Time spent with Covid-19 vaccine Q&A dialogues lead to an increase in positive vaccination attitudes and intentions to get vaccinated in a UK-based anti-vaccination population

Charlotte O. Brand[1] & Tom Stafford[1]

[1] University of Sheffield, Department of Psychology, Faculty of Science

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A recent study found that interacting with a chatbot for around five minutes led to an increase in Covid-19 vaccination attitudes and intentions in a French population, compared to a control condition (Altay et al. 2020). We wanted test this effect with a UK population whilst making some key modifications. Firstly we wanted to control the amount of information provided by the chatbot compared to the control condition, as well as the time spent with the information, how the trustworthiness of the information was communicated, and the interactivity of the information. By isolating the effect of the 'choice of information' in our experimental condition, we wished to discover what it was about the chatbot that was more effective than their control. In our control condition, participants were randomly exposed to four dialogues of Covid-19 vaccination information in a Q&A format of 200-500 words each, each containing two-three follow-up questions. Our experimental condition differed only in that participants could choose the four dialogues they were exposed to, and were given a choice of Five Question topics to choose from. Like the Altay Chatbot, we saw an increase in positive attitudes towards vaccination, as well as an increase in intention to get vaccinated, after viewing the information. Crucially, we found no difference in our conditions, in that choosing the questions did not increase vaccine attitudes, nor did it increase vaccine intentions, compared to randomly displaying the information. This is in contrast to Altay's experiment in which the Chatbot had a significantly greater effect than their Control. Importantly, in Altay's experiment their Control condition a) consisted of significantly less information b) did not provide information about the trustworthiness of the information and c) led to participants spending less time with the information. Similarly to the previous study, we also found an effect of time spent with the information, across both conditions, in that those who spent between 4 and 16 minutes (above the median) with the information were more likely to increase both their attitudes and their vaccination intentions. Another crucial difference is our sample, in that we specifically targeted those who were already either against or neutral towards covid-19 vaccinations specifically, and screened-out any who were already positive towards covid-19 vaccinations

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The authors made the following contributions. Charlotte O. Brand: Conceptualization, Project Administration, Data collection and analysis, Visualization, Writing - Original Draft Preparation, Writing - Review & Editing; Tom Stafford: Conceptualization, Funding Acquisition, Writing - Review & Editing.

Correspondence concerning this article should be addressed to Charlotte O. Brand, Enter postal address here. E-mail: c.brand@sheffield.ac.uk

Introduction

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Communicating the effectiveness, necessity and safety of vaccination to the general public is arguably one of science communication's most important and emblematic challenges. Appropriately, huge amounts of attention and research effort has been directed towards how to increase Covid-19 vaccination uptake. Due to the urgency and impact of the problem, a multi-pronged attack is warranted, and

thus research rightly spans many different strategies, from pre-empting misinformation on social media (Vraga & Bode 2021), presenting information on the comparison of Covid-19 symptoms to vaccination side-effects (Thorpe et al. 2021), presenting information on the timeline of vaccine development (Thorpe et al. 2021), different styles of myth-busting (Challenger et al. 20201), the use of social norms (Moehring et al. 2021) and even chatbots (Altay et al. 2020), all with varying levels of success.

Do I need a para here about chatbots in general? Usually used for tasks, only just starting to have real interest in their ability to have constructive dialogue etc? Check Altay's GMO chatbot paper intro for inspo.

Here we focus on the use of chatbots for attitude change. The use of chatbots to change attitudes is not restricted to vaccination hesitancy, and has previously been explored in the context of GMO attitudes (Altay et al. 2021). One such experiment that looked at the effect of a chatbot on GMO attitudes found that the chatbot had a positive effect on GMO attitudes compared to two comparisons; 1) a short description of GMOs 2) a description of the consensus scientific view, but it did not have a positive effect compared to a third condition that contained counterarguments. In this counterargument condition, participants were exposed to all GMO beliefs and counterarguments at once, rather than choosing which counterarguments to interact with. This suggested that choice of information, i.e. interactivity, was not the driving factor behind the success of the chatbot. Crucially, they did find that the positive attitudes were mediated by time spent in the conditions, and that people spent on average longer in the counterargument condition. They also found that in the chatbot condition, for three out of four arguments, the best predictor for selecting a given argument was how negative their initial view towards it was, so participants did seem to select arguments based on their concerns.

This idea that choice of information is important chimes with research into people's apparent preference for choosing their own actions, making their own decisions, and choosing what path to take, even if on average it leads to worse outcomes (Babadia-Suarez et al. 2017). More stuff here about choice? Or merge this with the previous para?

A recent study found that exposure to a chatbot increases positive attitudes towards Covid-19 vaccination compared to a control of 90 words (Altay et al. 2020). We would like to know what it is about chatbots that helps increase vaccination attitudes, as this experiment does not tell us whether it is the a) amount of information b) time spent with the information c) interactivity or choice of information or d) trustworthiness of the information. Role of trust "why should I trust you" section (Tom's trust ref?)

To address this, we used the same information but created two conditions in which the only difference was the interactivity of the information, but the amount of information, time spent on the information and trustworthiness of the information was the same for both conditions.

For reviews of this topic see Wickelgren (1977); Heitz (2014). Here is another example reference (e.g. Stafford, Pirrone, Croucher, & Krystalli, 2020)

Method

Participants

Based on Altay et al. 2021 we recruited 716 adults participants from the UK. Using the recruitment platform Prolific, we were able to prescreen for UK based participants aged between 18 and 65 who had previously answered that they were either "Against" the Covid-19 vaccinations, or "Neutral" towards the Covid-19 vaccinations (as opposed to "For" Covid-19 vaccinations). As there were 657 participants registered to Prolific who answered "Against" at the time of recruitment, we attempted to recruit as many from this pool as possible. We only recruited participants who answered "Against" for the first seven days of data collection, as per our pre-registration. This led to 479 participants who answered "Against" and 237 who answered "Neutral." The average age was X and X were male/female. 10 pilot participants were recruited on 26th April and their data used for pre-registering our analysis script. The remaining participants were recruited between 14th May and 24th May.

Materials

The baseline questionnaire was almost identical to Altay et al. except that we opted to use a 7 point Likert scale as opposed to 5 points (see x and x). We asked participants to rate how strongly they agree with the following statements (from 1 = Strongly Disagree to 7= Strongly Agree), I think Covid-19 vaccines are safe, I think Covid-19 vaccines are effective, I think we've had enough time to develop Covid-19 vaccines, I think we can trust those who produce Covid-19 vaccines, I think it is important to be vaccinated against Covid-19. We also asked participants if they had yet taken a dose of any Covid-19 vaccine (Y/N) and whether they would consider taking any future dose of an approved Covid-19 vaccine offered to them (Yes, No, Undecided).

The information we used for our two conditions was taken from the Altay et al. study. We translated the information into English using Google Docs, proof-read it, updated it with the most recent information at the time using official UK NHS and Government sources, and had the information verified again by an independent epidemiologist at the University of Sheffield (name him in acknowledgements?)

Instead of using a Chatbot ourselves, we converted all of this information into 5 main questions: 1) Is the vaccine safe? 2) Is the vaccine effective? 3) Has the vaccine been rushed? 4) Can we trust who makes the vaccine? 5) Is the vaccine necessary? We modified each section to consist of a short dialogue of between 200-500 words largely avoiding repetition. Each dialogue included a short answer, and two or three follow-up question-answer responses. These documents, along with a document recording the main changes made to each section compared to the Altay paper can be found here xxx).

At the beginning of each study, participants in both conditions saw a Question-Answer response saying:

(below should be italics and ideally indented like a quote) "Why should I trust you? - We are two independent researchers, Lotty Brand and Tom Stafford, funded by a research council, with no links to pharmaceutical companies or other competing interests.

We are interested in learning about people's vaccine attitudes, in providing reliable information about vaccines, and learning about people's engagement with this information.

All of the information in this study has been gathered via scientific articles and reports from the past 30 years of vaccine research, as well as the most recent studies on Covid-19. The information has been checked by experts in immunology and epidemiology as of May 12th 2021."

This is because this was one of the main questions present in the French chatbot ("why should I trust you?") and felt it could have been leading the difference in the chatbot's effectiveness (ref). We therefore removed this question and answer from the dialogue options and inserted it at the beginning of both conditions, so all participants would see it in both conditions. This ensured the level of trust in us and our information was consistent across both conditions.

Our post exposure questionnaire consisted of the same covid attitude questions as the pre-exposure questionnaire, as well as questions on how engaging the experience was and how clear the information was. We also asked how often they discuss vaccination with those who disagree with them and how often they actively learn about vaccines (e.g. via reading articles, listening to podcasts). Would recommend to a friend? Take part again in a month's time? Age, gender, education level.

We also had an attention check question amongst both the pre-exposure questionnaire and our post-exposure questionnaire ("We would like to check that you are paying careful attention to the information in this study. Please respond to the following item with 'Somewhat agree'."). We used both of these attention check answers alongside a free-response answer to check that participants were attending to the study information carefully.

Procedure

Participants were randomly assigned to either the Control or Choice Condition. Participants in both conditions provided informed consent (ethical approval provided by the University of Sheffield approval code xxxx) before answering a baseline questionnaire, interacting with the experimental material, and finally answering a questionnaire after the exposure.

In our Control Condition, participants viewed four randomly chosen dialogues of between 200-500 words each, out of 5 possible domains of vaccination concern (are they safe, are they effective, were they rushed, can we trust who makes them, do I need to get one?).

In our Choice Condition, participants were able to choose four dialogues in total of between 200-500 words each, out of 5 possible domains of vaccination concern, as above. Therefore the amount of information (and therefore the amount of time) that the participants were exposed to should be equivalent between the Control and the Choice condition, leaving only the effect of Choice of information (and 'interactivity') to be examined.

The information is displayed identically, in 200-500 word chunks at a time, thus the information itself should be equally engaging and easy to read.

We predict that the choice condition will show a greater effect due to the ability of participants to address the concerns most important to them. If we do find a difference, this is strong evidence that one of the important aspects of chatbots in changing attitudes is that it allows the participant to choose what information is addressed, aside from trust and amount of information.

Analysis

Our hypotheses, predictions and analyses were preregistered before data collection at https://osf.io/t4gav. All of our data, code and analysis scripts are available at www.github.com/lottybrand/clickbot_analysis

In line with our preregistration, we analysed whether participants changed their intention to be vaccinated using a Bayesian binomial regression model with the Rethinking package in R (McElreath (2018)).

Results

Preregistered hypotheses

We found that participants' unwillingness to have the vaccine decreased after both conditions (mean model estimate: -0.37, 89% Credible Interval: -0.54, -0.20). This was against

prediction 1; those in the choice condition were not more likely to show an increase in their intention to have the vaccine compared to the control condition (mean: -0.23, 89% CI: -0.57, 0.11).

(mention the model comparison here?) This change in vaccination attitudes can be seen in Figure 1 1, which shows the raw vaccination attitude ratings before and after the experiment. Figures displaying the differences in vaccination attitudes between different scale items can be found in the supplementary material.

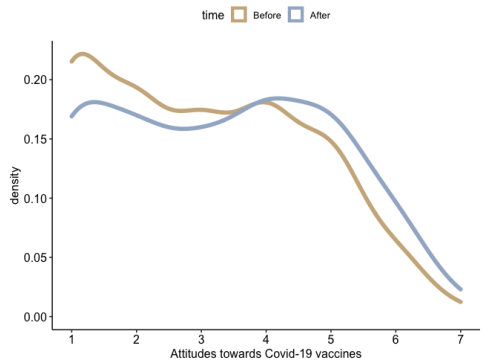

Figure 1. Density plot of raw vaccination attitudes before and after the experiment

Increase in average vaccination attitude can be seen in the violin plot in Figure 2 2.

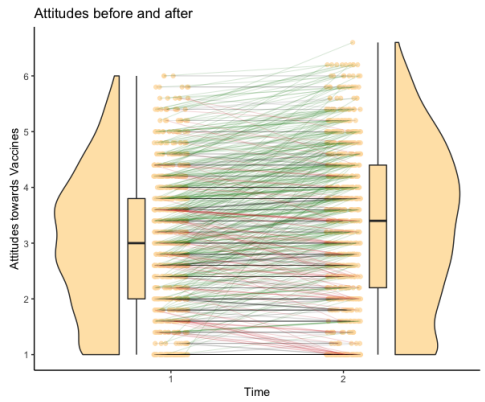

Figure 2. Violin plot of average vaccination attitudes before and after the experiment

Vaccine attitudes increased similarly across both conditions (mean: r precis(h2_exp)[2,1] , 89% CI: r precis(h2_exp)[2,3] , r precis(h2_exp)[2,4]). This was against prediction 2, as there was not an interaction between condition and time of ratings; vaccine attitudes were not most positive in the Post-Treatment ratings of the Choice Condition, but increased similarly in both conditions ((mean: ‘r precis(h2_int)[1,1] , 89% CI: r precis(h2_int)[1,3], r precis(h2_int)[1,4]).

Against prediction 3, we did not find that the Choice Condition was rated as more engaging than the Control Condition (mean =0.15, 89%CIs (-0.04,0.35).

Exploratory analysis

Participants who spent above the average (median) amount of time viewing the information (between 4 and 16 minutes, so between 1 - 4 minutes per dialogue), were more likely to increase their vaccination attitudes and intentions.

Although the majority of participants did not change their mind, overall we saw a 13% reduction in the number of people reporting that they did *not* intend to get vaccinated. In those who spent between 4 and 16 minutes reading the information, this increased to 15%

Discussion

We ran an experiment to test if choice of information affected the effectiveness of Question and Answer (Q&A) dialogues on popular Covid-19 vaccination concerns. We recruited over 700 adults based in the UK who had previously said they were “against” or “neutral” towards Covid-19 vaccines. Based on a chatbot experiment conducted with French participants, we created 20 Q&A dialogues split across the five topics; how safe the vaccines are, how effective they are; whether there has been enough time to develop them, whether we can trust who makes them; and whether they are necessary for young and healthy people. Participants were randomly assigned to two conditions; in one they could choose the Q&A dialogues they saw (Choice Condition), in the other the Q&A dialogues were randomly displayed (Control Condition). Overall, we found that participants’ vaccination attitudes shifted in a more positive direction after reading the dialogues, but we found no difference between the Choice and Control Condition. Crucially we found that participants who spent above the average (median) amount of time viewing the information (between 4 and 16 minutes, so between 1 - 4 minutes per dialogue), were more likely to increase their vaccination attitudes and intentions. We discuss the implications of our results in light of recent interest in using chatbots or other interventions to increase vaccination uptake. We argue that creating an engaging experience for participants that encourages them to spend quality time with the information is key for not only increasing positive attitudes towards vaccination

Overall, we found that the number of people who said that “No” they would not get a vaccination when one was offered to them decreased after taking part in our experiment. Out of 716 people, 93 were more likely to get vaccinated after the experiment. Out of these 93, 6 went directly from a “No” to a “Yes,” 25 went from an “Undecided” to a “Yes,” and 62

went from a "No" to an "Undecided." Although the majority of participants did not change their mind, overall we saw a 13% reduction in the number of people reporting that they did not intend to get vaccinated. In those who spent between 4 and 16 minutes reading the information, this increased to 15%. Similarly, we found an effect on vaccination attitudes in general, with x% of participants increasing their rating of agreement for the safety, efficacy, trustworthiness, timeliness and necessity of the vaccines. These figures are similar to the results of the Altay et al. chatbot condition that this study was based on, providing a conceptual replication of their results. This is reassuring as we used identical information to theirs, only editing for a UK based audience and with the latest epidemiological information at the time. In both their and our experiment, we found an effect of time spent with the information, in that those who spent longer with the chatbot were more likely to increase their vaccination intention and attitudes. This has potentially important implications for those designing public health information interventions, in that how engaging (and therefore how long participants are willing to attend to the information) is crucial.

Our effects also much greater than use of norms, which only showed a 5% decline in undecideds and no's. (Moehring paper). Also use of Q&A better than pure fact-based info (Challenger, SUmner & Bott paper).

In contrast to the Altay experiment, we found no difference between our conditions. However, there were crucial differences between our conditions and those of Altay's. The most obvious is that all of our participants saw information of the same length and quality. The fact that our conditions were equally effective then suggests that Altay's chatbot may have been more effective than their control condition simply because it delivered more information than the control.

The second most crucial difference between our experiment and Altay's is that we controlled for trustworthiness of information across both of our conditions. In Altay's chatbot experiment, the chatbot included a question "why should I trust you?" in which the participant saw information about who the researchers were and what their motives were. Previous research suggests trust plays a huge role in how effective science communication is (Tom's paper? Other ones? My plos one paper??). The information in Altay's control condition was therefore implicitly less trustworthy than the chatbot information, given the control condition had no source and was anonymous. In contrast, both of our conditions included the "Why should I trust you?" question and answer dialogue right at the start of the experiment, before any of the other dialogues were displayed. This dialogue included information about who we (the authors) were, where the information came from, and what our motives were. We also stated that we had no links to pharmaceutical companies or something else, similar to the Altay design. The fact that both of our conditions included this trustworthiness information, and we found no difference between the effectiveness of our conditions, suggests that the trustworthiness of information and/or being transparent about the source of information could be playing an important role.

By design, the only difference between the current study's two conditions was that in one participants had a choice of which information they saw, whereas in the other the information was shown at random. This suggests that having agency or "choice" over the information you engage with may not be the most crucial aspect of why chatbots are effective. Furthermore it suggests that addressing the concerns that are of most importance or interest to the participant may not be as crucial as previously thought (although check this with our choice data against our density plots per item. Put those in supplementary info). Previous research suggests participants prefer choice and agency over information when given the choice, but perhaps this preference isn't enough to override the effectiveness of the information when it is given to them without their actively choosing it. Furthermore, we did not find a difference in engagement ratings between our conditions. This suggests that our conditions were not different enough to cause one to be more engaging than the other. Indeed, participants spent a similar time across both conditions (check?). This suggests that making information engaging may be of crucial importance. Indeed, Altay's chatbot condition was rated as more engaging than the control (check) another factor that may explain the effect. Seemingly unimportant details of chatbots may account for their being engaging, or at least their ability to hold the attention of the participant. One aspect is the ability to go back and forth between different arguments, or the ability to select numerous counterarguments. Another is the display of the information, which is often more 'bitesize' with one sentence delivered at a time, or the "human" element of interacting with another 'agent' may be important.

IT could be argued that in our data all we are seeing is regression to the mean, particularly because we recruited from one end of the vaccination attitude spectrum, and we saw similar effects across both conditions. However, after investigating this possibility, it seems unlikely given that those who were rated as "against" vaccination as opposed to "neutral" were actually more likely to stay the same in their attitude ratings than the neutral participants, and were less likely than the neutral participants to increase their attitudes. See plot in supplementary material.

One aspect of our study worth noting is how the information was framed and how the participants were addressed throughout the study. Participants were asked if they were against, for, neutral, as is worded in Prolific. We thus used this as our prescreening criteria, so advertised the study as "your opinions on covid-19 vaccinations." Part of our study

(results not included for this publication) was to ask participants to give their reasons for and against vaccination, and, to imagine and put forward the opposite side's reasons for and against vaccination (this was conducted after their second round of attitudes, so would not influence the results of this study). We also offered participants an opportunity to provide any other feedback they had. These comments were insightful, and often suggested participants were keen to discuss their views and opinions, and did not have a reliable outlet for this. Anonymity perhaps allowed them to be honest. We also noted many thanked us for not referring to them, or anyone, as "anti vaccination" or "anti-vaxxers." We refrained from using this term throughout due to the knowledge that this community is often stereotyped and villainised. We wish to follow-up these comments, respond where necessary, and share them with the rest of the research community to help further destigmatise the anti vaccination community and help create an atmosphere of constructive dialogue and conversational receptiveness about these issues. (refs?)

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