Framing Messages For Vaccination Supporters

Sacha Altay & Hugo Mercier

Published at: *Journal of Experimental Psychology: Applied*¹

Altay, S., & Mercier, H. (2020). Framing messages for vaccination supporters. *Journal of Experimental Psychology: Applied*, 26(4), 567–578. <https://doi.org/10.1037/xap0000271>

ABSTRACT

Efficiently communicating information on vaccination is crucial to maintaining a high level of immunization coverage, but it implies finding the right content for the right audience. Pro-vaccination individuals, who represent the majority of the population, and who have been neglected in the literature, could play an important role relaying pro-vaccination messages through informal discussions, if only these messages are (i) found plausible, (ii) remembered, and (iii) shared. We conducted seven experiments on 2761 pro-vaccination online participants (U.S. and U.K.), testing whether the valence of a statement (positive or negative) and its rhetorical orientation (pro- or anti-vaccine) affected these three steps. Participants deemed more plausible, were more willing to transmit (and actually transmitted more), but did not remember better positively framed statements. Pro-vaccination rhetorical orientation had little or no effect. Overall, the framing effects observed were dramatic: one framing made participants very eager to transmit a statement, while another made them reluctant to transmit it at all. The framing effects also influenced vaccination attitudes, with participants exposed to positively framed statements reporting more positive attitudes toward vaccination. Since

¹ © 2020, American Psychological Association. This paper is not the copy of record and may not exactly replicate the final, authoritative version of the article. Please do not copy or cite without authors' permission. The final article will be available, upon publication, via its DOI: 10.1037/xap0000271

messages have to be framed one way or the other, the framing effects demonstrated here should be considered when designing public health messages.

Keywords: pro-vaccination; communication; framing; memorization; transmission; plausibility.

Public Significance Statement

Subtle changes in the way information about vaccination is presented can affect how people perceive it. Participants found more plausible, and were much more likely to share positively framed statements about vaccination than negatively framed statements. These framing effects should be taken into account when designing public health messages.

MAIN TEXT

Despite the clear scientific consensus on the safety and benefits of vaccines, a significant part of the population remains vaccine hesitant (i.e. holding doubts and concerns about the benefits and safety of vaccination; Larson, Jarrett, Eckersberger, Smith, & Paterson, 2014; MacDonald, 2015; Yaqub, Castle-Clarke, Sevdalis, & Chataway, 2014). Most efforts dedicated to increasing vaccine acceptance have aimed at vaccine hesitant individuals, examining whether pro-vaccination messages attenuate their misgivings (e.g. Chanel, Luchini, Massoni, & Vergnaud, 2011; Horne, Powell, Hummel, & Holyoak, 2015). Typically, these messages are meant to be part of health campaigns, or to be delivered by medical professionals. However, information about vaccination also spreads through other means, with significant portions of the public relying in part on informal sources such as friends, colleagues, and family (Freed et al., 2011). In the area of public opinion more generally, the role of peers to relay messages from the media or other official sources is well-known (see,

e.g., Katz & Lazarsfeld, 1955). In science communication, a recent study has shown that the more people know about the scientific consensus on global warming, the more likely they are to discuss it with their peers, which leads to a positive “pro-climate social feedback loop” (Goldberg, van der Linden, Maibach, & Leiserowitz, 2019, p.14804). In the case of vaccination, peers might play an equally important role of information transfer—for instance relatives’ opinions on vaccines are a strong predictor of vaccination attitudes (Brunson, 2013; Opel & Marcuse, 2013) and interpersonal communication is commonly used to address health problems (Knapp & Daly, 2002).

In most countries, the majority of the population supports vaccination at least to the extent that they and their children get vaccinated (Kennedy et al., 2011). We could therefore expect this majority to effectively help spread pro-vaccination messages, a strategy that has been successfully implemented by Schoeppe *et al.* (2017) in small communities. Unfortunately, most pro-vaccination members of the public are only willing or able to offer relatively weak arguments to defend their opinions, relying on personal anecdotes rather than proper evidence (Faasse, Chatman, & Martin, 2016; Fadda, Allam, & Schulz, 2015). Pro-vaccination individuals are also less likely to engage in online communication (McKeever et al., 2016), leading to an overrepresentation of anti-vaccination comments online (Feinberg et al., 2015; Lei et al., 2015; Pereira et al., 2013). This could reflect the fact that most vaccinees passively accept vaccination, and often lack information about its scientific backing and benefits (Das & Das, 2003; Nichter, 1995, p. 617; Yaqub et al., 2014; for a more detailed classification of attitudes towards vaccination, see, Streefland, Chowdhury, & Ramos-Jimenez, 1999). Moreover, studies have shown that even vaccinees often have concerns regarding the safety of vaccination (e.g. Casiday, Cresswell, Wilson, & Panter-Brick, 2006).

Many efforts at convincing staunchly anti-vaccine individuals have failed (Dubé et al., 2015; Sadaf et al., 2013) or have even backfired (e.g. Nyhan, Reifler, Richey, & Freed, 2014). These failures may reflect the lack of trust anti-vaccine individuals place in the medical establishment (Salmon et al., 2005; Yaqub et al., 2014). As a result, members of the public may be in a good position to convince vaccine hesitant individuals (at least fence-sitters, see Leask, 2011), if only they could muster convincing arguments. Thus, improving the argumentative arsenal of pro-vaccination individuals could indirectly help convince vaccine hesitant individuals—and it might further assuage the remaining concerns of pro-vaccine individuals.

So far, the effectiveness of pro-vaccination arguments has been measured in terms of persuasiveness. However, if arguments are to be further spread by pro-vaccine individuals, these individuals should not only accept the arguments, but they should also be able to memorize them, and be willing to transmit them to others. Although the field of cultural evolution has long paid attention to memory and willingness to transmit in theoretical (Boyer, 2018; Morin, 2015) and empirical work (for a recent review see, Miton & Charbonneau, 2018; for applications to vaccination see, Jiménez, Mesoudi, & Tehrani, In preparation; Jiménez, Stubbersfield, & Tehrani, 2018; Miton & Mercier, 2015), only one of these factors (memorization) has been examined in the case of vaccination (Pluviano *et al.*, 2017).

Studies on information transmission suggest that seemingly minor changes in the presentation of a piece of information can influence its likelihood of being accepted, remembered, and further transmitted. Framing is the best studied of these superficial changes: logically equivalent descriptions can lead to very different decisions when they are framed differently (Kahneman & Tversky, 1979; Tversky & Kahneman, 1981). One of the most robust framing

effects is valence framing, where negatively framed information is judged as truer (Fessler et al., 2014), is better memorized (Bebbington et al., 2017), and is transmitted more often (Heath, 1996) than positively framed information (a glass half empty is a negative frame while a glass half full would be a positive frame). However, there are relevant exceptions to this dominance of negative frames. When people are asked whether to approve medical treatments, emphasizing survival rates, by contrast with mortality rates, leads to more positive attitudes toward the treatment (Levin, Schnittjer, & Thee, 1988; Marteau, 1989; Wilson, Kaplan, & Schneiderman, 1987). This preference for positive frames is also found in cases such as rating basketball players (Levin, 1987), judging the quality of ground beef (Levin and Gaeth 1988), support for condom use (Linville et al., 1993), or evaluating industry project teams (Dunegan, 1993, 1995). Anecdotally, a survey on vaccine communication found that positive messages were rated as more convincing and more believable than negative messages (ASTHO, 2009), but the conclusions we can draw from this study are limited since the information available in the two frames was not equivalent.

Framing is unavoidable: a message has to be framed one way or the other. This is relevant for common pro-vaccination messages: those regarding side-effects and those regarding medical consensus. Since overestimating the dangerousness of vaccine side effects appears to be a major reason for vaccine refusal (Betsch & Wicker, 2012; Omer et al., 2009), pro-vaccination campaigns often stress the safety of vaccines (Dittmann, 2001; van der Linden et al., 2015; World Health Organization, 2016). Such messages can be framed positively (e.g. 999 out of 1000 people don't have any severe side effects after being injected with a vaccine) or negatively (e.g. 1 individual out of 1000 has severe side effects after being injected with a vaccine). For example, the World Health Organization opted for a negative frame when

tweeting “Severe side effects are extremely rare.”² Since knowledge that the medical consensus on the efficacy and safety of vaccination is positively correlated with favorable beliefs on vaccination (Dixon & Clarke, 2013), messages about medical consensus have also been used. These messages (e.g. 90 % of medical scientists agree that vaccines are safe; van der Linden et al. 2015) have managed to reduce belief in the autism-vaccine link and to increase public support for vaccination. Here as well, the message has to be framed either positively (90% of medical scientists agree that vaccines are safe) or negatively (10% of medical scientists do not agree that vaccines are safe). This type of simple framing has been classified as *attribute framing*, and it is considered “the most straightforward test of the influence of positive and negative framing” (for a typology of framing effects see: Levin, Schneider, & Gaeth, 1998, p.158).

Even though frames are logically equivalent, it has been suggested that they leak information, such as information about the speaker’s beliefs (McKenzie, 2004; McKenzie & Nelson, 2003; Shlomi Sher & McKenzie, 2006). Specifically, framing valence influences perceived rhetorical orientation—i.e. what conclusion the information appears to support. A speaker who uses the positive frame might be perceived as being pro-vaccine, while one who uses the negative frame might be perceived as being anti-vaccine. As a result, people who want to be perceived as either pro- or anti-vaccine may show a preference for either one of the frames, by being more eager to transmit messages that appear to reflect their position (see, Chung & Darke, 2006; Hennig-Thurau, Gwinner, Walsh, & Gremler, 2004; Sundaram, Mitra, & Webster, 1998). Rhetorical orientation could even affect the perceived plausibility of the messages. Studies in political science have shown that survey respondents often provide answers on factual questions as a way of expressing their political opinions (Bullock et al.,

² <https://twitter.com/WHO/status/1192071297230147584?s=20>

2013). Similarly, the plausibility ratings of statements related to vaccination could be used by participants to communicate their attitudes towards vaccination, with statements having a pro-vaccine rhetorical orientation being deemed more plausible by pro-vaccine individuals, and vice versa.

The goal of the study was to test whether framing influences the steps necessary for a statement to be used by a pro-vaccine individual in informal discussions: (i) evaluation of message plausibility (Experiments 2 and 5), (ii) memorization of the message (Experiment 3), (iii) willingness to transmit the message further (Experiments 4 and 6), and finally (iv) the propensity to use the statements to convince someone who refuses to vaccinate (Experiment 7). Experiment 1 aimed at establishing that our predictions about the direction of rhetorical orientation of the experimental statements (in favor or against vaccination) were accurate. Experiments 5 and 6 were replications of experiment 2 and 4 using a different sample. In each experiment, we compared statements that varied in valence (positively versus negatively framed) and in rhetorical orientation (whether they are associated with a pro- or an anti-vaccine position). However, statements with a rhetorical orientation in favor of vaccination also had a positive valence (“90% of medical scientists think that vaccines are safe” and “999 out of 1000 don’t have any severe side effects after being injected with a vaccine”). To disentangle the effects of valence framing and rhetorical orientation, we added a third variant, that was negatively framed but whose rhetorical orientation was likely to be perceived as pro-vaccine because it began with the word “only” (e.g. “Only 1 individual out of 1000 has severe side effects after being injected with a vaccine”). We hypothesized that (i) “only” would convey an evaluative judgment indicating that the given frequency is considered to be low, and (ii) that this evaluative judgement would be more likely attributed to a vaccination supporter than to someone holding negative views on vaccination.

The literature on the pragmatics of framing effects (McKenzie, 2004; McKenzie & Nelson, 2003; Sher & McKenzie, 2006) leads us to expect that the choice of frame made by a person will influence what ideological position others attribute them:

H₁: Positively framed statements with a rhetorical orientation in favor of vaccination will be more strongly associated with pro-vaccination individuals than statements with a negative valence and a rhetorical orientation against vaccination.

H₂: Negatively framed statements with a rhetorical orientation in favor of vaccination (i.e. the statements with “only”) will be more strongly associated with pro-vaccination individuals than statements with a negative valence and a rhetorical orientation against vaccination.

The literature on the negativity bias (e.g., Baumeister et al., 2001) leads us to expect that:

H₃: Negatively framed statements will be judged truer than positively framed statements.

H₄: Negatively framed statements will be better memorized than positively framed statements.

H₅: Negatively framed statements will more transmitted than positively framed statements.

The literature on attribute framing (e.g., Levin, Schneider, & Gaeth, 1998) leads us to expect that:

H₆: Positively framed statements will be judged truer than negatively framed statements.

H₇: Exposition to positively framed statements will create more positive attitudes towards vaccination than exposition to negatively framed statements.

The literature in political science (e.g., Bullock et al., 2013) leads us to expect the rhetorical orientation to have the following effects:

H₈: Statements with a rhetorical orientation in favor of vaccination will be judged truer than statements with a rhetorical orientation against vaccination.

H₉: Statements with a rhetorical orientation in favor of vaccination will be more shared than statements with a rhetorical orientation against vaccination.

Some of these predictions are conflicting (e.g. H₃ and H₆), others are unique (e.g. H₇). The present investigation aims at putting these theories to the test in the case of information about vaccines.

Experiment 1

In this first experiment we measured the perceived ideological position of individuals sharing the statements. We predicted that positively framed statements (with a rhetorical orientation in favor of vaccination) would be attributed to pro-vaccination individuals (H_1), and that the addition of the word “only” at the beginning of negatively framed statements would modify the statements’ perceived rhetorical orientation from anti-vaccination to pro-vaccination (H_2).

Participants

For Experiments 1 to 4, participants residing in the United States were recruited through Amazon Mechanical Turk (MTurk). Samples recruited on MTurk have proven suitable for similar experiments (Paolacci & Chandler, 2014). A power analysis for a chi-square test with an estimated effect size of $w = 0.5$ (we expected a large effect size since information leakage in attribute framing can have drastic effects, see, Sher & McKenzie, 2008), an α -level of 5%; and a power of 80%, suggested that we needed 52 participants per condition. Since we have six conditions, we needed a minimum of 312 participants. Because we did not know how many participants we would need to exclude and considering that we could have overestimated the expected effect size, we recruited 480 participants, who were paid \$0.30. Eleven participants failed to complete the survey, and we removed 50 participants categorized as being against vaccination, leaving 419 participants (184 women, $M_{Age} = 35.03$, $SD = 11.05$; Public Support Index (from one (negative attitudes) to seven (positive attitudes)): $M = 6.25$, $SD = 0.83$). Approval from ethic committee was obtain for all experiments (CER-Paris Descartes; N° 2019-03-MERCIER). All data presented in this article are available at <https://osf.io/ksa5b>.

Design and procedure

The overall design and procedures were similar for all experiments. Participants signed a consent form, took part in the experiment itself, then filled in a Public Support Index questionnaire developed by van der Linden *et al.* (2015) to assess respondents' position on vaccination. The index is composed of seven statements supporting vaccination that participants have to rate on a scale from one (Strongly disagree) to seven (Strongly agree). Participants who mostly agreed with these statements (i.e. average score higher than four) were considered to be in favor of vaccination, others against vaccination. Finally, in a debriefing, participants were provided with accurate information about vaccination, and then filled in demographic questions.

In Experiment 1, for the experimental task participants were provided with one of the six statements from Table 1, and asked to answer the question “*Would this person [the person who uttered the statement] more likely to be: in favor of vaccination or against vaccination?*”

Results and discussion

Table 1 provides the percentage of participants who thought the individual uttering each statement was more likely to be pro- or anti-vaccination.

Side Effects

Statement	Frame	Rhetorical Orientation	Perception as pro-vaccine	Plausibility (1-7)		Recall Rate	Willingness to Transmit (1-5)		
				U.S.	- U.K.		U.S.	- U.K.	U.K.
999 people out of 1000 don't have any severe side effects after being injected with a vaccine.	+	In favor of vaccination	99% N = 73	M = 4.87 SD = 1.95 N = 71	M = 5.09 SD = 1.71 N = 65	69.64% N = 56	M = 3.82 SD = 1.11 N = 72	M = 3.75 SD = 1.07 N = 68	
Only 1 individual out of 1000 has some severe side effects after being injected with a vaccine.	-	In favor of vaccination	91% N = 67	M = 4.88 SD = 1.55 N = 69	M = 4.23 SD = 1.56 N = 65	80.00% N = 55	M = 2.83 SD = 1.16 N = 70	M = 3.02 SD = 1.20 N = 68	
1 individual out of 1000 has some severe side effects after being injected with a vaccine.	-	Against vaccination	46% N = 71	M = 3.92 SD = 1.77 N = 66	M = 3.94 SD = 1.67 N = 68	83.64% N = 110	M = 2.56 SD = 1.22 N = 63	M = 2.90 SD = 1.30 N = 71	

Medical Consensus

Statement	Frame	Rhetorical Orientation	Perception as pro-vaccine	Plausibility (1-7)		Recall Rate	Willingness to Transmit (1-5)		
				U.S.	- U.K.		U.S.	- U.K.	U.K.
90 % of medical scientists think that vaccines are safe.	+	In favor of vaccination	97% N = 72	M = 5.97 SD = 1.37 N = 69	M = 5.86 SD = 1.11 N = 71	78.00% N = 50	M = 3.87 SD = 1.01 N = 77	M = 3.52 SD = 1.03 N = 63	
Only 10 % of medical scientists don't think that vaccines are safe.	-	In favor of vaccination	90% N = 67	M = 4.10 SD = 1.98 N = 67	M = 3.79 SD = 1.82 N = 65	73.33% N = 60	M = 2.62 SD = 1.31 N = 63	M = 2.66 SD = 1.38 N = 70	
10 % of medical scientists don't think that vaccines are safe.	-	Against vaccination	42% N = 69	M = 3.11 SD = 1.95 N = 66	M = 3.54 SD = 1.84 N = 69	81.08% N = 111	M = 2.03 SD = 1.14 N = 67	M = 2.34 SD = 1.05 N = 65	

Table 1. The messages used in all the experiments, along with whether they are framed positively or negatively, their presumed rhetorical orientation, and the results of all the experiments (Experiment 1 [U.S.]: Perception as pro-vaccine; Experiments 2 [U.S.] and 5 [U.K.]: Plausibility; Experiment 3 [U.S.]: Recall Rate; Experiments 4 [U.S.] and 6 [U.K.]: Willingness to Transmit).

As predicted by H₁, positively framed statements with a rhetorical orientation in favor of vaccination were more likely to be attributed to a pro-vaccination individual than negatively framed statements with a rhetorical orientation against vaccination ($\chi^2(1, N = 285) = 91.13, p < .001, \phi = 1.37$).

As predicted by H₂, negatively framed statements with a rhetorical orientation in favor of vaccination were more likely to be attributed to a pro-vaccination individual than negatively

framed statements with a rhetorical orientation against vaccination $\chi^2(1, N = 276) = 98.84, p < .001, \phi = 1.49$.

Statements perceived as having a pro-vaccination rhetorical orientation were more likely to be attributed to a pro-vaccination individual than statements perceived as having an anti-vaccination rhetorical orientation $\chi^2(1, N = 419) = 119.84, p < .001, \phi = 1.23$.

Experiment 2

In the second experiment we measured how valence framing and rhetorical orientation influence the perceived plausibility of the statements. The literature on the negativity bias predicts that negatively framed statements will be judged truer than positively framed statements (H₃), while the literature on attribute framing leads us to expect the opposite (H₆). The literature on political science leads us to expect that statements with a rhetorical orientation in favor of vaccination will be judged truer than statements with a rhetorical orientation against vaccination (H₈).

Participants

A power analysis for ANOVA with an estimated effect size of $f = 0.325$ (the literature led us to expect an effect size between medium and large, see, Fessler et al., 2014), an α -level of 5%, and a power of 80%, suggested that we needed a minimum of 77 participants per condition. Since we have six conditions, we needed a minimum of 462 participants. Considering that we would need to exclude participants, we recruited 480 participants, paid \$0.30. Five participants failed to complete the survey, and we removed 67 participants categorized as being against vaccination, leaving 408 participants (223 women, $M_{Age} = 36.19, SD = 11.29$; score on the Public Support Index: $M = 6.17, SD = 0.84$).

Design and procedure

Overall design and procedure were identical to Experiment 1. For the experimental task, each participant had to read one of the statements from Table 1 and answer “*How confident are you that the statement is TRUE or FALSE?*” on a seven-points Likert scale ranging from one, “*I’m absolutely certain this statement is FALSE*” to seven, “*I’m absolutely certain this statement is TRUE.*” The question is identical to the one used by Fessler *et al.* (2014).

Results and discussion

Plausibility score of each statement are presented in Table 1. A three-way analysis of variance (ANOVA) was conducted to compare the main effects of rhetorical orientation (pro- or anti-vaccine), valence (positive or negative), and type of statement (side-effects or consensus) on the plausibility ratings. There was a small effect of valence $F(1, 404) = 17.22, p < .001, \eta^2 = 0.04$, with participants rating positive statements ($M = 5.41, SD = 1.77$) as more plausible than negative statements ($M = 4.01, SD = 1.92$). The effect of rhetorical orientation was small $F(1, 404) = 19.36, p < .001, \eta^2 = 0.04$, with participants rating pro-vaccination statements ($M = 4.96, SD = 1.85$) as more plausible than anti-vaccination statements ($M = 3.52, SD = 1.90$). The type of statement had no influence on plausibility ratings $F(1, 404) = 0.66, p = .42, \eta^2 = 0.001$.

Contrary to the predictions of the negativity bias hypothesis (H_3), but in accordance with the literature on attribute framing (H_6), positively framed statements were found to be more plausible than negatively framed ones. We also found that statements with a rhetorical orientation in favor of vaccination were judged truer than statements with a rhetorical orientation against vaccination, supporting H_8 .

Experiment 3

In the third experiment we tested whether valence framing and rhetorical orientation of the statements would affect memorization. The literature on the negativity bias led us to expect that negatively framed statements would be better memorized than positively framed statements (H_4).

Participants

A power analysis for logistic regression with an estimated odds ratio of 2 (corresponding to an effect size between small and medium (Chen et al., 2010), as found in a previous experiment, see, Bebbington et al., 2017), an α -level of 5%, and a power of 80% suggested that we needed a minimum of 88 participants per condition. Since we have three conditions (across the six dialogues), we needed a minimum of 264 participants. Considering that we could have overestimated the expected effect size, we recruited 280 participants, paid \$0.40. Four participants failed to complete the survey, and we removed 33 participants categorized as being against vaccination based on their answers to the Public Support Index. We also removed 22 participants whose answers in the free recall task bore no relationship with the paragraph to be memorized, leaving 221 participants (99 women, $M_{Age} = 35.37$, $SD = 10.81$). The sample size is smaller compared to the other experiments but the number of data points is similar, since each participant had to read two statements instead of one. Due to constraints on the organization of the dialogue to be memorized, we could not counterbalance the three factors perfectly, so that negatively framed statements with a rhetorical orientation against vaccination (1/1000 and 10%) received more responses.

Materials

The statements were integrated in small dialogues, such as the following:

Denis: Can you come to the game on Monday?

Raymond: I can't, I have to take my kid to the pediatrician, he's getting his vaccines.

Denis: Do you know that [1 individual out 1000 has severe side effects after being injected with a vaccine?]

Raymond: Maybe, but [90 % of medical scientists think that vaccines are safe.]

A statement on vaccines side effects was always associated with a statement on the medical consensus with a different frame. In half of the dialogues a statement on vaccine side effects was presented first (as in the example) and in the other half statements on the medical consensus was presented first. Six different dialogues were used (1/1000 and 90%; 90% and 1/1000; 10% and 999/1000; 999/1000 and 10%; Only 1/1000 and 10%; Only 10% and 1/1000).

Design and procedure

The overall design and procedure were similar to those of Experiments 1 and 2. The experimental task consisted in asking participants to read the dialogue and, on the next page, write what they remembered of it. Such free recall tasks are frequently used in the literature on cultural evolution (e.g., Eriksson & Coultas, 2014).

Results and discussion

Each statement was attributed a score of one when the participant correctly recalled it (including the correct statistic) and a score of zero otherwise. The memorization scores of each statement are presented in Table 1.

We conducted a logistic regression with participants as random effect to compare the main effects of valence, rhetorical orientation, and statement type on the memorization score and found no significant effects (valence (positive compared to negative): $Z = 0.002$, $SE = 0.30$, $p = 0.99$; rhetorical orientation (in favor of vaccination compared to against vaccination): $Z = -1.05$, $SE = 0.29$, $p = 0.29$; type of statement (side effects compared to scientific consensus): $Z = 0.09$, $SE = 0.23$, $p = 0.93$). The hypothesis that negatively framed statements would be better remembered was not supported (H_4).

Experiment 4

In the fourth experiment we measured the effect of valence framing and rhetorical orientation on the willingness of participants to share the statements. The negativity bias hypothesis led us to expect that participants would be more willing to share negatively framed statements than positively framed statements (H_5). The literature in political science led us to expect that participants would be more willing to share statements with a rhetorical orientation in favor of vaccination (H_9).

Participants

A power analysis for ANOVA with an estimated effect size of $f = 0.325$ (based on previous findings we expected to find an effect size between medium and large, see Heath, 1996), an α -level of 5%, and a power of 80% suggested that we needed a minimum of 77 participants per condition. Since we have six conditions, we needed a minimum of 462 participants.

Considering we would need to exclude participants, we recruited 480 participants, paid \$0.30. Six participants failed to complete the survey, and we removed 62 participants categorized as

being against vaccination, leaving 412 participants (195 women, $M_{Age} = 36.69$, $SD = 11.99$; Public Support Index: $M = 6.14$, $SD = 0.86$).

Design and procedure

The overall design and procedure were similar to those of Experiments 1 and 2. The experimental task consisted in asking participants to read one of the statements and to answer “*How likely would you be to pass along this statement to other people*” on a five-points Likert scale ranging from one, “*very unlikely to pass along*” to five, “*very likely to pass along.*” This task is commonly used in the literature on cultural evolution (e.g., see van Leeuwen, Parren, Miton, & Boyer, in press), and has proven to be correlated (.44) with actual sharing patterns (Mosleh et al., 2019).

Results and discussion

The willingness to transmit ratings of each statement are presented in Table 1. A three-way ANOVA was conducted to compare the main effects of valence, rhetorical orientation, and statement type on the willingness to transmit rating. There was a medium effect of valence $F(1, 408) = 63.62$, $p < .001$, $\eta^2 = 0.13$, with participants more likely to transmit positively framed statements ($M = 3.85$, $SD = 1.05$) than negatively framed statements ($M = 2.51$, $SD = 1.24$). The effect of the rhetorical orientation was small $F(1, 408) = 9.17$, $p = .003$, $\eta^2 = 0.02$ with participants more willing to transmit pro-vaccines statements ($M = 3.33$, $SD = 1.27$) than anti-vaccines statements ($M = 2.30$, $SD = 1.21$). The type of statement had a very small influence on willingness to transmit rating $F(1, 408) = 4.77$, $p = .03$, $\eta^2 = 0.007$, with participants being slightly more willing to transmit statements on vaccine side effects ($M = 3.08$, $SD = 1.28$) than on the consensus ($M = 2.90$, $SD = 1.39$).

Again, our results go against the predictions of the negativity bias hypothesis (H_6), with people being more willing to transmit positively framed statements. Participants were also more willing to transmit statements whose rhetorical orientation they supported (H_9).

Experiment 5

In the fifth experiment we replicated Experiment 2 on the perceived plausibility of the statements with a different population sample: in the U.K. rather than the U.S. (for a review of the differences and commonalities between the two countries see: Wheelock, Thomson, & Sevdalis, 2013). Despite the differences between the two populations in attitudes toward vaccination, we expected to observe the same patterns.

Participants

425 participants were recruited through Prolific Academic and paid £0.20. We removed 22 participants categorized as being against vaccination, leaving 403 participants (274 women, $M_{Age} = 35.89$, $SD = 11.69$; score on the Public Support Index: $M = 6.19$, $SD = 0.78$).

Results and discussion

The plausibility ratings of each statement are presented in Table 1. A three-way analysis of variance was conducted to compare the main effects of the three independent variables on plausibility ratings.

There was a medium effect of valence ($F(1, 399) = 53.50$, $p < .001$, $\eta^2 = 0.11$) with participants rating positive statements ($M = 5.49$, $SD = 1.48$) as more plausible than negative statements ($M = 3.87$, $SD = 1.74$). The effects of rhetorical orientation ($F(1, 399) = 1.78$, $p = .18$, $\eta^2 = 0.003$) and of type of statement ($F(1, 399) = 0.001$, $p = .97$, $\eta^2 < .001$) were not significant. Experiment 5 thus replicates the effects of valence, but not of rhetorical orientation. These results again support H_6 in opposition to H_3 , but they do not support H_8 .

The aggregated results of Experiments 2 and 5 are displayed in Figure 1.

Figure 1. Aggregated results of Experiments 2 and 5 ($N = 811$): estimated plausibility (y axis) as a function of the type of statements (x axis). The boxes represent the middle 50% of the scores, the lines that divide the boxes is the median, upper and lower whiskers represent scores outside the middle 50% (except outliers), diamonds represent the means. * $p < .05$, ** $p < .01$, *** $p < .001$.

Experiment 6

The sixth experiment is an exact replication of Experiment 4 with a different population sample: crowdsourcing participants recruited in the U.K. (through Prolific Academic) rather than the U.S.

Participants

426 participants were recruited and paid £0.20. We removed 21 participants categorized as being against vaccination, leaving 405 participants (290 $M_{Age} = 36.88$, $SD = 12.80$; Public Support Index: $M = 6.09$, $SD = 0.78$).

Results and discussion

Willingness to transmit ratings attributed to each statement are presented in Table 1. A three-way analysis of variance was conducted to compare the main effects of the three independent variables on the willingness to transmit ratings. There was a medium effect of valence ($F(1, 401) = 30.50$, $p < .001$, $\eta^2 = 0.07$), with participants being more willing to transmit positively framed statements ($M = 3.64$, $SD = 1.05$) than negatively framed statements ($M = 2.73$, $SD = 1.26$). The effect of rhetorical orientation was not significant ($F(1, 401) = 2.2$, $p = .14$, $\eta^2 = 0.004$). The effect of type of statement was small $F(1, 401) = 10.64$, $p = .001$, $\eta^2 = 0.02$, with participants being more willing to transmit statements on vaccine side effects ($M = 3.22$, $SD = 1.25$) than on the consensus ($M = 2.83$, $SD = 1.27$).

Like Experiment 5, Experiment 6 replicates the effects of valence, but not of rhetorical orientation. In both experiments, participants were slightly more likely to share statements on vaccine side effects than on consensus. These results again contradict against H_5 , but they also do not support H_9 .

The aggregated results of Experiments 4 and 6 are displayed in Figure 2.

Figure 2. Aggregated results of Experiments 4 and 6 ($N = 817$): willingness to transmit (y axis) as a function of the type of statements (x axis). The boxes represent the middle 50% of scores for the group, the lines that divide the boxes is the median, upper and lower whiskers represent scores outside the middle 50% (except outliers), diamonds represent the means. * $p < .05$, ** $p < .01$, *** $p < .001$.

Cross-experiments analysis

Finally, we assessed the influence of being exposed to the statements on vaccine attitudes by merging the data of all the experiments except Experiments 2 and 7 in which participants were exposed to multiple statements. We did not exclude participants based on their attitudes towards vaccination since it was the main variable of interest in this analysis. The total sample was composed of 2273 participants (1274 women, $M_{Age} = 36.15$, $SD = 11.81$; initial score on the Public Support Index: $M = 5.84$, $SD = 1.31$).

We found that participants exposed to statements with a positive valence reported more positive attitudes toward vaccination ($M = 5.94$, $SD = 1.22$) than participants exposed to statements with a negative valence ($M = 5.79$, $SD = 1.35$; Welch's $t(1655.4) = 2.70$, $p = .007$, $d = 0.12$; see Figure 3). Participants exposed to statements with a positive rhetorical orientation were not more likely to report positive attitudes toward vaccination ($M = 5.85$, $SD = 1.33$) than participants exposed to statements with a negative rhetorical orientation ($M = 5.83$, $SD = 1.27$; Welch's $t(1578.4) = .28$, $p = .78$).

Figure 3. Influence of valence framing on vaccine attitudes across Experiments 1, 3, 4, 5, and 6 ($N = 2273$): participants' attitudes toward vaccination (y axis) as a function of the valence of the statements' participants have been exposed to (x axis). The boxes represent the middle

50% of scores for the group, the lines that divide the boxes is the median, upper and lower whiskers represent scores outside the middle 50% (except outliers), diamonds represent the means. * $p < .05$, ** $p < .01$, *** $p < .001$.

These results are consistent with participants saying that they find positively framed statements more plausible, and they are important from a practical standpoint given that participants reported a greater willingness to share positively framed statements (i.e. the most persuasive statements). These results also offer evidence in favor of H₇.

Experiment 7

In this last experiment, we measured the propensity of participants to use our statements in order to convince someone who refuses to vaccinate, a few minutes after reading them. We compared the arguments provided by participants who had read some of our statements to the arguments of participants who had not read the statements (Control Condition). This experiment offers a more ecological setting than the memorization task of Experiment 2.

Participants

We increased the sample size compared to Experiment 2 to make sure we would be sufficiently powered. 548 participants were recruited through Prolific Academic and paid £0.20. We removed 24 participants categorized as being against vaccination and two participants who failed at the attention check, leaving 522 participants (358 women, $M_{Age} = 36.59$, $SD = 12.29$; Public Support Index: $M = 6.52$, $SD = 0.78$).

Materials

We excluded statements with “only” because we wanted to focus on the statements’ valence, which appeared to play a more important effect on willingness to transmit. The statements were integrated in vignettes such as the following:

Imagine the following situation:

You’re listening to a program on the radio in which doctors and scientists are interviewed about vaccination. At some point, you hear:

“90 % of medical scientists think that vaccines are safe.”

A few minutes later you hear:

“1 individual out of 1000 has some severe side effects after being injected with a vaccine.”

A statement on vaccines side effects was always associated with a statement on the medical consensus with a different frame. In half of the dialogues the statement on vaccine side effects was presented first (as in the example) and in the other half the statement on the medical consensus was presented first.

Design and procedure

The overall design and procedure were similar to those of Experiment 2, with the exceptions that we introduced a control group receiving no arguments, and we added a distraction task lasting approximatively four minutes. Half of the participants read two statements on vaccination as described above, the other half did not. The experimental task consisted in

asking participant to convince someone to vaccinate. Participant were presented with the following text:

Imagine the following situation:

You are chatting with a friend of yours, and at some point she tells you: “Vaccines are not safe, I won’t vaccinate myself or my kids.”

Concerned for your friend and her children, you try to convince her that her opinion is misguided by answering:

[Free text entry]

Coding

We coded participants’ answer in the following way:

Side effects:

The participant mentioned that very few people suffer from side effects or that most people don’t suffer from any side effects.

Scientific consensus:

The participant mentioned that most medical scientists (or doctors) are in favor of vaccination or think it is safe, or that very few medical scientists (or doctors) are not in favor of vaccination or think it is unsafe.

Vaccines safety:

The participant mentioned the fact that vaccines are safe, but did not mention scientific consensus or the side effects.

Herd immunity:

The participants mentioned that vaccination is not only useful for individuals but for society at large or others.

Diseases are riskier than vaccines:

The participant argued that diseases that vaccines protect against are more dangerous than the vaccines themselves.

Scientific evidence:

The participant mentioned scientific evidence in favor of vaccination such as scientific articles or experiments.

Vaccines offer individual protection:

The participant mentioned the protective nature of vaccines for individuals.

Diseases are dangerous:

The participant mentioned that some diseases vaccines protect against are dangerous.

Not vaccinating is dangerous:

The participant mentioned that not vaccinating is dangerous (without explaining why).

Anecdotal evidence:

The participant used anecdotal evidence relying on first-hand experience to support vaccination.

No argument:

What the participant wrote could not fit into any of the categories above because it was not an argument.

20% of responses (104/522) were re-coded by an independent coder blind to our hypotheses. Coders agreed on 92.31% of the observations ($\kappa = 0.85$, $SE < .01$; 95% CI [0.83, 0.87]), the strength of agreement is considered to be ‘almost perfect’ (Landis & Koch, 1977).

Results and discussion

All the arguments used by participants can be found in Table 2.

Arguments	Experimental Conditions (N = 264)	Control Condition (N = 258)
Side Effects	58	1
Scientific Consensus	22	2
Vaccines are safe	62	83
Herd immunity	45	60
Diseases are riskier than vaccines	66	41
Scientific evidence support vaccination	41	40
Vaccines offer individual protection	21	56
Diseases are dangerous	15	25
Not vaccinating is dangerous	27	31
Anecdotal evidence	8	8
No arguments	48	41

Table 2. Types of arguments used by participants in Experiment 7 as a function of the condition.

In comparison to the Control Condition, participants in the Experimental Conditions were more likely to use arguments that relied on the low rate of side effects (58 *versus* 1, $Z = 0.21$, $p < .001$) or the scientific consensus on vaccination (22 *versus* 2, $Z = 0.08$, $p < .001$).

In the Experimental Conditions, participants who received the side effects statement positively framed were not more likely to use it as an argument that participants who received it negatively framed (31 *versus* 27, Pearson's Chi-squared test with Yates' continuity correction: $\chi^2(1, N = 58) = .14$, $p = 0.70$). Most participants reported the side effects framed

negatively (43 *versus* 15, chi-square goodness of fit test: $\chi^2(1, N = 58) = 13.52, p < .001, \phi = 0.48$), but most of them added “only” (27/43) or other rhetorical devices (8/43) to modify the rhetorical orientation of the statement.

Participants who received the consensus statement positively framed were more likely to use it as an argument than participants who received it negatively framed (19 *versus* 3, Pearson's Chi-squared test with Yates' continuity correction: $\chi^2(1, N = 22) = 10.91, p < .001, \phi = 0.70$). All the mentions of the scientific consensus were positively framed (22/22), as the three participants who had been presented with the consensus negatively framed reframed it positively. When the participants made use of the statements that had been provided—whether on the scientific consensus or the side effects—nearly all gave them a rhetorical orientation in favor of vaccination (76/80).

In the Experimental Conditions, participants who mentioned at least one of the statements used on average more arguments ($M = 2.36, SD = 0.96$) than participants who did not ($M = 1.35, SD = 0.61$; Welch's $t(521) = 7.85, p < .001, d = 1.36$), suggesting that these statements reinforced their argumentative arsenal.

These results suggest that it is important to frame the consensus statement positively because it increases the rate at which it is then used by readers in their arguments. However, it is not clear that it would be beneficial to frame positively the statement on the side effects. Framing these statements negatively while maintaining a pro-vaccination rhetorical frame (e.g. with ‘only’, which many participants spontaneously did) could minimize the effort required for participants to appropriate the argument.

General Discussion

Our studies tested the effects of framing on the estimated plausibility, memorization, and willingness to transmit of pro-vaccination statements among pro-vaccination individuals in

the U.S. and the U.K. The statements had two contents, relating either to vaccine side-effects or to the medical consensus on vaccination. As established by experiment 1, the statements' valence could be positive or negative, and the statements could be perceived as strongly pro-vaccination or as being ambiguous between being pro- and anti-vaccination.

Contrary to previous studies (Bebbington et al., 2017; Fessler et al., 2014), negatively framed statements, compared to positively framed statements, were not better memorized (Experiment 3), were deemed less plausible (Experiments 2 and 5), and were less appealing to transmit (Experiments 4 and 6). These effects in favor of positively framed statements ranged from small to large. The size of these effects and the conflicting direction of our results with the literature justified our decision to replicate Experiments 2 and 4.

The effects of rhetorical orientation were broadly as expected. Rhetorical orientation had no effect on memory, but participants deemed more plausible (Experiment 2) and were more willing to transmit (Experiment 4) statements whose rhetorical orientation better fitted their own views, compared to statements that didn't. While these effects ranged from small to medium for participants residing in the U.S., there was no significant effect of rhetorical orientation on plausibility or willingness of transmission with the sample from the U.K. It is unclear what drove this potential difference between U.S. and U.K. populations. Nonetheless, this discrepancy does not affect the practical conclusions that can be drawn from this study, since the same statements were found to be more plausible and more transmissible in the two populations.

Visual inspection of the results on plausibility and willingness to transmit in Figures 1 and 2 reveal the striking effects of framing. Comparing the most favorable frame (positive with pro-

vaccination rhetorical orientation) to the most negative frame (negative with ambiguous rhetorical orientation), we move from statements deemed very plausible to statements deemed barely plausible, and from statements participants are keen to transmit to statements participants would rather not transmit.

These strong framing effects have at least two significant practical consequences. First, positively valenced statements prompted participants to adopt a more positive attitude towards vaccination. Second, in the case of statements about the scientific consensus, positively valenced statements were more likely to be used by participants to argue against someone who opposes vaccination. Moreover, framing effects were also clearly perceptible in the way participants framed the arguments they chose to use, with nearly all arguments being framed with a pro-vaccination rhetorical orientation.

In relation with the literature on framing, our results confirm that the choice of frame induces information leakage (McKenzie, 2004; McKenzie & Nelson, 2003; Sher & McKenzie, 2008, 2008), as frames informed readers about the attitudes of the speakers towards vaccination. Moreover, our results join a growing body of research in questioning the generality of the negativity bias (for a literature review, see, Levin et al., 1998; for more recent findings, see, (Berriche & Altay, 2019; Stubbersfield et al., 2019; van Leeuwen et al., 2018). It is thus important to test on a case-by-case basis the effects of positive or negative framing, and to acknowledge that framing could affect differently memorization, plausibility evaluations, willingness to share, and actual sharing behaviors. We thus encourage future research to combine different measures and not to presume that framing will have the same effect on multiple measures.

Some limitations of our study should be pointed out. First, we obviously do not claim that our manipulation will be sufficient to overcome vaccine hesitancy on its own—indeed, it is not even its direct goal. However, we suggest that seemingly superficial features of vaccine communication might have a substantial impact on how some pro-vaccine individuals process the communication, making it more or less likely that they transmit it further. In particular, some frames—in the case at hand, positive frames—appear to make pro-vaccine participants more likely to accept and transmit pro-vaccine messages, which are intrinsically desirable outcomes. For example, information campaigns often frame information about vaccines side effects negatively, albeit with a pro-vaccination rhetorical orientation, as in the example above: “Severe side effects are extremely rare.” A positive frame (e.g. “The overwhelming majority of people do not have any side effects”) might be more easily further transmitted by pro-vaccination audiences.

Most research on vaccination-related messaging has focused on its direct effects on vaccine hesitant individuals, largely disregarding vaccination supporters (Vanderslott, 2018). Yet, in most countries, the majority of the population is pro-vaccine, suggesting that these individuals could play a significant role in propagating pro-vaccination messages through informal communication. The present study reveals that messages aimed at reinforcing the argumentative tools of pro-vaccination individuals must consider the way the messages are framed. Finally, our research highlights the importance of conducting experiments on the specific messages we wish to provide to the population, rather than extrapolating purely from past results, since the major framing effects we observed went in the opposite direction from what was expected from the some of the existing literature.

Acknowledgements

We are grateful to Aurélien Allard for statistical advice. We would also like to thank Camille Williams and Brent Strickland for valuable feedback and suggestions.

Funding

This research was supported by the grant EUR FrontCog ANR-17-EURE-0017 and ANR-10-IDEX-0001-02 PSL. Sacha Altay's PhD thesis is funded by the Direction Générale de l'Armement (DGA).

Conflict of interest

The authors declare no conflict of interest.

References

- ASTHO. (2009). *Communicating Effectively About Vaccines : New Communication Resources for Health Officials*.
<http://www.astho.org/Programs/Immunization/Communicating-Effectively-About-Vaccines--Summary-of-a-Survey-of-U-S--Parents-and-Guardians/>
- Baumeister, R. F., Bratslavsky, E., Finkenauer, C., & Vohs, K. D. (2001). Bad is stronger than good. *Review of General Psychology*, 5(4), 323-370. <https://doi.org/10.1037//1089-2680.5.4.323>
- Bebbington, K., MacLeod, C., Ellison, T. M., & Fay, N. (2017). The sky is falling : Evidence of a negativity bias in the social transmission of information. *Evolution and Human Behavior*, 38(1), 92–101.
- Berriche, M., & Altay, S. (2019). « Sister, I Love You! » Phatic Posts Are More Successful on Facebook Than Health Misinformation. <https://psyarxiv.com/nj2sr/>
- Betsch, C., & Wicker, S. (2012). E-health use, vaccination knowledge and perception of own risk : Drivers of vaccination uptake in medical students. *Vaccine*, 30(6), 1143–1148.
- Boyer, P. (2018). *Minds Make Societies : How Cognition Explains the World Humans Create*. Yale University Press.
- Brunson, E. K. (2013). The impact of social networks on parents' vaccination decisions. *Pediatrics*, peds–2012.

- Bullock, J. G., Gerber, A. S., Hill, S. J., & Huber, G. A. (2013). *Partisan bias in factual beliefs about politics*. National Bureau of Economic Research.
<http://www.nber.org/papers/w19080>
- Casiday, R., Cresswell, T., Wilson, D., & Panter-Brick, C. (2006). A survey of UK parental attitudes to the MMR vaccine and trust in medical authority. *Vaccine*, 24(2), 177–184.
- Chanel, O., Luchini, S., Massoni, S., & Vergnaud, J.-C. (2011). Impact of information on intentions to vaccinate in a potential epidemic : Swine-origin Influenza A (H1N1). *Social Science & Medicine*, 72(2), 142–148.
- Chen, H., Cohen, P., & Chen, S. (2010). How big is a big odds ratio? Interpreting the magnitudes of odds ratios in epidemiological studies. *Communications in Statistics—Simulation and Computation*®, 39(4), 860–864.
- Chung, C. M., & Darke, P. R. (2006). The consumer as advocate : Self-relevance, culture, and word-of-mouth. *Marketing Letters*, 17(4), 269–279.
- Das, J., & Das, S. (2003). Trust, learning, and vaccination : A case study of a North Indian village. *Social science & medicine*, 57(1), 97–112.
- Dittmann, S. (2001). Vaccine safety : Risk communication—a global perspective. *Vaccine*, 19(17-19), 2446–2456.
- Dixon, G. N., & Clarke, C. E. (2013). Heightening uncertainty around certain science : Media coverage, false balance, and the autism-vaccine controversy. *Science Communication*, 35(3), 358–382.
- Dubé, E., Gagnon, D., MacDonald, N. E., & SAGE Working Group on Vaccine Hesitancy. (2015). Strategies intended to address vaccine hesitancy : Review of published reviews. *Vaccine*, 33(34), 4191–4203. <https://doi.org/10.1016/j.vaccine.2015.04.041>
- Dunegan, K. J. (1993). Framing, cognitive modes, and image theory : Toward an understanding of a glass half full. *Journal of Applied Psychology*, 78(3), 491.
- Dunegan, K. J. (1995). Image theory : Testing the role of image compatibility in progress decisions. *Organizational Behavior and Human Decision Processes*, 62(1), 79–86.
- Eriksson, K., & Coultas, J. C. (2014). Corpses, maggots, poodles and rats : Emotional selection operating in three phases of cultural transmission of urban legends. *Journal of Cognition and Culture*, 14(1-2), 1–26.
- Faasse, K., Chatman, C. J., & Martin, L. R. (2016). A comparison of language use in pro-and anti-vaccination comments in response to a high profile Facebook post. *Vaccine*, 34(47), 5808–5814.
- Fadda, M., Allam, A., & Schulz, P. J. (2015). Arguments and sources on Italian online forums

on childhood vaccinations : Results of a content analysis. *Vaccine*, 33(51), 7152–7159.

Feinberg, Y., Pereira, J. A., Quach, S., Kwong, J. C., Crowcroft, N. S., Wilson, S. E., Guay, M., Lei, Y., Deeks, S. L., Delivery, P. H. A. of C. I. of H. R. I. R. N. (PCIRN) P., & Group, E. (2015). Understanding public perceptions of the HPV vaccination based on online comments to Canadian news articles. *PloS one*, 10(6), e0129587.

Fessler, D. M., Pisor, A. C., & Navarrete, C. D. (2014). Negatively-biased credulity and the cultural evolution of beliefs. *PloS one*, 9(4), e95167.

Freed, G. L., Clark, S. J., Butchart, A. T., Singer, D. C., & Davis, M. M. (2011). Sources and perceived credibility of vaccine-safety information for parents. *Pediatrics*, 127(Supplement 1), S107–S112.

Goldberg, M. H., van der Linden, S., Maibach, E., & Leiserowitz, A. (2019). Discussing global warming leads to greater acceptance of climate science. *Proceedings of the National Academy of Sciences*, 116(30), 14804–14805.

Heath, C. (1996). Do people prefer to pass along good or bad news? Valence and relevance of news as predictors of transmission propensity. *Organizational Behavior and Human Decision Processes*, 68(2), 79–94.

Hennig-Thurau, T., Gwinner, K. P., Walsh, G., & Gremler, D. D. (2004). Electronic word-of-mouth via consumer-opinion platforms : What motivates consumers to articulate themselves on the internet? *Journal of interactive marketing*, 18(1), 38–52.

Horne, Z., Powell, D., Hummel, J. E., & Holyoak, K. J. (2015). Countering antivaccination attitudes. *Proceedings of the National Academy of Sciences*, 201504019.
<https://doi.org/10.1073/pnas.1504019112>

Jiménez, Á. V., Mesoudi, A., & Tehrani, J. (In preparation). No evidencednce that omission and congruity biases affect the perception and recall of vaccine-related information. *Psyarxiv*.

Jiménez, Á. V., Stubbersfield, J. M., & Tehrani, J. J. (2018). An experimental investigation into the transmission of antivax attitudes using a fictional health controversy. *Social Science & Medicine*.

Kahneman, D., & Tversky, A. (1979). Prospect Theory : An Analysis of Decision under Risk. *Econometrica*, 47(2), 263-292.

Katz, E., & Lazarsfeld, P. F. (1955). *Personal influence : The part played by people in the flow of mass communications*. Free Press.

Kennedy, A., Basket, M., & Sheedy, K. (2011). Vaccine attitudes, concerns, and information sources reported by parents of young children : Results from the 2009 HealthStyles survey. *Pediatrics*, peds–2010.

- Knapp, M. L., & Daly, J. A. (2002). *Handbook of interpersonal communication*. Sage.
- Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *biometrics*, 159–174.
- Larson, H. J., Jarrett, C., Eckersberger, E., Smith, D. M., & Paterson, P. (2014). Understanding vaccine hesitancy around vaccines and vaccination from a global perspective : A systematic review of published literature, 2007–2012. *Vaccine*, 32(19), 2150–2159.
- Leask, J. (2011). Target the fence-sitters. *Nature*, 473(7348), 443.
- Lei, Y., Pereira, J. A., Quach, S., Bettinger, J. A., Kwong, J. C., Corace, K., Garber, G., Feinberg, Y., Guay, M., Delivery, P. H. A. of C. I. of H. R. I. R. N. (PCIRN) P., & Group, E. (2015). Examining Perceptions about mandatory influenza vaccination of healthcare workers through online comments on news stories. *PloS one*, 10(6), e0129993.
- Levin, I. P., Schneider, S. L., & Gaeth, G. J. (1998). All frames are not created equal : A typology and critical analysis of framing effects. *Organizational behavior and human decision processes*, 76(2), 149–188.
- Levin, I. P., Schnittjer, S. K., & Thee, S. L. (1988). Information framing effects in social and personal decisions. *Journal of experimental social psychology*, 24(6), 520–529.
- Linville, P. W., Fischer, G. W., & Fischhoff, B. (1993). *AIDS risk perceptions and decision biases*.
- MacDonald, N. E. (2015). Vaccine hesitancy : Definition, scope and determinants. *Vaccine*, 33(34), 4161–4164.
- Marteau, T. M. (1989). Framing of information : Its influence upon decisions of doctors and patients. *British Journal of Social Psychology*, 28(1), 89–94.
- McKeever, B. W., McKeever, R., Holton, A. E., & Li, J.-Y. (2016). Silent majority : Childhood vaccinations and antecedents to communicative action. *Mass Communication and Society*, 19(4), 476–498.
- McKenzie, C. R. M. (2004). Framing effects in inference tasks—And why they’re normatively defensible. *Memory & cognition*, 32, 874–885.
- McKenzie, C. R. M., & Nelson, J. D. (2003). What a speaker’s choice of frame reveals : Reference points, frame selection, and framing effects. *Psychonomic Bulletin and Review*, 10(3), 596–602.
- Miton, H., & Charbonneau, M. (2018). Cumulative culture in the laboratory : Methodological and theoretical challenges. *Proc. R. Soc. B*, 285(1879), 20180677.
- Miton, H., & Mercier, H. (2015). Cognitive obstacles to pro-vaccination beliefs. *Trends In Cognitive Sciences*, 19(11), 633–636.

- Morin, O. (2015). *How Traditions Live and Die*. Oxford University Press.
- Mosleh, M., Pennycook, G., & Rand, D. (2019). Self-reported willingness to share political news articles in online surveys correlates with actual sharing on Twitter. *PLoS One*.
- Nichter, M. (1995). Vaccinations in the Third World : A consideration of community demand. *Social Science & Medicine*, 41(5), 617–632.
- Nyhan, B., Reifler, J., Richey, S., & Freed, G. L. (2014). Effective messages in vaccine promotion : A randomized trial. *Pediatrics*, 133(4), e835–e842.
- Omer, S. B., Salmon, D. A., Orenstein, W. A., deHart, M. P., & Halsey, N. (2009). Vaccine refusal, mandatory immunization, and the risks of vaccine-preventable diseases. *New England Journal of Medicine*, 360(19), 1981–1988.
- Opel, D. J., & Marcuse, E. K. (2013). Window or mirror : Social networks’ role in immunization decisions. *Pediatrics*, 131(5), e1619–e1620.
- Paolacci, G., & Chandler, J. (2014). Inside the Turk : Understanding Mechanical Turk as a participant pool. *Current Directions in Psychological Science*, 23(3), 184–188.
- Pereira, J. A., Quach, S., Dao, H. H., Kwong, J. C., Deeks, S. L., Crowcroft, N. S., Quan, S. D., & Guay, M. (2013). Contagious comments : What was the online buzz about the 2011 Quebec measles outbreak? *PLoS One*, 8(5), e64072.
- Pluviano, S., Watt, C., & Della Sala, S. (2017). Misinformation lingers in memory : Failure of three pro-vaccination strategies. *PloS one*, 12(7), e0181640.
- Sadaf, A., Richards, J. L., Glanz, J., Salmon, D. A., & Omer, S. B. (2013). A systematic review of interventions for reducing parental vaccine refusal and vaccine hesitancy. *Vaccine*, 31(40), 4293–4304.
- Salmon, D. A., Moulton, L. H., Omer, S. B., Patricia deHart, M., Stokley, S., & Halsey, N. A. (2005). Factors associated with refusal of childhood vaccines among parents of school-aged children : A case-control study. *Archives of pediatrics & adolescent medicine*, 159(5), 470–476.
- Schoeppe, J., Cheadle, A., Melton, M., Faubion, T., Miller, C., Matthys, J., & Hsu, C. (2017). The Immunity Community : A Community Engagement Strategy for Reducing Vaccine Hesitancy. *Health Promotion Practice*, 18(5), 654-661.
<https://doi.org/10.1177/1524839917697303>
- Sher, S., & McKenzie, C. R. M. (2008). Framing effects and rationality. *The probabilistic mind: Prospects for Bayesian cognitive science*, 79.
- Sher, Shlomi, & McKenzie, C. R. (2006). Information leakage from logically equivalent frames. *Cognition*, 101(3), 467–494.

- Streefland, P., Chowdhury, A. M. R., & Ramos-Jimenez, P. (1999). Patterns of vaccination acceptance. *Social science & medicine*, 49(12), 1705–1716.
- Stubbersfield, J. M., Dean, L. G., Sheikh, S., Laland, K. N., & Cross, C. P. (2019). Social transmission favours the ‘morally good’ over the ‘merely arousing’. *Palgrave Communications*, 5(1), 3.
- Sundaram, D. S., Mitra, K., & Webster, C. (1998). Word-of-mouth communications : A motivational analysis. *ACR North American Advances*.
- Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, 211(4481), 453–458.
- van der Linden, S. L., Clarke, C. E., & Maibach, E. W. (2015). Highlighting consensus among medical scientists increases public support for vaccines : Evidence from a randomized experiment. *BMC public health*, 15(1), 1207.
- van Leeuwen, F., Parren, N., Miton, H., & Boyer, P. (2018). Individual choose-to-transmit decisions reveal little preference for transmitting negative or high-arousal content. *Journal of Cognition and Culture*.
- Vanderslott, S. (2018). Exploring the meaning of pro-vaccine activism across two countries. *Social Science & Medicine*.
- Wheelock, A., Thomson, A., & Sevdalis, N. (2013). Social and psychological factors underlying adult vaccination behavior : Lessons from seasonal influenza vaccination in the US and the UK. *Expert review of vaccines*, 12(8), 893–901.
- Wilson, D. K., Kaplan, R. M., & Schneiderman, L. J. (1987). Framing of decisions and selections of alternatives in health care. *Social Behaviour*, 2(1), 51–59.
- World Health Organization. (2016). *Vaccine safety communication : Guide for immunization programme managers and national regulatory authorities*. Manila: WHO Regional Office for the Western Pacific.
- Yaqub, O., Castle-Clarke, S., Sevdalis, N., & Chataway, J. (2014). Attitudes to vaccination : A critical review. *Social Science & Medicine*, 112, 1–11.