




ARTICLE

How to debunk misinformation? An experimental online study investigating text structures and headline formats

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Abstract

Objectives: Misinformation is a crucial problem, particularly online, and the success of debunking messages has so far been limited. In this study, we experimentally test how debunking text structure (truth sandwich vs. bottom-heavy) and headline format (statement vs. questions) affect the belief in misinformation across topics of the safety of COVID vaccines and GMO foods.

Design: Experimental online study.

Methods: A representative German sample of 4906 participants were randomly assigned to reading one of eight debunking messages in the experimentally varied formats and subsequently rated the acceptance of this message and the agreement to misinformation statements about the mentioned topics and an unrefuted control myth.

Results: While the debunking messages specifically decreased the belief in the targeted myth, these beliefs and the acceptance of the debunking message were unaffected by the text structures and headline formats. Yet, they were less successful when addressing individuals with strong pre-existing, incongruent attitudes and distrust in science.

Conclusions: The risk of backfire effects in debunking misinformation is low. Text structure and headline format are of relatively little importance for the effectiveness of debunking messages. Instead, writers may need to pay attention to the text being comprehensive, trustworthy and persuasive to maximize effectiveness.

Helge Giese and Laura M. König contributed equally.

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KEYWORDS

attitude, communication, Covid-19, genetically modified food, vaccination

Statement of contribution***What is already known on this subject?***

- Debunking messages need to be carefully crafted to not accidentally strengthen belief in misinformation.
- Presenting corrective information first and last in a text may reduce the likelihood of this backfire effect.
- Also, headline formats may impact perceived credibility.

What does this study add?

- This study provides an empirical test of superiority of two text structures and headline formats to debunk misinformation.
- Belief in health-related misinformation can be reduced through short written communication.
- Test structure and headline format do not impact effectiveness of the refutation message.

BACKGROUND

Overcoming current global challenges, including the COVID-19 pandemic and climate change, is hindered by the rapid spread of misinformation via social media and other sources (e.g., Imhoff & Lamberty, 2020; Nakov et al., 2021). To counteract this development, high-quality science communication addressing these myths in public media is imperative. One way of doing so is to correct misinformation by debunking messages, yet the success of such attempts is mixed and highly dependent on the quality and content of such messages (van der Linden, 2022).

To weaken instead of accidentally strengthening existing agreement to misinformation, debunking refutation messages thus need to be carefully designed and advice to do so is manifold (Paynter et al., 2019; Pluviano et al., 2019; see also Lewandowsky et al., 2012 for a discussion). For instance, refutation messages should include an explanation on why the myth is incorrect (Ecker et al., 2020), provide an alternative causal explanation for a false belief and make the corrective statement more salient (Paynter et al., 2019). However, there is still a lack of research comparing different debunking strategies on their effect on misperceptions in detail (van der Linden, 2022). Therefore, the present study focuses on the impacts of different text structures and headline formats of such refutation texts on the belief of misinformation.

The impact of text structure

Several guidelines on refuting misinformation (e.g., Lewandowsky et al., 2020, 2021) recommend the ‘truth sandwich’ text structure, which consists of two blocks with correct information bordering a middle block containing and explicitly debunking the misinformation. This recommendation is based on the theoretical assumption that presenting the misinformation at the beginning or end of a debunking message may backfire and strengthen the belief in the misinformation due to primacy and recency effects and thus should be avoided (Swire-Thompson et al., 2020; see Kenix & Manickam, 2020, for a summary).

However, it is debated whether a familiarity-based backfire effect of debunking information generally exists (Ecker et al., 2022) and research contrasting the effectiveness of the truth sandwich format is scarce (Swire-Thompson et al., 2020). In practice, the truth sandwich format is not yet widely adopted and ‘bottom-heavy’ texts that present the myth at the beginning followed by one or more blocks of debunking information are more common in public media (Kenix & Manickam, 2020). These ‘bottom-heavy’ texts incorporate some of the principles for refutations found in misinformation literature, such as offering an alternative explanation and giving an emphasis on the facts without reinforcing the myth (Lewandowsky et al., 2012). König (2023) showed that debunking messages in a truth sandwich structure were successful, but did not contrast this structure with other potential set-ups of the format. In a direct comparison, Anderson et al. (2019) did not find differences in effectiveness between ‘truth sandwich’ and ‘bottom-heavy’ structure, but the sample size and lack of representativeness of the sample limit both its generalizability and the ability to infer no effect based on the achieved power. Therefore, the current study aims to test experimentally with a sufficiently powered and representative sample whether the truth sandwich is a more effective debunking message structure compared to a bottom-heavy one. Accordingly, we hypothesized that the agreement with misinformation will be lower and the evaluation of the text as well as its perceived social impact will be rated higher if the participants read a debunking message with a truth sandwich format.

The impact of the headline

In addition, the headlines of the debunking messages may also play an important role in refuting misinformation. Information presented in headlines may result in a bias in the readers' memories of and reasoning about information presented in the text of news articles (Ecker et al., 2014; Pennycook & Rand, 2021). Furthermore, perceived credibility and the extent to which the text is considered informative may be influenced by the format of the headline: questions could be considered as less credible and informative than statements (Janét et al., 2022; Scacco & Muddiman, 2016). Finally, the headline may impact acceptance and sharing of articles and information (Pennycook & Rand, 2021). Thus, their influence on the effectiveness of debunking texts should be further scrutinized. In this study, we hypothesized that the agreement with misinformation will be lower and the evaluation of the text as well as its perceived social impact will be rated higher if the participants read a debunking message with a statement headline.

Individual characteristics influencing the effectiveness of debunking interventions

Furthermore, writers of debunking messages need to be aware of the readership of the message: For instance, people that distrust science (e.g., Agle & Xiao, 2021) or already hold beliefs and attitudes consistent with a misinformation should be particularly susceptible to this misinformation, because these subpopulations are more likely exposed to the misinformation in homophilic social networks (e.g., Del Vicario et al., 2016; Zollo et al., 2017) and more readily accepting it for confirming their prior intuitions (e.g., Giese et al., 2021; Schmid & Betsch, 2019). Accordingly, a successful debunking message should be particularly geared towards convincing these susceptible subgroups and not just the general public, even if this could be particularly difficult as the qualities that increase the impact of the misinformation may also decrease the effects of a potential debunking message (e.g., Walter & Tukachinsky, 2020; Zollo et al., 2017). In exploratory analyses of this study, we therefore expect that the participants' trust in science as well as their attitude towards the debunking topic are negatively associated with agreement to the misinformation and positively associated with the evaluation and perceived social impact of the text.

Current study

In this study, we aim to systematically investigate the success of headline format (question vs. statement) and text structure (truth sandwich vs. bottom-heavy) of debunking messages. Because patterns may vary by outcomes (e.g., Pennycook & Rand, 2021), we evaluate the success of the debunking messages on the agreement to misinformation as well as acceptance of the debunking texts and their perceived social impact. Beyond the general success of the debunking message to the specific myth, we expect that statement headlines and truth sandwich formats are better suited to debunk the respective myths. Furthermore, we are interested in whether the success of the messages in debunking the myth is mediated by the acceptance of the presented message as the quality of the information presented in the text is an important factor for successful debunking messages (van der Linden, 2022). Finally, we tested whether trust in science and general attitudes towards the topics moderated the experimental effects. Research questions and hypotheses as preregistered under König et al. (2022a) are listed in Table 1.

In the debunking texts, we chose to address two topics that were frequently discussed in the media at the time that the study was conducted, that is, the Covid-19 vaccination and genetically modified foods. Both may induce relatively high risk perception in the general public due to them being novel technologies (mRNA/ CRISPR-Cas; Slovic et al., 1980). Due to a lack of knowledge about these novel technologies and the potential direct impact of human health since modified substances are taken up by the body, desire to obtain information to relieve feelings of uncertainty may be especially high. At the same time, misinformation about both technologies is already circulating among the public that can and should be targeted in a debunking intervention (e.g., Loomba et al., 2021; Wang & Song, 2020).

METHODS

Sample

Participants were recruited via the ZPID PsychLab platform. Eligible participants had to be at least 18 years old and be able to read and write German. To reliably detect small effects (Cohen's $d=.2$) in paired comparisons with independent samples t -tests ($\alpha=.008$ due to six planned comparisons; $1-\beta=.8$), a total sample of $N=4904$ (determined with G*Power 3.1; Faul et al., 2007) or $n=613$ participants per group were required.

In total, $N=10,116$ potential participants started the survey. Throughout the survey, $n=689$ participants withdrew. Quotas (see König et al., 2022a) were used to obtain a representative sample for the German population in gender, age (Bund-Länder Demografie Portal, 2023), level of education (OECD, 2021) and household income (Bundeszentrale für Politische Bildung, 2020). Once the quotas were filled, additional participants fulfilling these criteria were rejected ($n=4267$; see Figure 1 for reasons). Participants were also ineligible if they indicated to be younger than 18 years of age ($n=28$), and were excluded if they failed two attention checks ($n=223$). Finally, three participants took part in the study twice; only their first attempt was taken into account. This yielded a final sample of $N=4906$ and $n=613$ for each of the eight experimental conditions except for one condition with $n=615$.

Study design

The current study uses a 2 *Text Structure* (truth sandwich vs. bottom-heavy format) \times 2 *Headline Format* (question vs. statement) \times 2 *Debunk Topic* (COVID-19 vaccines vs. GMO food) between-subjects experimental design. Accordingly, participants were assigned randomly to one out of eight groups. The primary outcome, agreement to misinformation, contrasted three *Myth Topics* (Vitamin C vs. COVID-19 vaccines vs. GMO food) within participants, while the secondary outcomes, evaluation of the presented

TABLE 1 Overview of research questions and related hypotheses tested in this study.

Research question	Hypotheses
Do text structure and headline format impact the agreement with the targeted misinformation?	<ul style="list-style-type: none"> • The agreement with the misinformation will be lower when directly addressed as a topic of the debunking article (vs. when it is not addressed) • The agreement with the misinformation will be lower if participants read a text in the truth sandwich format (vs. the bottom-heavy format) and when participants read an article with a statement headline (vs. a question headline)
Are there differences in how the articles are evaluated depending on their structure and the headline format?	<ul style="list-style-type: none"> • The overall evaluation of the presented information will be more positive (i.e., mean of comprehensiveness, trustworthiness and persuasiveness will be higher) when participants read a text in the truth sandwich format (vs. the bottom heavy format) and when participants read an article with a statement headline (vs. a question headline) • The article will be evaluated as more comprehensible, trustworthy, and persuasive when participants read a text in the truth sandwich format (vs. the bottom heavy format) • The text will be evaluated as more comprehensible, trustworthy, and persuasive when participants read an article with a statement headline (vs. a question headline)
Are there differences in the perceived social impact of the articles depending on their structure and headline format?	<ul style="list-style-type: none"> • The perceived social impact (i.e., mean of mentioning the information in personal communication and sharing the information on social media) will be higher when participants read a text in the truth sandwich format (vs. the bottom heavy format) and when participants read an article with a statement headline (vs. a question headline) • The perceived social impact, defined as being mentioned in personal communication/ being shared on social media, will be higher when participants read a text in the truth sandwich format (vs. the bottom heavy format) • The perceived social impact, defined as being mentioned in personal communication/being shared on social media, will be higher when participants read an article with a statement headline (vs. a question headline) • We explore whether the social impact (assessed by individual items and mean value) differs depending on the text structure
Does the evaluation of the article mediate the relationship between text structure/ headline format and agreement with the targeted misinformation?	<ul style="list-style-type: none"> • We explore whether the experimental effects of the structure and heading on the agreement to the misinformation will be mediated by the overall evaluation of the presented article
How does general trust in science and general attitudes of the targeted topic affect the effectiveness of the structures and headline formats?	<ul style="list-style-type: none"> • It is expected that Trust in Science is negatively associated with the agreement to the misinformation and positively associated with the overall evaluation of the debunking article and its perceived overall social impact • It is expected that the negative association of Trust in Science with the agreement to the misinformation is decreased, if the misinformation is the topic of the debunking article and the debunking text is presented in a sandwich format • It is expected that the positive association of Trust in Science with the overall evaluation of the debunking article and the overall perceived social impact is decreased when presented in a sandwich format • It is expected that attitude towards the topic is negatively associated with the agreement to the topic-specific misinformation and positively associated with the overall evaluation of the debunking article and its perceived overall social impact • It is expected that this negative association of attitude with the agreement to the misinformation is decreased, if the misinformation is the topic of the debunking article and the debunking text is presented in a sandwich format • It is expected that the positive association of the attitude with the overall evaluation of the debunking article and the overall perceived social impact is decreased when presented in a sandwich format

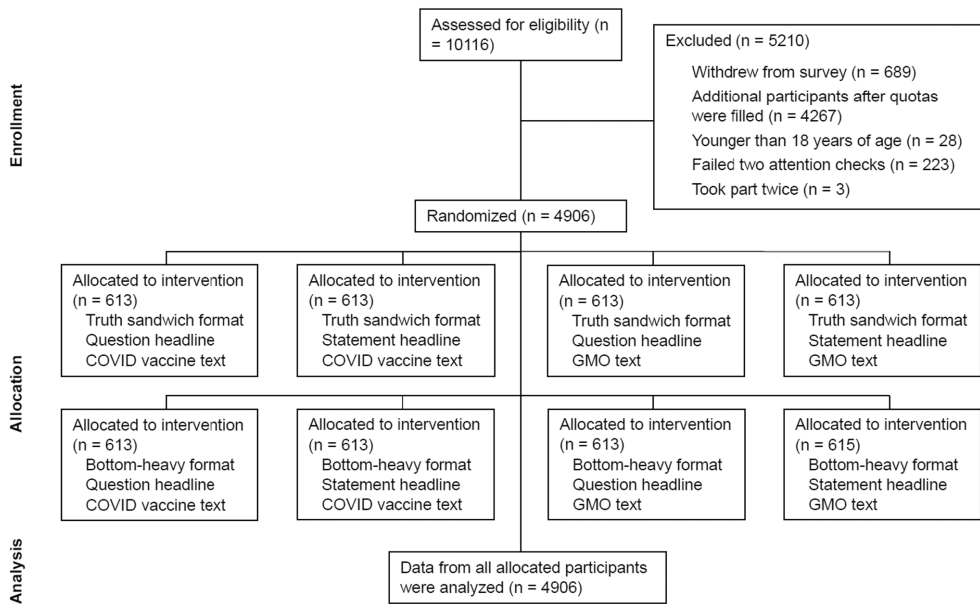


FIGURE 1 Flowchart with exclusion criteria for participants and allocation to the eight experimental conditions.

information and perceived social impact of the debunk message, varied by the *Debunk Topic* presented to the participants.

Procedure

This study received ethical approval by the Ethics Committee of the University of Bayreuth. Participants were recruited via an agency that distributed the link to the survey. First, participants provided informed consent by ticking a box. They then indicated basic demographic information, followed by trust in science and attitude towards genetically modified crops and vaccinations. Afterwards, participants were randomly assigned to one of the eight experimental groups. They read the debunking text that they were randomly assigned to and then evaluated the information of this message and its perceived social impact. Agreement to misinformation statements was assessed before participants were debriefed and redirected to the recruitment platform for payment. Throughout the survey, we implemented forced responses to ensure that participants give a response for all items and no missing values occurred.

Materials and measures

The questionnaires (original German version and translated English version) are available from König et al. (2022b) (see <https://doi.org/10.23668/psycharchives.5372>). The reliabilities of the scales are presented in Table 2.

Experimental manipulation: debunking texts

The four debunking texts used were structured according to recommendations provided for debunking misinformation (Lewandowsky et al., 2020). Furthermore, the structure and length of the texts were based on a previous study by König (2023) where texts in truth sandwich format have shown to be

successful at debunking myths. To ensure that the bottom-heavy texts were identical to the truth sandwiches in all aspects except the structure, the paragraphs of the truth sandwich texts were restructured so that the first paragraph (instead of the second) listed the myth. All texts contained approximately 200 words and can be found in the [Supplementary Material](#).

With regards to content, the texts about COVID-19 vaccines were based on fact-checking websites of the German Federal Ministry of Health (Bundesministerium für Gesundheit, 2023) and the Federal Institute for Vaccines and Biomedicines (Paul-Ehrlich-Institut, 2022). The texts about GMO foods were based on fact-checking websites of the US Food and Drug Administration (2022) and the Alliance for Science of the Boyce Thompson Institute (n.d.).

Primary outcome: agreement to misinformation

Participants indicated the degree of agreement to six statements on a 7-point Likert scale from 1 ('I do not at all agree') to 7 ('I fully agree'). For each topic, we provided one positive item (misinformation statement, e.g., 'Food produced from genetically modified crop plants is harmful to health') and one negative item (correct statement, e.g., 'The safety of food from genetically modified crops has been adequately tested in the EU'). The negative items were recoded for the analyses.

Secondary outcomes

Evaluation of the text was assessed with three items assessing how comprehensive, trustworthy and convincing the information is on a 7-point scale from 1 ('very incomprehensible/untrustworthy/unpersuasive') to 7 ('very comprehensible/very trustworthy/very persuasive') (Giese et al., 2021).

Perceived social impact was assessed with two items on a 7-point Likert scale adapted from previous research (Giese et al., 2021). The two items assessed whether participants would share the information in the text when talking to other people and whether they would share them on social media on a scale from 1 ('no, definitely not') to 7 ('yes, definitely').

Moderators

Trust in science was measured with three items assessing general trust in research, trust in researchers at universities and trust in researchers in the health sector on a 5-point Likert scale from 1 with 'I do not trust at all' to 5 with 'I trust completely' (Wissenschaft im Dialog/Kantar, 2021).

Attitude towards GMOs and vaccinations were each assessed with three items on a semantic differential scale from 1 to 7 with the poles 'harmful-beneficial', 'unpleasant-pleasant' and 'bad-good' based on the attitude construct in the Theory of Planned Behaviour (Conner & Sparks, 2005) and on items used in previous research regarding attitudes towards vaccination (e.g., Giese et al., 2020).

Data analysis

We used R-4.1.3 with packages 'afex' (Singmann et al., 2022) for conducting ANOVAs and exploratory GLMs, 'emmeans' (Lenth, 2022) to compute paired comparisons, 'lavaan' (Rosseel, 2012) to compute path models and 'stats' for linear regression analyses. The researcher conducting the preregistered analyses was blinded to the independent variables to reduce bias. The analysis plan is outlined in detail in König et al. (2022a).

Age was assessed with an open text box and slider (from 0 to 100 years); this led to $n=195$ participants (4%) to indicate that they were 100 years old, which is highly unlikely given the distribution of age in the

TABLE 2 Descriptive statistics of study variables for the full sample (N = 4906).

Variable	M	SD	4	5	6	7	8	9	10	11	12	13
1. Age	47.64	18.28	-.04**	-.03*	.10**	-.07**	.04*	-.08**	.01	.00	.14**	-.14**
2. Proportion of female participants	.50		.07**	.05**	.02	.01	-.04	-.03	-.06**	-.04**	-.08**	-.06**
3. Years of education	14.43	2.77	.02	-.17**	-.09**	.11**	.14**	.04	.09**	.27**	.13**	.06**
4. Agreement with misinformation (Vitamin C)	4.51	1.2	.31** ^a	.12**	-.01	.07**	-.08**	.06**	-.05*	.00	-.07**	-.01
5. Agreement with misinformation (COVID)	3.3	1.66	.58** ^a	.32**	-.28**	-.14**	-.02**	-.43**	-.47**	-.52**	-.20**	
6. Agreement with misinformation (GMO)	3.76	1.32	.53** ^a	-.59**	-.28**	-.39**	-.22**	-.31**	-.22**	-.31**	-.27**	-.55**
7. Evaluation of the text (GMO)	5.04	1.26	.81 ^b	-.54**	-.33**	-.40**	-.44**	-.44**	-.44**	-.44**	-.44**	-.44**
8. Evaluation of the text (COVID)	5.28	1.36	.84 ^b	-.54**	-.33**	-.40**	-.44**	-.44**	-.44**	-.44**	-.44**	-.44**
9. Perceived social impact (GMO)	3.34	1.54	.51** ^a	-.26**	-.19**	-.19**	-.19**	-.19**	-.19**	-.19**	-.19**	-.19**
10. Perceived social impact (COVID)	3.77	1.65	.52** ^a	-.39**	-.39**	-.39**	-.39**	-.39**	-.39**	-.39**	-.39**	-.39**
11. Trust in science	3.78	.80	.90 ^b	.48**	.48**	.48**	.48**	.48**	.48**	.48**	.48**	.48**
12. Attitude towards vaccination	5.43	1.31	.85 ^b	.22**	.22**	.22**	.22**	.22**	.22**	.22**	.22**	.22**
13. Attitude towards GMOs	3.5	1.67	.95 ^b									

^aPearson's correlation coefficient between two items as measure of internal consistency.

^bMcDonald's ω as measure of internal consistency.

^cEvaluations and perceived social impact were assessed between conditions, thus no correlation can be reported.

German population (Bund-Länder Demografie Portal, 2023). We thus present analyses for the full sample ($N=4906$) in text as preregistered; in addition, we report results for participants who indicated to be between 18 and 99 years of age ($N=4711$) in [supplementary data analysis](#) files provided in König et al. (2022c).

To test whether text structure and headline format impacted agreement to misinformation, a mixed 2 *debunk topic* \times 2 *text structure* \times 2 *headline format* \times 3 *myth topic* ANOVA was conducted. The within factor *myth topic* was dropped for the evaluations of the debunking texts. For mediation analyses, we used 10,000 bias-corrected bootstrap confidence intervals, effect-coded factors and ζ -standardized outcomes, all in accordance with the preregistration.

In addition to these preregistered analyses, we exploratively report correlations between the variables and explored the differential effectiveness of the debunking messages by adding standardized (a) trust in science or (b) attitudes towards the respective topic and all their interactions with the experimental factors to the mixed ANOVA, yielding a GLM.

RESULTS

Sample description

Participants were on average 47.6 ($SD=18.3$) years old.¹ Two thousand four hundred and sixty-two participants (50.2%) indicated to be men, 2435 indicated to be a woman (49.6%) and nine indicated their gender to be diverse (.2%). The mean years of education were 14.4 ($SD=2.8$) years and the median household income was from 2600€ to less than 3600 € with an interquartile range of three income categories. Descriptive statistics for the full sample are listed in [Table 2](#). The associations between demographic information and study variables were generally small. Most notably, trust in science was higher for the more educated participants.

Is the agreement to the myths affected by the debunking texts?

Overall, there were general differences in the agreement to the three myth topics across manipulations (*myth topic*: $F(1.95, 9556.51)=1139.87, \eta_p^2=.189, p<.001$) and in reaction to the debunk topic (*debunk topic*: $F(1, 4989)=10.71, \eta_p^2=.002, p=.001$) illustrated by the respective main effects. Furthermore, the debunking messages were successful in specifically addressing the targeted myths (*debunk topic* \times *myth topic*: $F(1.95, 9556.51)=219.70, \eta_p^2=.043, p<.001$) as expected showing that the texts were successful at addressing the specific belief: While agreement with the control statements about Vitamin C was not differentially affected by the two debunking messages ($b=.01, t(4898)=.382, p=.7026, d=.01$), agreement to misinformation about the COVID-19 vaccine was decreased by the text about the vaccine compared to the text about GMOs ($b=-.41, t(4898)=-8.673, p<.001, d=-.25$), and vice versa ($b=.66, t(4898)=17.904, p<.001, d=.51$).

However and unexpectedly, *text structure* did not yield any significant effects on agreement to misinformation (all effects involving text structure: $F\leq 1.96, \eta_p^2<.001, p\geq .142$). Similarly, the *headline format* statement only slightly increased effectiveness of the fitting debunking message with an irrelevant effect size (*headline format* \times *debunk topic* \times *myth topic*: $F(1.95, 9556.51)=3.19, \eta_p^2<.001, p=.043$, see [Figure 2](#)). Accordingly, planned contrasts yielded no meaningful differences beyond these effects (see [Supplementary Material](#)).

To what an extent are the two debunking texts differentially perceived based on text structure and headline format?

Regarding the general evaluation of the debunking texts, the text addressing the COVID-19 vaccine ($M=5.28, SD=1.36$) was generally more accepted than the text addressing GMOs ($M=5.04, SD=1.26$;

debunk topic: $F(1, 4989) = 43.99, \eta_p^2 = .009, p < .001$) with no other statistically significant effects (all $F(1, 4989) \leq 2.36$, all $\eta_p^2 > .001, p \geq .124$). This effect of the *debunk topic* was also present for the specific items trustworthiness ($F(1, 4989) = 73.27, \eta_p^2 = .015, p < .001$), persuasiveness ($F(1, 4989) = 53.50, \eta_p^2 = .011, p < .001$), but not for comprehensiveness ($F(1, 4989) = .59, \eta_p^2 < .001, p = .443$) of the texts. No other effects emerged on the item level (all $F(1, 4989) \leq 3.51$, all $\eta_p^2 < .001, p \geq .061$).

Similarly, the willingness to share the text about the COVID-19 vaccine ($M = 3.77, SD = 1.65$) was higher than that of the text about GMOs ($M = 3.34, SD = 1.54$) for the aggregate measure ($F(1, 4989) = 88.50, \eta_p^2 = .018, p < .001$), as well as for the specific items (personal communication: $F(1, 4989) = 90.77, \eta_p^2 = .018, p < .001$, social media: $F(1, 4989) = 47.62, \eta_p^2 = .010, p < .001$). For the willingness to share the debunk in personal communication, there was some indication that the question headline format was more successful in a truth sandwich text structure ($F(1, 4989) = 4.13, \eta_p^2 < .001, p = .042$). However, the effect was negligibly small, and no other effects were found in any of the willingness to share outcomes (all $F(1, 4989) \leq 2.74$, all $\eta_p^2 < .001, p \geq .098$).

How are the outcomes related to each other and do the texts differentially mitigate confirmation bias effects?

Overall, topic-specific message acceptance, willingness to share, disagreement with myth, attitude and trust in science were all positively associated with each other with medium to large effect sizes (see Table 2). Further, in line with the confirmation bias literature, additional exploratory analyses on the agreement to myths by text format revealed that both debunking texts were slightly less effective in people with low trust in science compared to high trust in science (*debunk topic* \times *myth topic* \times *trust*: $F(1.99, 9710.46) = 18.96, \eta_p^2 = .004, p < .001$) and incongruent vaccination attitudes compared to congruent ones (*debunk topic* \times *myth topic* \times *COVID attitude*: $F(1.96, 9483.53) = 8.93, \eta_p^2 = .002, p < .001$). Regarding GMO attitudes, the debunking message was slightly more effective in individuals with lower GMO attitudes compared to higher GMO attitudes (*debunk topic* \times *myth topic* \times *GMO attitude*: $F(1.96, 9483.53) = 6.09, \eta_p^2 = .001, p = .003$).

Given that the text structures and headlines had no relevant effects on outcomes, it is unsurprising that message acceptance did also not mediate any of these effects on agreement to the myth (all $|\beta_y| \leq .01$, all $p \geq .137$; for full mediation models including negligible direct headline effects, see the Supplementary Files provided in König et al., 2022c). Likewise, they did only mitigate effects of trust in science and attitudes on very select outcomes and in a negligible small size (all $|\beta| = .05$, all $p = .0082$, see Supplementary Files provided in König et al., 2022c, also for negligible small headline effects when controlling for covariates).

DISCUSSION

This study experimentally tested the effectiveness of different text structures and headline formats of debunking texts in a representative sample. There were no meaningful differences in text structure or headline format conditions regarding agreement to misinformation statements, evaluation of the text or perceived social impact. Since there is no experimental effect of text structure and headline format, a mediation by the evaluation of the text could also not be found in exploratory analyses. Still, participants agreed less with the misinformation for which they were presented with a text compared to the other two topics, indicating that all interventions were successful. The results thus support the notion that presenting correcting information in an intelligible way might be most important when debunking misinformation, while structural aspects of the presentation are of relatively little importance (Swire-Thompson et al., 2021).

Still, while both implemented structures were equally effective, both text structures ended with the debunking information and other structures ending with the myth may still suffer from backfire effects:

Previous studies that compared the effectiveness of truth sandwich and bottom-heavy texts to ‘top-loaded’ texts, which ended by presenting the myth, showed that such structures were indeed less successful in refuting misinformation than truth sandwiches or bottom-heavy texts (Anderson et al., 2019; see also Dai et al., 2021 for similar results). Accordingly, recency effects might have contributed to the factual information being remembered more easily in both text structures applied in the current study (Baddeley & Hitch, 1993). Therefore, we concur that debunking texts should not end with misinformation to avoid strengthening, instead of reducing, belief in myths.

In comparison to the structure of the text, its perceived acceptance and social impact of the study were much more relevant for the success of the debunking message. This indicates that the content of the message needs to be carefully crafted and the quality of the information has more impact than formal structure (van der Linden, 2022).

Furthermore, participants' personal characteristics were related to agreement to misinformation and the debunking message: participants with lower trust in science or more negative attitudes towards the targeted topic showed stronger agreement to the misinformation and lower acceptance of the debunking message. These findings are in line with previous studies indicating that, for instance, perceptions of messages about such sensitive topics like vaccination are very strongly linked to pre-existing attitudes and reluctant to change by information that is contradicting these attitudes (Giese et al., 2020, 2021). Furthermore, trust in science was an important predictor for accepting and adopting protective measures and health messages during the COVID-19 pandemic (Dohle et al., 2020). This highlights that debunking messages should be particularly targeted and tailored to distrusting individuals that are also more susceptible to misinformation. For instance, this group may be more accepting of messages that also disclose uncertainties and evidence quality (Kerr et al., 2022). In addition, previous research has found identity-affirming tasks before presenting corrections to be effective for developing more accurate beliefs especially when corrections contradicted existing attitudes (Carnahan et al., 2018). Future studies could therefore assess the effectiveness of such self-affirming tasks to overcome pre-existing attitudes when debunking myths with refutation texts that might be worldview-threatening. Targeting susceptible subgroups with effective debunking texts is essential because those groups are making informed decisions based on false information that may have direct consequences either on the healthcare system in the case of COVID vaccines or on global food security in the case of GMOs.

Similarly, and in line with previous research (Walter & Tukachinsky, 2020), the debunking message was less successful in reducing beliefs in misinformation if participants' trust in science was low or attitudes towards vaccinations were negative. Nevertheless, it is important to note that the debunking information did not backfire and cause reactance even in these groups holding beliefs consistent with the misinformation, but just reduced agreement to the misinformation to a lesser degree (Swire-Thompson et al., 2020). Conversely, the effect that the GMO debunking message was more successful in people with low GMO attitudes—while dependent on controlling for vaccination attitudes—may be regarded as an indication that losses in debunk effectiveness may be situational (Schmid & Betsch, 2019), or alternatively that debunking messages can only affect people that initially believed the misinformation to some extent.

Other effects were comparable between topics of the debunking message. However, agreement to misinformation about GMOs was stronger than agreement to misinformation about the COVID-19 vaccination. Genetically modified crops are discussed as an important factor for reducing greenhouse gas emissions and combating world hunger by increasing yield per acre. A debate is ongoing whether organic farming should employ GMOs (e.g., in breeding) to achieve the United Nations' Sustainable development goals rather than prohibiting them as it is currently practiced (Purnhagen et al., 2021). This study supports previous research indicating that public perception of GMOs is distorted and GMOs are seen as unnatural even though research underlines that GMOs bear no additional risks to human health (Siegrist et al., 2016) and highlights the need for more targeted communication regarding GMO foods being safe to eat. To assess the impact of this naturalistic bias on the acceptance of debunking messages, future research could compare effects in groups who believe that the COVID-19 outbreak

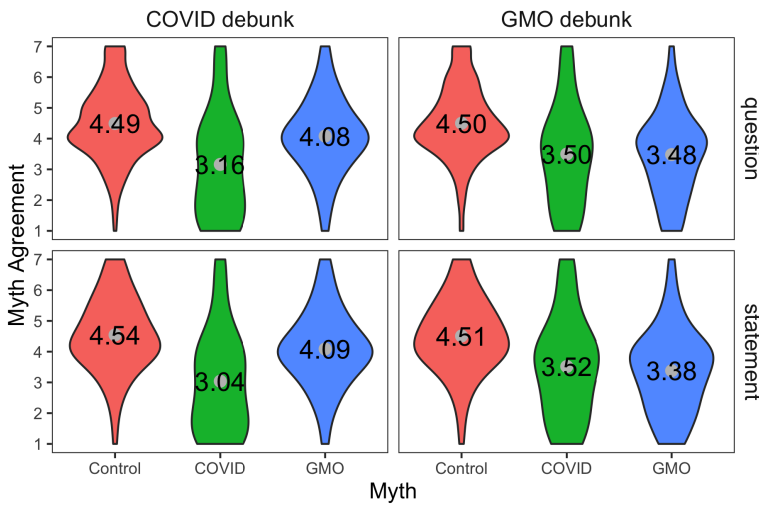


FIGURE 2 Agreement to myths depending on the presented debunking text and headline format. Grey dots indicate means; outlines depict the distribution of the data.

had natural causes with groups who believe that it had unnatural origins such as being crafted in a lab (c.f., van Mulukom et al., 2022).

Other possible explanations for a difference in acceptance of the texts could be that the perceived affective risk of COVID-19 infections might already have been lower at the time of data collection than in the earlier phases of the pandemic (COSMO - COVID-19 Snapshot Monitoring, 2022a, 2022b). Furthermore, the vast majority of the German population was vaccinated and fear of COVID-19 vaccines was rather low in this group during the time of data collection (COSMO - COVID-19 Snapshot Monitoring, 2022a, 2022b). This could have resulted in a higher acceptance of debunking texts about COVID-19 vaccines and a higher willingness to share this information. This is also mirrored in the fact that belief in misinformation related to GMOs was stronger than belief in misinformation related to the COVID-19 vaccination, and that the sample held more positive attitudes towards the COVID-19 vaccination compared to GMOs.

The results of this study are based on a large, nationally representative sample for Germany. The study procedure and data analysis plan were preregistered prior to data collection, and the data analyst was blinded to the conditions. Nonetheless, some limitations need to be acknowledged. Most importantly, the study was cross-sectional and thus cannot provide insights into changes over time. A meta-analysis suggests that even after being exposed to the correction of misinformation, the misinformation has a continued impact (Lewandowsky et al., 2012). Even though the debunking messages showed an immediate effect on the agreement with misinformation, this effect could be obliterated over time by the continued influence of the misinformation. Schmid and Betsch (2022) have shown that this might actually be the case with text-based refutations. Therefore, further research is needed to evaluate if different characteristics of debunking messages such as text structure and headlines can attenuate the influence of misinformation over a longer time period after the debunking occurred. Furthermore, influence on actual behaviour was not assessed; previous research suggests that people tend to make judgements based on false beliefs even after they have been exposed to debunking messages (Walter & Tukachinsky, 2020). It is furthermore important to note that the study was presented as a study conducted by a university research team, which may have been considered a credible source by most people (Hoogeveen et al., 2022; Wissenschaft im Dialog/Kantar, 2022). Since the source of the debunking message plays a role in the acceptance of the information (Ecker & Antonio, 2021), future studies could benefit from varying the source of the information presented to assess the impact of source credibility on the continued influence of misinformation over time especially for subgroups that are more susceptible to misinformation.

To conclude, both truth sandwich and bottom-heavy texts are suited to debunk misinformation, as are texts with both statement and question headlines. This experimental study indicates that the risk of strengthening, rather than weakening, belief in misinformation due to repeating myths in refutation attempts is low, at least as long as an explanation for why the claim is false is included (Swire-Thompson et al., 2020). Instead of focusing on the text structure and headline format, writers may need to pay attention to the text being comprehensive, trustworthy and persuasive to the reader for maximum effectiveness, for example, by avoiding aggressive language (König & Jucks, 2019) and highlighting scientific consensus and replication success if applicable (Bode et al., 2021; Hendriks et al., 2020).

AUTHOR CONTRIBUTIONS

Johannes Kotz: Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; writing – original draft. **Helge Giese:** Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; resources; supervision; visualization; writing – review and editing. **Laura M. König:** Conceptualization; data curation; funding acquisition; investigation; methodology; project administration; resources; supervision; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

All authors declare no conflict of interest.

OPEN RESEARCH BADGES



This article has earned Open Data, Open Materials and Preregistered Research Design badges. Data, materials and the preregistered design and analysis plan are available at <https://doi.org/10.23668/psycharchives.5373>.

DATA AVAILABILITY STATEMENT

The preregistration as well as all data and materials are publicly available from PscArchives: <https://doi.org/10.23668/psycharchives.5373>.

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ENDNOTE

¹ Age without participants who indicated to be 100 years old: $M = 45.5$, $SD = 15.2$.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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