when a large portion of a community becomes immune to a disease.
- This makes the spread of disease from one person to another less likely.
- Herd immunity is crucial for protecting vulnerable people in the community who cannot be vaccinated.
- There is now evidence that the COVID-19 vaccines reduce transmission and so can provide some protection through herd immunity

If few people are vaccinated...



...disease spreads fast once one person is infected.

But if many people are vaccinated...

...disease spreads slower and not as far.

Want to learn more?

https://www.nhs.uk/conditions/coronavirus-covid-19/coronavirus-vaccination/coronavirus-vaccine/
https://www.immunology.org/sites/default/files/BSI_GuidetoCOVIDvaccinations_Mar22.pdf
https://www.cdc.gov/coronavirus/2019-ncov/index.html
https://www.ecdc.europa.eu/en/covid-19