Vaccine 39 (2021) 6407–6413

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Determinants of information diffusion in online communication on vaccination: The benefits of visual displays ☆

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ARTICLE INFO

Article history:
Received 11 February 2021
Received in revised form 25 August 2021
Accepted 3 September 2021
Available online 22 September 2021

Keywords:
Vaccination
Informed medical decisions
Icon arrays
Risk literacy
Echo chambers
Vaccine hesitancy

ABSTRACT

Objective: Social media are an increasingly important source of information on the benefits and risks of vaccinations, but the high prevalence of misinformation provides challenges for informed vaccination decisions. It is therefore important to understand which messages are likely to diffuse online and why, and how relevant aspects—such as scientific facts on vaccination effectiveness—can be made more comprehensible and more likely to be shared. In two studies, we (i) explore which characteristics of messages on flu vaccination facilitate their diffusion in online communication, and (ii) whether visual displays (i.e., icon arrays) facilitate the comprehension and diffusion of scientific effectiveness information.
Methods: In Study 1, 208 participants each rated a random sample of 15 out of 63 messages on comprehensibility, trustworthiness, persuasiveness, familiarity, informativeness, valence, and arousal, and then reported which information they would share with subsequent study participants. In Study 2 (N = 758), we employed the same rating procedure for a selected set of 9 messages and experimentally manipulated how scientific effectiveness information was displayed.
Results: Study 1 illustrated that scientific effectiveness information was difficult to understand and thus did not diffuse well. Study 2 demonstrated that visual displays improved the understanding of this information, which could, in turn, increase its social impact.
Conclusions: The comprehensibility of scientific information is an important prerequisite for its diffusion. Visual displays can facilitate informed vaccination decisions by rendering important information on vaccination effectiveness more transparent and increasing the willingness to share this information.

1. Introduction

The growing use of the internet to obtain health information provides many challenges to informed medical decision making, particularly in the domains of vaccinations [1,2]. While the accessibility of medical information increases, lay people may rely on strategies that lead to a biased sampling of information and may thus tend to avoid vaccinations they would clearly profit from [3,4]. This problem is exacerbated when people tend to selectively share biased mis- and disinformation with others [5] and form so-called echo chambers, wherein extreme positions on vaccination are reinforced [6,7]. To alleviate such problems, this article aims to determine (a) which types of vaccination information proliferate in online communication, and (b) how scientifically-sound vaccination information can be designed to not only facilitate its use in medical decision making, but also to support its proliferation in online media [8].

Prior research has identified some message characteristics believed to facilitate its proliferation. People tend to share communication that elicits high (negative) emotional arousal [9–11] or messages that are novel to them [5]. Similarly, the credibility and trustworthiness of the broadcasting source were recognized as key features that determine a message's success [8,12,13]. Importantly, these principles still need to be transferred to the design of vaccination information.

One reason why existing recommendations may not have been elaborated for vaccinations is the fact that most of the identified characteristics are at best neutral towards the aims of informed medical decision making: For instance, while both threat appeals and the use of narrative testimonials may help to increase a transmission of the desired health information and behavior by increasing the arousal of the information [14,15], they neither convey a clear picture of disease susceptibility nor of vaccination effectiveness. As such, although transparent information is indispensable for fully informed medical decision making and could foster trust

☆ The second study of this article was preregistered under osf.io/4f8qn.

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https://doi.org/10.1016/j.vaccine.2021.09.016
0264-410X/

in the communicating institutions, it may conflict with the goal of creating impactful pro-vaccination messages [16–18]. In this line of reasoning, it is also of interest how well governmental actors like the Centers for Disease Control and Prevention (CDC) and scientific information—such as meta-analyses and randomized controlled trial results—fare in the online competition for public attention.

In this article, we report two studies that investigate the conditions under which relevant flu-vaccination information is shared in online-environments. The first study scrutinizes a large and diverse set of online messages to determine a) which characteristics predict the diffusion to other study participants, b) how well information from different sources (like narratives, the CDC, and scientific studies) is transmitted in an online setting, and c) how people evaluate those types of messages. The second study follows up on Study 1 by experimentally testing whether the diffusion and the evaluation of scientific information about vaccination effectiveness profits from displaying visualizations, which has been shown to foster both the comprehensibility as well as the impact of clinical evidence (e.g., [19]).

2. Study 1

2.1. Methods

2.1.1. Participants and procedure

A sample of 257 US-participants were recruited via Amazon Mechanical Turk. After informed consent, participants were asked to indicate their perception of flu vaccinations. Each participant received 15 randomly sampled messages on flu vaccination from a set of 63 messages and asked to rate each message on multiple scales (see Measures). The population of 63 messages were collected from various online sources by conducting an unstructured search of the topic via Google (see Supplement 1 for a full list). In addition, one attention check statement was mixed in and disguised as an additional message (with specific instructions how to respond appropriately). After the presentation and rating of all messages, participants were asked to indicate their perception of flu vaccinations a second time and compose a message for future participants in an open text field. Finally, demographics (age: *M* = 33.37, *SD* = 9.57; 45.2% females; education *Md* = 3(*2-year post high school degree*)) and a seriousness item were assessed. From the total of 257 participants, 208 provided valid entries (i.e., complete responses with passed attention check, a completion time indicating they items were read (>350 s), and an indication that their data may be trusted). The study took part in August 2017, adheres to the Declaration of Helsinki, and was conducted in compliance with relevant laws and institutional guidelines, including those of the University of Konstanz ethics board.

2.1.2. Measures

2.1.2.1. Ratings of the messages. Each participant rated each of 15 messages on 6 differential semantic rating scales asking how much each message advocated against/for flu vaccination (stance towards vaccination), how comprehensible, trustworthy, persuasive, familiar, and informative the message was (each scale ranging from 1 to 5). Additionally, the degrees of experienced valence and arousal while reading the message were assessed via a self-assessment manikin [20] (1–5). Finally, the willingness to share the information with others was rated on a 7-point semantic differential scale (from 1: *certainly no* to 7: *certainly yes*).

2.1.2.2. Coding. A double-blinded coder rated whether a presented message was adopted in the open text field. Furthermore, the source of a reported message was coded as deriving from a scientific study, from the CDC, contained a narrative, or nothing of the above (such as newspaper article content; see Supplement 1 for a full list of messages used), which served as message type classification in the analyses.

2.1.2.3. Perception of flu vaccinations. Participants also reported their perception of flu vaccinations: Perceptions were assessed by intentions, flu risk perception, flu vaccine risk perception, and recommendation of vaccines (see [6] for a detailed description). The sample of valid participants expressed a medium-level initial intention to get vaccinated ("*Do you intend to receive the flu vaccine for the seasonal flu during the upcoming flu season?*" 1: *not at all* – 7: *yes, definitely; M* = 3.58, *SD* = 2.56). As changes in these perceptions of vaccinations were assessed on the participant level and cannot be used to infer any meaning per message, this information is merely presented to disclose all measures used in the study.

2.1.3. Statistical analyses

In order to assess the potential for diffusion of all message characteristics, we aggregated data across participants and obtained mean ratings for each message. These mean ratings of message characteristics were then explored via correlations. For determining the relevance of the messages on the different rating scales, Table S1 shows how much variance of each rating can be explained by the participants vs. by the messages. For instance, the stance towards vaccination rating is highly dependent on the messages, while the messages did not explain much of the variance in arousal and familiarity ratings.

To test how the message types affected their adoption rate in the open text field, we used a negative binomial regression model with the logits of the times a message was presented and the stance towards vaccination as covariate.[1] Different message types were entered into the model by dummy-coding and analyses were again performed with messages as unit of observation. The rated willingness to share the messages was tested with the same predictors in an ANCOVA, also controlling for message stance towards vaccination. Likewise, the effects of the message type on the other ratings were tested in a MANCOVA. Significant effects were followed up by ANCOVAs for the MANCOVA, and Bonferroni-corrected post-hoc comparisons for the ANCOVAs and the negative binomial regression model.

2.2. Results and discussion

Generally, very few messages were adopted in open texts: 21 (33.3%) of the presented messages were not mentioned at all, and 53 (84.1%) had an adoption rate of 5% or lower (Fig. S1). Table 1 illustrates that the mean adoption rate of a message in an open text field correlated positively with the willingness to share this information, higher comprehensibility, and lack of familiarity. The willingness to share was highly correlated with most ratings of the message.

Comparing the likelihoods of a message adoption given their type, messages derived from scientific studies were particularly unsuccessful (see Fig. 1A for means and confidence intervals, $\chi^2(3) = 8.78$, $p = .032$, $R^2_L = 0.05$): In direct contrast, CDC statements

[1] Cognitive dissonance theory [31], the literature on confirmation bias [32], and previous vaccination studies (e.g., [6]) led us to expect that several measures (such as the willingness to share the messages) should be highly dependent on the fit of the pre-assessed attitude of the individual to the perceived stance of the presented message. Because this was also the case in this study (effects for willingness to share the message: *individual vaccination intention* × *individual message stance* towards vaccination: $b = 0.11$, $t(448.06) = 5.84$, $p < .001$; additional effect of *individual vaccination intention* × *average message stance*: $b = 0.05$, $t(2848.53) = 3.07$, $p = .002$;), the average message stance towards vaccination was used as a covariate in all tests comparing different types of messages.

Table 1
Correlations of mean ratings of the messages in study 1 (N = 63).

	Willingness to Share	Stance (Con/Pro)	Comprehensiveness	Trustworthiness	Persuasiveness	Familiarity	Informativeness	Valence	Arousal
Adoption Rate	0.34**	0.13	0.35**	0.18	0.21+	−0.37**	0.16	0.09	0.01
Willingness to Share		0.73***	0.80***	0.81***	0.92***	−0.24+	0.85***	0.73***	−0.38**
Stance (Con/Pro)			0.50***	0.83***	0.79***	−0.18	0.69***	0.92***	−0.64***
Comprehensiveness				0.51***	0.74***	−0.53***	0.56***	0.53***	−0.16
Trustworthiness					0.89***	−0.05	0.91***	0.77***	−0.63***
Persuasiveness						−0.21	0.89***	0.78***	−0.42***
Familiarity							0.05	−0.18	−0.02
Informativeness								0.65***	−0.41***
Valence									−0.65***

Note. + p < .10, ** p < .01, *** p < .001.

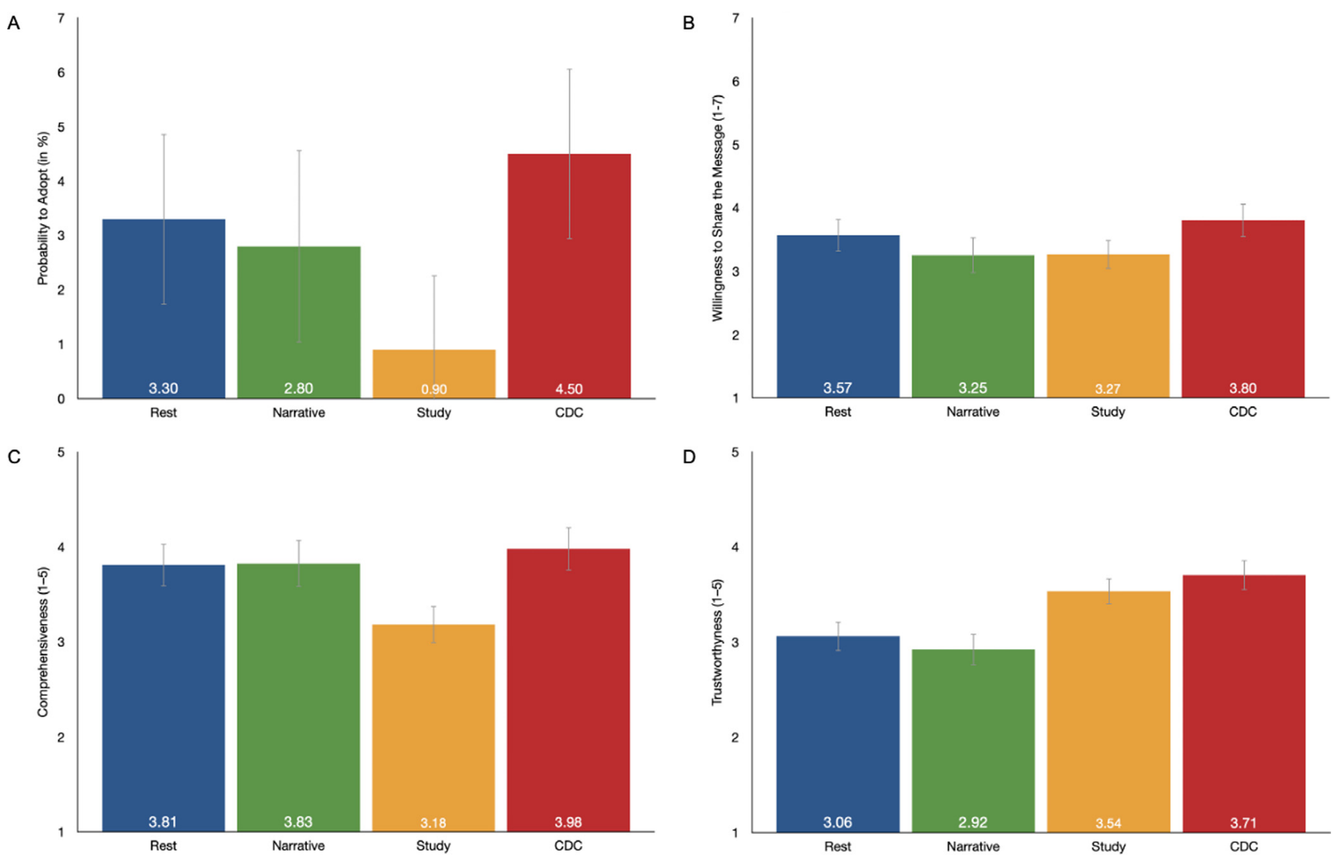

Fig. 1. Effects of the Message Type with 95% Confidence Intervals for Estimates with Mean Stance Towards Vaccination. *Note.* Scientific study results (shown as the third bar, in gold color) scored (A) lowest on probability to adopt, (B) (among) lowest with regard to willingness to share, (C) lowest with regard to comprehensibility (and similarly familiarity; not shown here), yet was (D) higher than narratives and on par with CDC recommendations with regard to trustworthiness (as well as informativeness; not shown here).

were 4.6 times as likely to be reported (b = 1.53, p = .028, OR 95 %CI [1.11,19.18]), with no other contrast being significant (all $p \geq 0.146$). A similar pattern emerged for the ratings of the willingness to share the message ($F(3,58) = 3.97$, $p = .012$, $\eta_p^2 = .170$). In this case, not only scientific study information (p = .018) was rated less likely to be shared compared to CDC statements, but this also held true for portrayed narratives, at least marginally (p = .090, see Fig. 1B also for means and confidence intervals).

MANCOVAs revealed that the message type also affected other ratings (Pillai's trace V = 1.415, $F(21, 162)$ = 6.89, $p \leq 0.001$, η_p^2 = .472). While no significant differences emerged for ratings of persuasiveness (p = .087, η_p^2 = .106) and valence (p = .401, η_p^2 = .049), messages derived from scientific studies were rated as less comprehensible and as less familiar than all other types of messages (all $p \leq 0.001$, type: $\eta_p^2 \geq 0.390$, see Fig. 1C also for means and confidence intervals). Moreover, participants rated narratives to be more arousing than information from scientific studies (p = .034, type: η_p^2 = .155, p = .020). However, both CDC and scientific study information were rated as more informative than narratives and as more trustworthy than both other types (all $p \leq 0.002$, *type*: $\eta_p^2 \geq 0.219$, see Fig. 1D, also for means and confidence intervals).

In sum, we simulated a typical search scenario for vaccination information and evaluated how typical—albeit potentially not fully representative—messages are perceived and proliferate in an online setting. While the scientifically-based CDC information was rather successful, our results demonstrate that the impact and transfer of any scientific evidence that would enable fully informed medical decision making (as found in [21,22]) is comparatively low. Furthermore, the pattern of the ratings for scientific messages suggests that low adoption and transfer rates may be due to a lack of comprehensibility. As our sample size is rather small, some effects may have been missed due to a lack of power.

In conclusion, Study 1 illustrates that additional measures are required to improve the understanding of clinical effectiveness information and to foster informed decision making regarding vaccinations in online settings. One vehicle for promoting these goals may be the use of icon-arrays, which have been shown to improve literacy of clinical trial information in other domains (e.g., [23,24]).

3. Study 2

Study 2 tests whether the use of an icon-array a) facilitates the diffusion of scientific flu-vaccine effectiveness information and b) improves its understanding and the evaluation of this message. Furthermore, it c) evaluates potential mechanisms how the diffusion of the message may be facilitated using mediation analyses. To rule out alternative explanations due to a general shift of attention to visualizations, we contrast the effects of an icon-array with those of non-informative displays (logos of scientific societies) as a control.

3.1. Methods

3.1.1. Participants and procedure

The general procedure, and measures were similar to Study 1. In contrast to Study 1, all participants received the same 9 messages (selected from Study 1, and characterized by a balanced stance towards vaccination and high willingness to share; see also [6]) plus the same attention check item, the open text field for transmitting a message (directly after the messages), and related pre-post perception measures (intentions to vaccinate, vaccination recommendation, norms, perceived behavioral control, attitudes, flu risk perception, risk perception side effects, knowledge, perceived vaccine effectiveness, as in [6]). For two messages, the visual display was experimentally manipulated between participants: One message providing scientific effectiveness information of the flu vaccine derived from a Cochrane *meta*-analysis [22] was either displayed as text only ("*A meta-analysis summarizing scientific evidence from various studies published by the Cochrane Library in 2014 found that 1 of 100 vaccinated* vs. *2 of 100 unvaccinated adults contracted a laboratory-confirmed flu in randomized controlled trials.*"), or supplemented with the logo of the Cochrane society, or with an icon array displaying the same statistical information as the text (created by the R package riskyr [25], see Fig. 2). To control for unspecific effects of visual salience, another message providing positive information on the vaccine from the CDC website was either supplemented by the CDC logo or not. This study was pre-registered (osf.io/4f8qn), adheres to the Declaration of Helsinki, and was conducted in compliance with relevant laws and institutional guidelines, including those of the University of Konstanz ethics board.

A total of 1040 participants took part in the study conducted in August 2018. Of those, 758 participants provided valid responses (see Table 2 for descriptive statistics). In contrast to Study 1, there were two blinded coders that evaluated the adoption of each message in the open text field. A message was considered as adopted when one coder rated that the message was mentioned in the open text field (ϕ = 0.62).

3.1.2. Statistical analyses

Effects on the adoption of the scientific effectiveness information provided by the Cochrane review were tested by a 3 *Study display* (*text only*/ *text + logo*/ *text + icon-array*) $\times$ 2 *CDC logo* (*yes*/ *no*) (effect-coded) design in a logistic regression. The same design was used to test how the manipulation affected the rated willingness to share the Cochrane review in an ANOVA. The *CDC logo* factor, though supplementing a different message, was introduced and preregistered as an additional visual salience control for the message's adoption in the open text field. As further controls, the same analyses were conducted with the other message ratings, the message rating of the CDC message, and for changes in flu vaccine-related perceptions in MANOVAs, additionally including the effect of *Time* (*pre*/ *post*) for changes in perceptions. Significant effects were followed-up by preregistered predicted contrast comparisons and MANOVAs by ANOVAs.

In order to test whether the experimental effects on the diffusion of the scientific effectiveness information were mediated by the comprehensiveness of the message, we conducted two mediation analyses (one with comprehensiveness as the sole mediator, one full model also adding the other ratings as mediators) via SEM in Mplus8. In the SEMs, both adoption in open text (full model: R^2 = 0.17) and the willingness to share (full model: R^2 = 0.45) were combined into a latent diffusion variable. Indirect mediation effects were estimated with bias-corrected 5000 bootstrapped confidence intervals. Both models had adequate model fit (full model: $\chi^2(6)$ = 11.275; *p* = 0.0802; *RMSEA* = 0.034 [0; 0.064]; for the other model, refer to Fig. 4).

3.2. Results and discussion

Study display significantly altered the willingness to share the scientific effectiveness information of the Cochrane review ($F(2,752)$ = 4.28, η^2_p = .011; *p* = 0.014), while the *CDC logo* effect and the interaction were insignificant (both $\eta^2_p \leq 0.002$; $p \geq 0.502$). As predicted, the icon-array (*M* = 4.15; *SE* = 0.12; 95% CI[3.91, 4.38]) increased the willingness to share the message compared to both the *text only* condition (*M* = 3.67; *SE* = 0.13; 95% CI [3.42,3.92]; *d* = 0.25; *p* = .006) and the *text + logo* condition (*M* = 3.77; *SE* = 0.13; 95% CI[3.53,4.02]; *d* = 0.19; *p* = .032, see Fig. 3). However, the test of the manipulation on the actual likelihood of adopting the scientific effectiveness information in the open text field was insignificant (*Study display*: $\chi^2(2)$ = 2.84, *p* = .241; *CDC logo*: $\chi^2(1)$ = 0.04, *p* = .848; *Study display* $\times$ *CDC logo*: $\chi^2(2)$ = 0.44, *p* = .801): 75 of 758 participants mentioned the scientific effectiveness information in their open text field across all conditions (9.9%).

The effect of *Study display* also emerged across the other ratings for the scientific Cochrane information (Pillai's trace *V* = 0.05, $F(16, 1492)$ = 2.56, *p* = .001, η^2_p = .027, *CDC logo* and interaction: $\eta^2_p \leq 0.005$; $p \geq 0.888$) with significantly higher values for comprehensibility (η^2_p = .028; $p \leq 0.001$), trust (η^2_p = .013; *p* = 0.008), persuasiveness (η^2_p = .030; $p \leq 0.001$), informativeness (η^2_p = .013; *p* = 0.008) and positive valence (η^2_p = .011; *p* = 0.015) for the version with the icon array (see Table S2 for all means, standard errors and confidence intervals).[2]

Mediation analyses revealed that differences in the combined diffusion of scientific effectiveness information measure between the *text + icon-array* and the *text only* (β_y = 0.22, $p \leq 0.001$, 95% CI[0.12; 0.35]) and between the *text + icon-array* and the *text + logo condition* (β_y = 0.15, *p* = .006, 95% CI[0.05; 0.26]) were mediated by the comprehensiveness rating of the message (Fig. 4). However, indirect effects shifted towards persuasiveness

[2] The MANOVA on ratings of the CDC statement revealed no effects of both manipulations ($\eta^2_p \leq 0.015$; $p \geq 0.204$). Likewise, all flu-vaccine related perceptions were not affected by any experimental manipulations ($\eta^2_p \leq 0.018$; $p \geq 0.150$), while participants generally changed their views mainly in favor of the vaccine (Pillai's trace *V* = 0.263, $F(9, 744)$ = 29.51, $p \leq 0.001$, η^2_p = .263; contrary to the overall effect in the ANOVAs of all other variables, we found no *time* effect for perceived behavioral control, and a reduction for vaccine efficacy beliefs).

Fig. 2. The Presented Icon Array Displaying the Effectiveness of the Flu Vaccine as Found in the Cochrane Review.

Table 2
Descriptive statistics of participants in study 2.

Condition	N	Vaccinated (%)	Female (%)	Age M (SD)	Education (Md)
Text only	240	35.0 [28.6; 41.4]	49.2 [42.6; 56.1]	35.8 (10.7) [34.5; 37.1]	Post-High School
Text + Logo	242	33.1 [26.7; 39.4]	55.8 [49.1; 62.4]	37.5 (11.0) [36.2; 38.8]	Post-High School
Text + Icon Array	276	41.7 [35.5; 47.8]	52.5 [46.3; 58.8]	35.7 (9.7) [34.5; 36.9]	Bachelor
Overall	758	36.8 [33.2; 40.4]	47.4 [48.9; 56.3]	36.3 (10.5) [35.6; 37.1]	Bachelor

Notes. 95 % CI in brackets.

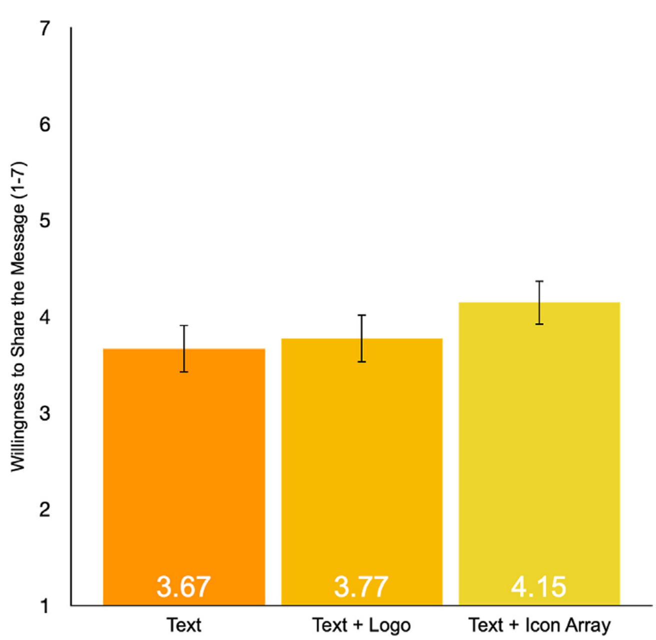

Fig. 3. Effects of the Icon Array on the Willingness to Share Information with 95% Confidence Intervals. *Note.* An icon array supplementing vaccine effectiveness information increases participants' willingness for sharing this information. This effect cannot be explained solely by the attention to the visually salient graphic, as effects exceed those of the same information supplemented with the logo of the Cochrane society.

($\beta_y \geq 0.07$, $p \leq 0.033$) and informativeness ($\beta_y \geq 0.10$, $p \leq 0.039$) ratings, when all other rating scales were included in the SEM (comprehensiveness: $\beta_y \leq 0.03$, $p \geq 0.237$).

Overall, we find evidence for an effect of using visualizations for conveying scientific vaccination effectiveness information, such that a scientific message with a corresponding icon-array is preferred by recipients and increases their willingness to share the message with others. As logos did not yield this effect, it cannot be explained by visual attention merely being captured by the salience of a visual display. However, a clear mechanism how the perception of the statement is altered by visualizations cannot be discerned.

4. General discussion

While the CDC successfully conveys messages on flu vaccination that people trust and are most willing to share with others, conveying the explicit scientific evidence of vaccination efficiency trials for facilitating informed medical decision making is more challenging: Although participants rated the scientific evidence to be as informative and trustworthy as the CDC messages, they were much less likely to share it with others. The primary reason for this reluctance was the low comprehensibility of scientific evidence. Messages like "An annual seasonal flu vaccine is the best way to reduce your risk of getting sick with seasonal flu [...]." (CDC website, 2018) are easier to grasp and to communicate than *meta*-analytic clinical trial information, such as "15.6% of unvaccinated participants versus 9.9% of vaccinated participants developed [influenza like illness (ILI)] symptoms, whilst only 2.4% and 1.1%, respectively, developed laboratory-confirmed influenza." [22].

This does not imply that it is advisable and sufficient to communicate the more easily comprehensible CDC recommendations (that are based on the scientific evidence), rather than communicating the scientific evidence itself. Given the goal of fully informed

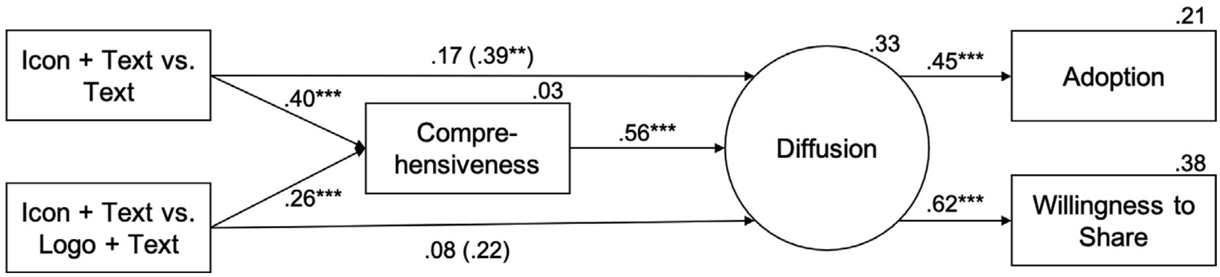

Fig. 4. SEM of the Mediation of Experimental Effects of the Icon Array on Message Diffusion by Comprehensiveness. *Note.* Comprehensiveness mediates experimental effects when comparing the icon array and the text only conditions ($\beta y = 0.22$, $p \leq 0.001$, [0.12; 0.35]) and when comparing the icon-array and the Cochrane logo conditions ($\beta_y = 0.15$, $p = .006$, [0.05; 0.26]). The experimental effects are dummy coded (icon array condition 0, logo and text only −1, respectively), all other variables are standardized (total effects in parentheses). R^2 is presented on the upper right corner of predicted variables. SEM fit: $\chi^2(2) = 11.275$, $p = 0.2673$, *CFI* = 0.995, *RMSEA* = 0.021 [0; 0.078].

decisions and a potential science-skeptical societal environment, conveying the underlying scientific evidence in a transparent fashion must remain a central goal of science and health communication [18]. Importantly, the results from our second study show that there does not need to be a trade-off between easily comprehensible and communicable information on the one hand, and conveying the details necessary for individuals to make fully informed decisions and justifying vaccination recommendations on the other. Rather, if the scientific evidence is made transparent, as shown here by the means of an icon array, this information is more comprehensible for people, they are more willing to share it, and rate it as more trustworthy and more persuasive. Thus, it is possible to convey more complex, but also more relevant information without decreasing the intention to seek a treatment (see also [16,23,24]).

In addition, icon arrays may circumvent transparency issues arising from different statistical expressions of the same vaccine effectiveness information. For instance, the cited effectiveness information derived from the Cochrane *meta*-analysis [22] on laboratory-confirmed flu can alternatively be expressed as a relative risk reduction (51.7%), an absolute risk reduction (1.2% points), a number needed to treat (82), or an odds ratio (0.47) (see [26], for the links between these measures). Whereas the relative risk reduction appears quite vaccine-favorable, reporting the number needed to treat may render the same information less convincing to laypeople. For full transparency, therefore, it is advisable to communicate the complete contingency information, for both the vaccination and the control group, illustrating both the relative risk reduction (by comparing the proportional difference between the vaccinated and the non-vaccinated) as well as the absolute risk reduction (by comparing the absolute difference). All this information is contained and visualized in the icon array [23,27–29]. As an additional benefit, Fagerlin, Wang and Ubel [30] showed experimentally that undue effects of narratives on medical decision-making could be alleviated if accompanied with icon arrays representing the actual effectiveness of two measures.

As a potential limitation, this study only included icon arrays on the effectiveness information of vaccines. We omitted an icon array on the vaccine's safety, because the data from the *meta*-analysis used here showed no evidence for an association with serious vaccine-adverse events [22]. Moreover, the effect sizes and transmission rates in open text field of the full information were relatively small, leaving much room for improvements of the display of transparent vaccination trial information and for further facilitating informed medical decision making for vaccines in online communication. However, given that we emulated the diffusion of online messages, even small effects could have a large impact on a societal level that is hard to gauge on the basis of our limited, self-reported data. Additionally, we may expect higher positive effects on the evaluation of vaccines when reporting higher effectiveness values than those of the flu vaccine that were reported in the current study.

5. Conclusion

In conclusion, simple statements (as proliferated by the CDC) seem to diffuse most effectively in online settings, whereas facts on clinical evidence (i.e., scientific results) are shared to a much lesser degree. A central barrier seems to be the comprehensibility of scientific information. As a potential remedy, icon arrays that explain clinical evidence in a transparent fashion may contribute to a better understanding and a higher proliferation of this relevant, but also more complex information. In addition, the higher transparency of icon arrays may further increase trust in scientific communication on vaccinations and thereby foster the promotion of effective vaccines.

6. Authors' contributions

All authors contributed to the conceptual development of the work. Helge Giese programmed the studies, and collected the data. H.G. analyzed and interpreted the data with critical inputs from Hansjörg Neth and Wolfgang Gaissmaier. H.G. produced the first draft. All authors provided critical revisions and approved the final version.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: [Wolfgang Gaissmaier has received honoraria for lecturing/consultation from Amgen, Bayer, Biogen, Celgene, Genzyme, Merck Serono, MSD, Mundipharma, Novartis Pharma, Roche, Sanofi, and Teva, as well as research support from Biogen].

Acknowledgements

This work was supported by the German Research Foundation [DFG] under Grant FOR 2374 (DFG Research Unit), the project Grant Number 441541975, and under Germany's Excellence Strategy—EXC 2117—422037984. We would like to thank Larissa Baer and Joachim Gassert for their support in rating the material.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2021.09.016.

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