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DEBUNKING MISINFORMATION ABOUT A CAUSAL LINK BETWEEN VACCINES AND AUTISM: TWO PREREGISTERED TESTS OF DUAL-PROCESS VERSUS SINGLE-PROCESS PREDICTIONS (WITH CONFLICTING RESULTS)

Bertram Gawronski, Skylar M. Brannon, and Nyx L. Ng
University of Texas at Austin

Dual-process and single-process theories lead to conflicting predictions about whether debunking messages negating a state of affairs should change responses on implicit measures in a manner intended by the message. Two preregistered studies (N_1 = 550; N_2 = 880) tested these predictions using official health information from the U.S. Centers for Disease Control and Prevention debunking the idea that vaccines would cause autism. Consistent with predictions derived from dual-process learning theories, Experiment 1 found that debunking-via-negation increased responses linking vaccines to autism on implicit measures, although it effectively reduced self-reported judgments linking vaccines to autism on explicit measures. Using the same measures and materials, Experiment 2 found that debunking-via-negation effectively reduced responses linking vaccines to autism on both implicit and explicit measures, consistent with predictions derived from single-process propositional theories. Potential reasons for the conflicting outcomes are discussed, including their implications for the debate between dual-process and single-process theories.

Keywords: associative processes, debunking, dual-process theories, misinformation, single-process propositional theories

Although measles was declared eradicated in the United States in 2000, the number of measles infections reached record levels in 2014, followed by even higher rates in 2019 (Patel et al., 2019). The resurgence of measles has been attributed to vaccine hesitancy, which the World Health Organization (2019) identified as a global health

The data and supplemental materials are available at https://osf.io/vn8gu/

Address correspondence to: Bertram Gawronski, Department of Psychology, University of Texas at Austin, 108 E. Dean Keeton, Austin, TX 78712. E-mail: gawronski@utexas.edu

threat that may undo the progress made in controlling communicable diseases. In the United States, this hesitancy is at least partly rooted in a controversial study that claimed to show a link between the measles, mumps, and rubella (MMR) vaccine and autism. Although the study was retracted 12 years after its publication (Eggertson, 2010) and numerous follow-up studies did not find any evidence for the presumed link (Taylor et al., 2014), the belief that vaccines can cause autism is still widespread. In response to the health threat posed by this belief, government agencies, media outlets, and social media giants have invested great efforts to debunk misinformation about the presumed dangers of vaccines.

In the current research, we used the presumed link between vaccines and autism as a real-world case to test competing predictions about the effectiveness of debunking in changing responses on explicit and implicit measures. Although single-process and dual-process theories share the prediction that messages negating a causal link between vaccines and autism should reduce self-reported beliefs about a link between vaccines and autism on explicit measures, they lead to conflicting predictions for responses on implicit measures. Utilizing original health messages from the U.S. Centers for Disease Control and Prevention (CDC), we investigated whether debunking messages negating a causal link between vaccines and autism would ironically enhance responses linking vaccines to autism on implicit measures, as suggested by dual-process theories that distinguish between associative and propositional learning mechanisms (Gawronski & Bodenhausen, 2006, 2011). This prediction was tested against the alternative possibility that messages negating a causal link between vaccines and autism would reduce responses linking vaccines to autism on implicit measures, as suggested by single-process propositional theories (De Houwer, 2018; De Houwer et al., 2020). The main goal of the current research was to test these conflicting predictions regarding the effectiveness of debunking messages in changing responses on implicit measures.

RANGE AND LIMITS OF DEBUNKING

A substantial body of research suggests that debunking of misinformation is often ineffective in eliminating effects of the debunked information (Chan et al., 2017; Lewandowsky et al., 2012). One explanation for this phenomenon is that debunking messages tend to repeat the to-be-debunked information, which increases the fluency of processing this information (Schwarz et al., 2007). Because people use the experienced fluency of processing information as a cue to judge its validity (Brashier & Marsh, 2020), debunking can have the ironic effect of strengthening people's belief in the debunked information (Skurnik et al., 2005). Such ironic effects can be exacerbated by the fact that negations of an idea require initial comprehension of the idea before it can be rejected (Gilbert, 1991). Because the latter step requires more cognitive effort compared to the initial comprehension of an idea, negations are often ineffective in eliminating the impact of a negated idea on judgments and decisions (Strack & Deutsch, 2004).

In the current research, we investigated a related, albeit distinct mechanism that could lead to ineffective debunking of misinformation. Some dual-process

theories suggest that mere co-occurrence of two stimuli automatically produces a mental association between the two in memory (Gawronski & Bodenhausen, 2006, 2011). Because negations involve a co-occurrence of stimuli whose relation is negated, automatic association formation can undermine the effectiveness of messages that negate a particular state of affairs. Applied to our thematic example, exposure to the message *vaccines do not cause autism* involves mere co-occurrence of the stimuli *vaccines* and *autism*, which may lead to ironic effects by reinforcing a mental association between the concepts *vaccines* and *autism*. Such ironic effects are assumed to occur even when message recipients update their beliefs in a way intended by the message.

According to dual-process learning theories that distinguish between associative and propositional mechanisms (Gawronski & Bodenhausen, 2006, 2011), such conflicting effects can be detected with a combination of explicit and implicit measures (for a review, see Gawronski & De Houwer, 2014). Whereas verbal self-reports on explicit measures are assumed to reflect propositional beliefs about states of affairs (e.g., the propositional belief *vaccines do not cause autism*), the performance-based scores derived from implicit measures are assumed to reflect mental associations that are activated automatically upon encountering a stimulus (e.g., an automatic association between *vaccines* and *autism*). These assumptions lead to the prediction that messages negating the idea that vaccines cause autism should strengthen automatic associations between vaccines and autism on implicit measures even when the messages are effective in reducing propositional beliefs about a causal link between vaccines and autism on explicit measures. This idea goes beyond prior research on debunking, which predominantly focused on the ineffectiveness of debunking messages in changing propositional beliefs on explicit measures (for reviews, see Lewandowsky et al., 2012; Schwarz et al., 2007).

Although dual-process theories have been highly influential (for reviews, see Chaiken & Trope, 1999; Gawronski et al., in press; Sherman et al., 2014), they have not gone unchallenged. Regarding the current question, a significant challenge is posed by single-process theories that reject the idea of automatic association formation (De Houwer, 2018; De Houwer et al., 2020). These theories have advanced the alternative hypotheses that (a) all learning effects arise from the generation and truth assessment of propositional beliefs about states of affairs and (b) stored propositional beliefs underlie responses on both explicit and implicit measures.[1] These hypotheses are consistent with an accumulating body of evidence (Corneille & Stahl, 2019; Kurdi & Dunham, 2020). For the current investigation, two relevant examples are studies suggesting that negations can be effective in reversing effects of negated information on implicit measures (e.g., Peters & Gawronski, 2011) and studies suggesting that effects of new information on implicit measures depend on

1. From the perspective of single-process propositional theories, dissociations between implicit and explicit measures could be accounted for by assuming that different propositional beliefs underlie responses on the two kinds of measures. Although we agree that some dissociations in the literature might be driven by differences in the measured contents, such cases tend to involve methodological confounds between measurement type and measured content that should be avoided because they undermine the interpretations of dissociations in terms of measurement type (for a discussion, see Gawronski, 2019).

the believability of the new information (e.g., Cone et al., 2019). Consistent with the assumptions of single-process propositional theories, these findings suggest that messages negating the idea that vaccines cause autism should reduce propositional beliefs about a causal link between vaccines and autism, and this effect should be reflected on both explicit and implicit measures.

EXPERIMENT 1

The main goal of Experiment 1 was to test the competing predictions derived from dual-process and single-process theories. Toward this end, participants were presented with official debunking information from the CDC explaining that there is no evidence for a causal link between vaccines and autism. Participants in a control condition were presented with information from the CDC on a health-relevant topic unrelated to vaccines and autism. After reading the article, participants in both conditions completed an explicit and an implicit measure regarding the link between vaccines and autism.

A secondary goal of Experiment 1 was to explore whether messages negating the idea that vaccines cause autism are more effective when they include additional information about true causes of autism. In line with this idea, some theories suggest that negations are more effective in reducing the impact of negated information when they are supplemented with information that specify an alternative state of affairs (e.g., Petty et al., 2007). To explore this possibility, Experiment 1 included an additional condition in which participants were presented with information from the CDC that debunked a causal link between vaccines and autism and provided further information on genetic factors as the primary cause of autism. Because dual-process and single-process predictions for this condition would depend on several auxiliary assumptions that go beyond their theoretical core assumptions, and because different sets of auxiliary assumptions would lead to different predictions, the effectiveness of debunking via alternative information was tested for purely exploratory purposes.

METHOD

Experiment 1 was preregistered prior to data collection at https://osf.io/ygp27/. The data were collected in June 2019 using Inquisit 4 Web by Millisecond. We report all data, all measures, and all experimental conditions. The data, analysis codes, and materials are available at https://osf.io/vn8gu/.

Participants and Design. Participants were recruited using Prolific Academic, a crowdsourcing platform that provides access to demographically diverse samples for psychological research (Peer et al., 2017). Due to the significance of the vaccine–autism debate in the United States, recruitment was limited to participants from the United States. To this end and to ensure data quality, eligibility for participation was restricted to Prolific members with the following qualifications: (a) age: 18+; (b) nationality: United States; (c) country of residence: United States;

(d) approval rate: 95%+; (e) number of previous submissions: >0. The study took approximately 10–12 minutes and participants received $1.50 compensation for their time. The study included a 3 (Message: neutral message vs. debunking-via-negation vs. debunking-via-alternative) × 2 (Measurement Order: implicit-explicit vs. explicit-implicit) × 2 (Measurement Type: implicit vs. explicit) factorial design with the first two factors varying between subjects and the last factor varying within subjects. Participants were randomly assigned to one of the three Message conditions and one of the two Measurement Order conditions via their Subject ID number, which was assigned sequentially via Millisecond's web script hosting service. Our desired sample size prior to exclusions was 600 participants, which provides a statistical power of 90% in detecting a small effect of $f = .09$ in testing the critical interaction between Message and Measurement Type (two-tailed). Following our preregistered protocol, data collection ended once 600 participants had been approved for payment on Prolific. Of the 640 cases in the original data file, 32 cases were from participants who did not complete the study until the end and 7 cases were from participants who started the study more than once. Of the remaining 601 participants in the data file,[2] 49 failed to pass an instructional attention check (see below) and 2 showed an error rate higher than 40% on the implicit measure (see below). Following our preregistered exclusion criteria, data from these participants were excluded from analyses, leaving us with a final sample of 550 participants (257 women, 281 men, 9 other, 1 prefer not to say, 2 missing). The age of participants in the final sample ranged from 18 to 76 years ($M = 34.36$, $SD = 12.63$).

Procedure. After providing informed consent, participants were presented with one of three health-related messages. Participants in the *neutral-message* condition were presented with an informational, non-debunking article from the CDC website on a topic that was unrelated to vaccines and autism (i.e., chronic obstructive pulmonary disease); participants in the *debunking-via-negation* condition were presented with an article adapted from the CDC website explaining that there is no evidence for a causal link between vaccines and autism; and participants in the *debunking-via-alternative* condition were presented with an article adapted from the CDC website explaining that there is no evidence for a causal link between vaccines and autism and that genetic factors are the true cause of autism. To provide information about the source of the presented information, the articles in the three conditions were presented with a CDC header at the top of the screen. Afterward, participants completed an explicit and an implicit measure assessing responses linking vaccines and autism. The order of the two measures was counterbalanced across participants. Finally, participants were asked to provide personal information in a demographic questionnaire, which included an instructional attention check to screen for participants who may not have read the materials (see below).

2. One participant completed the study without submitting a request for payment.

Measures. The explicit measure was a standard self-report measure, which asked participants to indicate their agreement with the following four statements: (a) *Vaccines cause autism*; (b) *Autism can be caused by vaccines*; (c) *Vaccination is unrelated to autism* (reverse coded); (d) *There is no connection between vaccines and autism* (reverse coded). For exploratory purposes, participants were also asked to indicate their agreement with the following four statements: (a) *Genetic mutations cause autism*; (b) *Autism can be caused by genetic mutations*; (c) *Genes are unrelated to autism* (reverse coded); (d) *There is no connection between genetic factors and autism* (reverse coded). Responses were measured with 7-point rating scales ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Each item was presented on a separate screen with the order of items being randomized.

The implicit measure was a sequential priming task in which participants were asked to identify target words as quickly as possible (Banaji & Hardin, 1996). On each trial, participants were presented with a fixation cross for 500 msec, followed by a prime word for 200 msec, which was replaced by a target word until participants made their response. The prime words were *vaccine*, *genetics*, and *desk*; the target words were *autism* and *health.* Participants were instructed to press the *E* key on their keyboard when they saw the word *autism* and the *I* key when they saw the word *health*. When participants correctly identified the target word, a blank screen appeared for 1,000 msec before the next trial started. When they incorrectly identified the target word, the word *ERROR!* appeared on the screen for 1,000 msec, followed by a blank screen for 1,000 msec before the next trial started. The task included 20 blocks of six trials with one trial for each of the six prime–target combinations, summing up to a total of 120 trials. The order of trials was randomized within each block.

At the end of the study, participants were asked to complete a series of demographic questions about their political ideology, party affiliation, gender, age, and ethnicity. These data were collected only for descriptive purposes and were not used in any of the preregistered analyses.

Attention Check. To screen for participants who may not have read the materials, the demographic survey at the end of the study included a one-item instructional attention check (Oppenheimer et al., 2009). Participants were presented with the following text:

> Most modern theories of decision-making recognize the fact that decisions do not take place in a vacuum. Individual preferences and knowledge, along with situational variables can greatly impact the decision process. In order to facilitate our research on decision-making we are interested in knowing certain factors about you, the decision maker. Specifically, we are interested in whether you actually take the time to read the directions; if not, then some of our manipulations that rely on changes in the instructions will be ineffective. So, in order to demonstrate that you have read the instructions, please do not select any of the options below. Instead, simply continue on to the next question. Thank you very much.

Below this text, participants were presented with the question *Which of these activities do you engage in regularly? (check all that apply)*, followed by the response options *Football*, *Soccer*, *Dancing*, *Watersports*, *Triathlon*, *Running*, *Volleyball*, and *I engage in other activities*. Participants failed the attention check if they did not follow the instructions and instead checked one or more of the eight response options.

Exclusions. Following our preregistered exclusion criteria, participants were excluded from analyses if they (a) failed to pass the instructional attention check or (b) showed error rates higher than 40% in the sequential priming task.

Data Aggregation. Responses linking vaccines to autism on the explicit measure were aggregated by reverse coding scores on the two negatively framed items (see above) and averaging responses to the four questions in a single index (Cronbach's α = .90). Higher scores on this index reflect a stronger tendency to link vaccines to autism on the explicit measure. Responses on the implicit measure were aggregated by calculating priming scores for responses to the target word *autism*. Following our preregistered data aggregation plan for responses on the implicit measure, we excluded all trials with incorrect responses (4.7%) and trials with response times shorter than 300 msec or longer than 1,000 msec (7.3%) (see Koppehele-Gossel et al., 2020). Priming scores were calculated by subtracting the average response latency on trials in which the target word *autism* followed the prime word *vaccine* from the average response latency on trials in which the target word *autism* followed the prime word *desk*. This facilitation index reflects the extent to which exposure to the prime word *vaccine* facilitates identification of the target word *autism* compared to baseline (Wentura & Degner, 2010; Wittenbrink, 2007). Higher scores on this index indicate a stronger tendency to link vaccines to autism on the implicit measure. To obtain a common metric for the two measures, aggregate indices derived from the two measures were transformed into standardized *z* scores prior to analyses.

RESULTS

Descriptive Statistics. Unstandardized mean scores and 95% confidence intervals of responses linking vaccines to autism on the implicit and the explicit measure are presented in Table 1. Aggregate scores on the implicit and the explicit measure were not significantly correlated across conditions ($r = -.03$, $p = .439$).[3]

3. Although low correlations between implicit and explicit measure are sometimes interpreted as evidence for distinct underlying constructs, such interpretations should be treated with caution because low correlations could also be due to measurement error (see Gawronski & Brannon, 2019). Consistent with this concern, scores on the implicit measure showed an internal consistency of Cronbach's α = .14 (estimated based on priming scores in the first versus second half of the task). Although low internal consistency of implicit measures does not necessarily pose a challenge for the detection of experimental effects, it does pose a challenge for the detection of correlations with other measures (see Koppehele-Gossel et al., 2020).

TABLE 1. Unstandardized Scores of Responses Linking Vaccines to Autism as a Function of Measurement Type (Explicit vs. Implicit) and Message Condition (Neutral Message; Debunking-via-Negation; Debunking-via-Alternative; Debunking-via-Affirmation)

	Explicit measure		Implicit measure	
	M	95% CI	*M*	95% CI
Experiment 1				
Neutral message	2.14	[1.94, 2.34]	−14.17	[−19.76, −8.58]
Debunking-via-negation	1.61	[1.41, 1.80]	−5.38	[−10.84, 0.08]
Debunking-via-alternative	1.87	[1.69, 2.08]	−11.10	[−17.02, −5.19]
Experiment 2				
Neutral message	2.13	[1.98, 2.29]	−7.36	[−11.44, −3.28]
Debunking-via-negation	1.93	[1.77, 2.09]	−13.07	[−17.32, −8.81]
Debunking-via-affirmation	2.06	[1.91, 2.22]	−14.94	[−19.06, −10.83]

Note. Higher scores indicate a stronger tendency to link vaccines to autism.

Confirmatory Analyses. To test our preregistered hypotheses, we first submitted standardized indices of responses linking vaccines to autism to a 2 (Message: neutral message vs. debunking-via-negation) × 2 (Measurement Order: explicit-implicit vs. implicit-explicit) × 2 (Measurement Type: explicit vs. implicit) mixed ANOVA with the first two factors varying between subjects and the last one varying within subjects. Dual-process learning theories predict a significant interaction between Message and Measurement Type: Compared to the neutral-message condition, debunking-via-negation should reduce scores on the explicit measure and increase scores on the implicit measure. In contrast, single-process learning theories predict an unqualified main effect of Message: Compared to the neutral-message condition, debunking-via-negation should reduce scores on both the explicit and the implicit measure.

Consistent with the predictions of dual-process learning theories and inconsistent with the predictions of single-process propositional theories, the only statistically significant effect in the ANOVA was a significant two-way interaction between Message and Measurement Type, $F(1, 379) = 18.04$, $p < .001$, $\eta_p^2 = .045$ (see Figure 1). Confirmatory analyses further revealed that scores on the explicit measure were significantly *lower* in the debunking-via-negation condition compared to the neutral-message condition, $t(337.09) = 3.64$, $p < .001$, $d = .375$, while scores on the implicit measure were significantly *higher* in the debunking-via-negation condition compared to the neutral-message condition, $t(357.60) = -2.24$, $p = .026$, $d = .230$.

Exploratory Analyses. Expanding on the test of our preregistered hypotheses, we conducted a 3 (Message: neutral message vs. debunking-via-negation vs. debunking-via-alternative) × 2 (Measurement Order: explicit-implicit vs. implicit-explicit) × 2 (Measurement Type: explicit vs. implicit) mixed ANOVA to explore the effectiveness of debunking with an alternative state of affairs. The only statistically

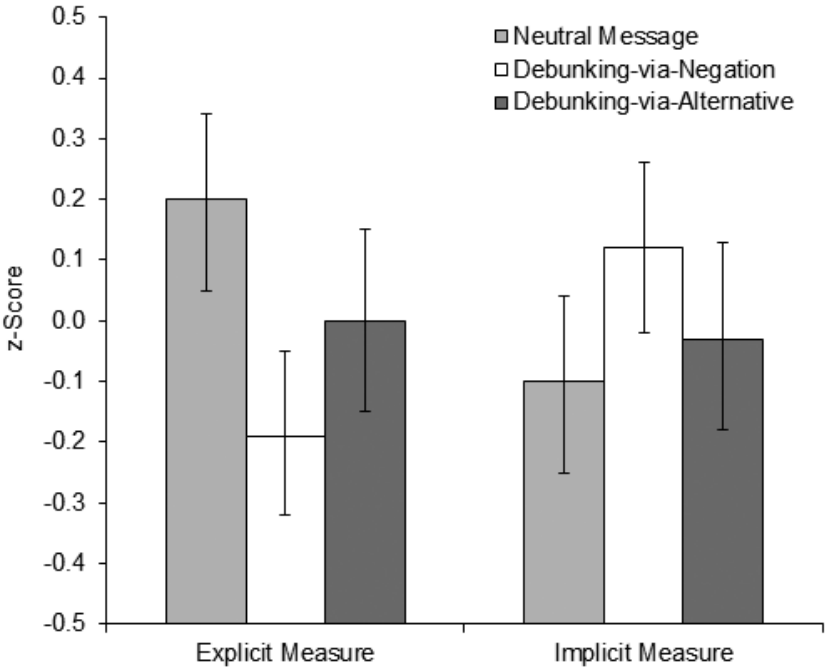

FIGURE 1. Standardized *z* scores of responses linking vaccines to autism as a function of measurement type (explicit vs. implicit) and message condition (neutral message vs. debunking-via-negation vs. debunking-via-alternative), Experiment 1. Higher scores indicate a stronger tendency to link vaccines to autism. Error bars depict 95% confidence intervals. The standardization of scores on the explicit and the implicit measure permits a comparison of scores across debunking conditions within a given measure, but it does not permit a comparison of scores across measures within a given message condition. A score of zero reflects the sample mean on a given measure, which does not represent a neutral reference point. The neutral reference point for each measure is the score obtained in the neutral message condition.

significant effect in the ANOVA was a significant two-way interaction between Message and Measurement Type, $F(2, 544) = 8.84$, $p < .001$, $\eta_p^2 = .031$ (see Figure 1). Further analyses revealed that, compared to the neutral-message condition, debunking-via-alternative tended to reduce scores on the explicit measure, but this difference did not reach statistical significance, $t(348.49) = 1.75$, $p = .081$, $d = .184$. Moreover, scores on the explicit measure tended to be lower in the debunking-via-negation condition compared to the debunking-via-alternative condition, but this difference also did not reach statistical significance, $t(336.23) = 1.95$, $p = .052$, $d = .207$. Scores on the implicit measures in the debunking-via-alternative condition did not significantly differ from the neutral-message condition, $t(352) = -0.70$, $p = .483$, $d = .075$, and the debunking-via-negation condition, $t(325.70) = 1.44$, $p = .151$, $d = .154$.

DISCUSSION

The results of our confirmatory analysis suggest that messages negating the idea that vaccines cause autism can reinforce responses linking vaccines and autism

on implicit measures, even when the messages are effective in combatting self-reported beliefs linking vaccines and autism on explicit measures. These results are consistent with predictions derived from dual-process learning theories (Gawronski & Bodenhausen, 2006, 2011), but they are inconsistent with predictions derived from single-process propositional theories (De Houwer, 2018; De Houwer et al., 2020). According to dual-process theories that distinguish between associative and propositional learning mechanisms, messages negating the idea that vaccines cause autism should strengthen automatic associations between vaccines and autism (captured by implicit measures) even when they are effective in reducing propositional beliefs about a causal link between vaccines and autism (captured by explicit measures).

Counter to theories suggesting that messages negating a state of affairs might be more effective when they are supplemented with information that specify an alternative state of affairs (e.g., Petty et al., 2007), our exploratory analyses obtained mixed effects of such a message. Although additional information about genetic factors as a true cause of autism buffered ironic effects of debunking on the implicit measure, it also tended to reduce the effectiveness of debunking in changing self-reported beliefs on the explicit measure. In terms of dual-process learning theories, these findings suggest that reinforcing an association between genetics and autism may weaken the behavioral impact of an association between vaccines and autism. However, identifying genetic factors as a cause of autism does not logically contradict the possibility that autism could also be caused by other factors. The latter aspect could make debunking messages focusing on true causes (e.g., genetics) less effective in changing self-reported beliefs compared to debunking messages focusing on the falsity of information about a presumed cause (i.e., vaccines).

EXPERIMENT 2

The goals of Experiment 2 were twofold. First, we aimed to replicate the main finding of Experiment 1, showing that messages negating the idea that vaccines cause autism reinforce responses linking vaccines and autism on implicit measures, even when the messages are effective in combatting self-reported beliefs linking vaccines and autism on explicit measures. Second, we aimed to investigate whether affirming a state of affairs that is opposite to a debunked idea can prevent ironic effects of debunking via negation. Previous research suggests that encoding of negated information in terms of a specific referent representing the logical opposite (e.g., not guilty = innocent) increases the effectiveness of negations in reversing the impact of the negated information (Mayo et al., 2004). Although the idea that vaccines do not cause autism does not have a specific referent at the same level of abstraction, debunking messages could be rephrased at a higher level of abstraction, so that debunking can occur via affirmation of the opposite (i.e., *vaccines are safe*) rather than negation of the focal idea (i.e., *vaccines do not cause autism*). According to dual-process learning accounts, such messages should be effective in producing the intended effects on both implicit and explicit measures, because automatic association formation should influence responses in a direction that is

consistent with the propositional content of the message. For example, messages stating *vaccines are safe* may reinforce a mental association between the concepts *vaccines* and *safe*, which should prevent the ironic effect of messages stating *vaccines do not cause autism*. Thus, whereas debunking via negation should lead to conflicting outcomes on implicit and explicit measures, debunking via affirmation of the opposite should influence responses in the intended direction on both implicit and explicit measures. To test this prediction, Experiment 2 replaced the debunking-via-alternative condition with a debunking-via-affirmation condition. The message in the debunking-via-affirmation condition was identical to the one in the debunking-via-negation condition, the only difference being that statements negating the presumed link between vaccines and autism (e.g., *vaccines do not cause autism*) were changed to affirm the safety of vaccines (e.g., *vaccines are safe*).

METHODS

Experiment 2 was preregistered prior to data collection at https://osf.io/brfxa/. The data were collected in May 2021 using Inquisit 4 Web by Millisecond. We report all data, all measures, and all experimental conditions. The data, analysis codes, and materials are available at https://osf.io/vn8gu/.

Participants and Design. Participants were recruited using Prolific Academic (Peer et al., 2017). Eligibility for participation was restricted to Prolific members with the following qualifications: (a) age: 18+; (b) nationality: United States; (c) country of residence: United States; (d) approval rate: 95%+; (e) number of previous submissions: >100; (f) did not participate in Experiment 1. The study took approximately 10–12 minutes and participants received $2.00 compensation for their time. The study included a 3 (Message: neutral message vs. debunking-via-negation vs. debunking-via-affirmation) × 2 (Measurement Order: implicit-explicit vs. explicit-implicit) × 2 (Measurement Type: implicit vs. explicit) factorial design with the first two factors varying between subjects and the last factor varying within subjects. Participants were randomly assigned to one of the three Message conditions and one of the two Measurement Order conditions via their Subject ID number, which was assigned sequentially via Millisecond's web script hosting service. Our desired sample size prior to exclusions was 900 participants. The critical interaction between Debunking Message and Measurement Type in Experiment 1 had an effect size of $f = .179$. A sample of 900 participants provides a power of 99.9% power to detect an interaction effect of the same size (two-tailed). The critical post-hoc test for the difference between the debunking-via-negation and the neutral-message condition was $d = .230$ in Experiment 1. A sample of 900 participants (300 in each of the three Debunking conditions) provides a power of 80% to detect a difference of the same size in a *t*-test for independent means (two-tailed). Following our preregistered protocol, data collection ended once 900 participants had been approved for payment on Prolific. Of the 946 cases in the original data file, 45 cases were from participants who did not complete the study until the end and 6 cases were from participants who started the study more than once. Of the remaining

895 participants in the data file, 10 failed to pass an instructional attentional check and 5 showed an error rate higher than 40% on the implicit measure. Following our preregistered exclusion criteria, data from these participants were excluded from analyses, leaving us with a final sample of 880 participants (417 women, 447 men, 13 other, 2 prefer not to say, 1 missing). The age of participants in the final sample ranged from 18 to 78 years (M = 39.63, SD = 14.10).

Procedure. The materials, measures, procedures, and attention check were identical to Experiment 1, the only difference being that we replaced the debunking-via-alternative condition with a condition labeled debunking-via-affirmation. Participants in this condition were presented with a slightly modified version of the article in the debunking-via-negation condition. Like the original article, the modified article addressed the presumed link between vaccines and autism, citing evidence contradicting this idea. However, different from the dominant focus on negations in the original article, statements negating the presumed link between vaccines and autism (e.g., *vaccines do not cause autism*) were changed to affirm the safety of vaccines (e.g., *vaccines are safe*). The exclusion criteria, data aggregation, and data analytic plan were identical to Experiment 1. Following our preregistered data aggregation plan for responses on the implicit measure, trials with incorrect responses (4.5%) and trials with response times shorter than 300 msec or longer than 1,000 msec (7.2%) were not included in the calculation of priming scores (see Koppehele-Gossel et al., 2020).

RESULTS

Descriptive Statistics. Unstandardized mean scores and 95% confidence intervals of responses linking vaccines to autism on the implicit and the explicit measure are presented in Table 1. Aggregate scores on the implicit and the explicit measure were not significantly correlated across conditions (r = –.004, p = .909).[4]

Confirmatory Analyses. Following the data analytic approach in Experiment 1, we first conducted a 2 (Message: neutral message vs. debunking-via-negation) × 2 (Measurement Order: explicit-implicit vs. implicit-explicit) × 2 (Measurement Type: explicit vs. implicit) mixed ANOVA with the first two factors varying between subjects and the last one varying within subjects. Despite the use of identical materials, measures, and procedures, the results of the ANOVA were remarkably different from the results in Experiment 1. Consistent with the predictions of single-process propositional theories and inconsistent with the predictions of dual-process learning theories, the only statistically significant effect in the ANOVA was a significant main effect of Message, $F(1, 578) = 6.42$, p = .012, η_p^2 = .011 (see Figure 2). The two-way interaction of Message and Measurement Type was not statistically significant, $F(1, 578) < 0.01$, p = .931, $\eta_p^2 < .001$. Further analyses revealed that, compared to the neutral-message condition, scores tended

4. Consistent with the results of Experiment 1, the low correlation between the two measures seems to be due to low internal consistency of the implicit measure (Cronbach's α = .00).

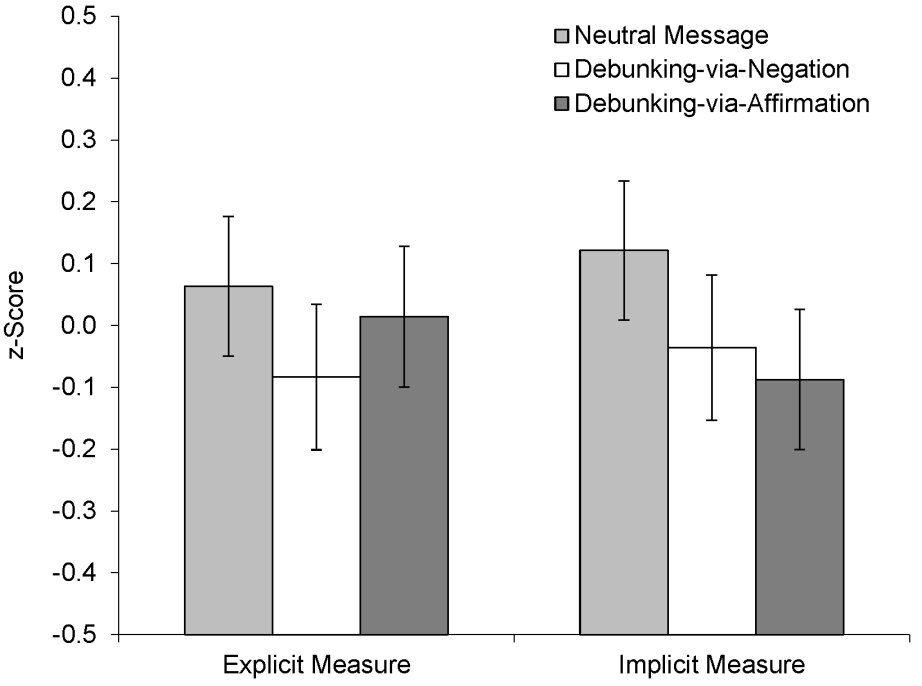

FIGURE 2. Standardized *z* scores of responses linking vaccines to autism as a function of measurement type (explicit vs. implicit) and message condition (neutral message vs. debunking-via-negation vs. debunking-via-affirmation), Experiment 2. Higher scores indicate a stronger tendency to link vaccines to autism. Error bars depict 95% confidence intervals. The standardization of scores on the explicit and the implicit measure permits a comparison of scores across debunking conditions within a given measure, but it does not permit a comparison of scores across measures within a given message condition. A score of zero reflects the sample mean on a given measure, which does not represent a neutral reference point. The neutral reference point for each measure is the score obtained in the neutral message condition.

to be *lower* in the debunking-via-negation condition on both the explicit measure, $t(579.60) = 1.75$, $p = .080$, $d = .145$, and the implicit measure, $t(580) = 1.85$, $p = .065$, $d = .153$.

Expanding on this analysis, we conducted a 3 (Message: neutral message vs. debunking-via-negation vs. debunking-via-affirmation) × 2 (Measurement Order: explicit-implicit vs. implicit-explicit) × 2 (Measurement Type: explicit vs. implicit) mixed ANOVA to test the effectiveness of debunking-via-affirmation. The only statistically significant effect in the ANOVA was again a significant main effect of Message, $F(2, 874) = 4.01$, $p = .018$, $\eta_p^2 = .009$ (see Figure 2). Further analyses revealed that, compared to the neutral-message condition, debunking-via-affirmation significantly reduced scores on the implicit measure, $t(599) = 2.60$, $p = .010$, $d = .212$, but not the explicit measure, $t(599) = 0.58$, $p = .563$, $d = .047$. There was no significant difference between the debunking-via-negation and the debunking-via-affirmation condition on either the implicit measure, $t(575) = 0.59$, $p = .553$, $d = .049$, or the explicit measure, $t(575) = -1.22$, $p = .223$, $d = .102$.

DISCUSSION

Consistent with the hypothesis that debunking via affirmation of the opposite can prevent ironic effects, a message emphasizing the safety of vaccines reduced responses linking vaccines to autism on an implicit measure. However, counter to the findings of Experiment 1, the same effect occurred for debunking via negation. In the current study, a message emphasizing that vaccines do not cause autism reduced responses linking vaccines to autism on both the implicit and the explicit measure. Thus, Experiment 2 not only failed to replicate the main finding of Experiment 1 despite the use of identical measures and materials; the two experiments obtained opposite effects on implicit measures with contradictory theoretical implications. While the conflicting effects of debunking via negation on implicit and explicit measures in Experiment 1 are consistent with the predictions of dual-process learning theories and inconsistent the predictions of single-process propositional theories, the parallel effects in Experiment 2 are consistent with the predictions of single-process propositional theories and inconsistent with the predictions of dual-process learning theories.

GENERAL DISCUSSION

The main goal of the current research was to test competing predictions of dual-process and single-process theories about whether debunking messages negating a state of affairs would change responses on implicit measures in a manner intended by the message. Toward this end, we utilized original health messages from the CDC explaining that there is no evidence for the idea that vaccines cause autism. According to dual-process theories that distinguish between associative and propositional learning mechanisms (e.g., Gawronski & Bodenhausen, 2006, 2011), messages negating the idea that vaccines cause autism should reinforce a mental association between the concepts *vaccines* and *autism* via mere co-occurrence, even when message recipients update their beliefs in a way intended by the message. These effects should be reflected in conflicting outcomes on implicit and explicit measures, in that debunking via negation should increase responses linking vaccines to autism on implicit measures, even when they effectively reduce self-reported judgments linking vaccines to autism on explicit measures. In contrast, single-process propositional theories postulate that (a) all learning effects arise from the generation and truth assessment of propositional beliefs about states of affairs and (b) stored propositional beliefs underlie responses on both explicit and implicit measures (e.g., De Houwer, 2018; De Houwer et al., 2020). From this perspective, debunking messages negating the idea that vaccines cause autism should reduce propositional beliefs about a causal link between vaccines and autism, and this effect should be reflected on both explicit and implicit measures. The surprising outcome of the current research is that, while the results of Experiment 1 confirmed the predictions of dual-process learning theories and disconfirmed the predictions of single-process propositional theories, the results of Experiment 2 confirmed the predictions of single-process propositional theories

and disconfirmed the predictions of dual-process learning theories. These conflicting results were obtained although the two studies used identical measures and materials.

One potential interpretation of these conflicting results is that the effects of debunking-via-negation on the implicit measures in Experiments 1 and 2 are both false positives, which turn into an overall null effect in an integrative analysis of the combined data from the two studies (see Curran & Hussong, 2009). Yet, in such an integrative data analysis, an overall null effect on the implicit measure would still differ from the reliable effect obtained on the explicit measure, suggesting that debunking-via-negation effectively reduced responses linking vaccines to autism on the explicit measure, but not the implicit measure (see supplemental materials, section 1). Such an interpretation would be consistent with the idea that the message in the debunking-via-negation condition was ineffective in changing participants' mental representation of vaccines, and that participants merely shifted their self-reported judgments in response to the message (see Fazio & Olson, 2003), potentially reflecting a demand effect. Although we cannot rule out such an interpretation, we deem it implausible. It is correct that even small effects can reach statistical significance in studies with large sample sizes. However, this statistical truism alone does not explain the emergence of directionally opposite effects in the two studies. Moreover, although it is certainly possible that both effects are false positives driven by random error, the large sample sizes in the two studies should reduce random error, rendering false positives extremely unlikely.

In our view, it seems more plausible that incidental aspects of the two studies are responsible for the conflicting outcomes. Because all measures and materials were identical and participants in the two studies were recruited from the same pool, one potential factor might be the broader societal context at the time when the two studies were conducted. Whereas Experiment 1 was conducted in June 2019, several months before the outbreak of the COVID-19 pandemic, Experiment 2 was conducted in May 2021, a few months after the first COVID-19 vaccines received emergency approval in the United States and many other countries around the world. Thus, it is possible that the topic of vaccines was much more salient during the data collection for Experiment 2, potentially leading to greater involvement and more elaborate processing of vaccine-related messages compared to Experiment 1. Based on these considerations, the conflicting outcomes of the two studies may be rooted in different levels of cognitive elaboration, in that debunking via negation may effectively reduce responses linking vaccines to autism on implicit measures when the message is processed in an elaborate manner, but enhance responses linking vaccines to autism on implicit measures when the message is processed superficially. These assumptions are consistent with the results of our exploratory analyses indicating that participants in Experiment 2 tended to spend more time reading the debunking-via-negation article than participants in Experiment 1 (see supplemental materials, section 2).

Although it is extremely difficult to experimentally test this post-hoc interpretation at a time when vaccines are highly salient and people are deeply engaged in

debates about vaccines,[5] an interesting question is whether and how such an interpretation can be reconciled with dual-process and single-process theories. From the perspective of dual-process learning theories, greater cognitive elaboration may certainly increase the impact of debunking-via-negation on explicit measures. However, it remains unclear how greater cognitive elaboration may reverse ironic effects of debunking-via-negation on implicit measures, given that the proposed process of automatic association formation is assumed to operate regardless of the degree of cognitive elaboration during encoding (see Gawronski & Bodenhausen, 2014).

Single-process propositional theories seem superior in capturing this idea, in that they offer a potential interpretation in terms of selective-retrieval mechanisms. To account for dissociative effects on implicit and explicit measures predicted by dual-process learning theories (e.g., Hu et al., 2017; Moran & Bar-Anan, 2013), some researchers suggest that incomplete retrieval of stored propositional information can lead to mere co-occurrence effects that resemble the ones predicted by the notion of automatic association formation (Van Dessel et al., 2019). For example, after learning and storing the proposition *vaccines do not cause autism*, people may show enhanced responses linking vaccines to autism when retrieval of the stored proposition is incomplete in the sense that the retrieved information is missing the negation (e.g., *vaccines cause autism*) or broader details of the specific relation (e.g., *vaccines are related to autism*). To the extent that (1) time pressure during the expression of behavioral responses increases the likelihood of incomplete retrieval and (2) time pressure is greater on implicit measures compared to explicit measures, these assumptions explain why implicit measures can show ironic effects of debunking-via-negation even when explicit measures show the effect intended by the debunking message (as found in Experiment 1). However, when cognitive elaboration during encoding is high, the likelihood of complete retrieval under time pressure may increase, such that debunking-via-negation may show corresponding effects on implicit and explicit measures that are in line with the content of the message (as found in Experiment 2). Thus, although our interpretation of the conflicting outcomes in terms of differential cognitive elaboration is admittedly post-hoc, such an interpretation seems easier to reconcile with single-process propositional theories than with dual-process learning theories.

Irrespective of the obtained outcomes, it is worth emphasizing that the primary purpose of the current research was to test competing predictions about the effects of debunking-via-negation on implicit and explicit measures. Although evidence regarding these predictions is informative for the debate between dual-process and single-process theories, conclusions about practical implications for understanding vaccine hesitancy in behavioral decisions are less straightforward. To the extent that debunking messages negating a link between vaccines and autism are effective in changing responses on both explicit and implicit measures (as predicted

5. Operationally, it is much easier to experimentally increase processing motivation under default conditions of low motivation than to experimentally decrease processing motivation under default conditions of high motivation.

by single-process theories), it remains unclear why such debunking messages are often ineffective in reducing vaccine hesitancy in behavioral decisions. Moreover, if debunking messages negating a link between vaccines and autism are effective in changing responses on explicit but not implicit measures (as predicted by dual-process theories), persistent vaccine hesitancy in behavioral decisions could be explained as the product of ironic effects of debunking-via-negation on implicit measures. However, such a conclusion conflicts with the dual-process hypothesis that explicit measures should be superior to implicit measures in predicting deliberate, intentional behavior, whereas implicit measures should be superior to explicit measures in predicting spontaneous, unintentional behavior (Fazio & Olson, 2003; Strack & Deutsch, 2004). Because vaccination decisions fall into the category of deliberate, intentional behavior, it remains unclear how dissociative effects of debunking-via-negation on explicit and implicit measures might help to understand vaccine hesitancy in behavioral choices. This concern is bolstered by meta-analytic findings suggesting that changes on implicit measures do not necessarily lead to corresponding changes in behavior (Forscher et al., 2019).

To address this concern, it is worth noting that debunking-via-negation had opposite effects on explicit and implicit measures in Experiment 1, suggesting inconsistent underlying cognitions about vaccines. Such inconsistencies are different from the zero-order relations addressed by meta-analyses and dual-process theories of behavior determination, in that conflicting underlying cognitions may involve interactive effects of implicit and explicit measures in predicting downstream behavior (Perugini et al., 2010). Because cognitive inconsistency undermines action (Harmon-Jones et al., 2009; Van Harreveld et al., 2009) and vaccination decisions require action, conflicting effects of debunking messages could have a negative impact on vaccination decisions by promoting inaction via inconsistent cognitions. Another possibility is that, in cases involving conflicting effects on implicit and explicit measures, immediate effects on explicit measures might be short-lived, in that delayed effects on explicit measures converge to the ones obtained on implicit measures (e.g., Ranganath & Nosek, 2008). In such cases, dissociative effects of debunking on explicit and implicit measures (like the ones obtained in Experiment 1) might be indicative of delayed ironic effects on both explicit and implicit measures, which would explain why debunking-via-negation may be ineffective in reducing vaccine hesitancy in behavioral decisions (see Carey et al., 2022). Although the primary goal of the current research was to test competing predictions about the effects of debunking on implicit and explicit measures, future research would be helpful to provide insights into the downstream impact of the obtained effects on behavior.

In addition to offering valuable insights for the debate between dual-process and single-process theories, the current findings also provide a reminder that even large sample sizes and preregistration do not guarantee reproducibility of an observed effect. Although both practices are clearly important and helpful to improve the reliability of scientific findings, they are insufficient to ensure reproducible outcomes. Despite the use of relatively large samples and preregistration in both studies, Experiment 2 not only failed to reproduce the main finding of

Experiment 1, but also produced a pattern that was opposite to the one previously obtained. Although we cannot rule out that the conflicting outcomes in the two studies are both false positives, our proposed post-hoc interpretation aligns with concerns that some effects may be real but difficult to replicate, because they are sensitive to contextual influences (Van Bavel et al., 2016). In fact, our post-hoc interpretation suggests that unrecognized influences of contextual factors may even lead to conflicting theoretical conclusions. While Experiment 1 supported the predictions of dual-process learning theories, Experiment 2 supported the predictions of single-process propositional theories. Yet, the full set of findings seems easier to reconcile with single-process propositional theories and difficult to explain with dual-process learning theories. These considerations suggest that theory can be fundamentally important for understanding the reproducibility of an observed effect, echoing concerns about the atheoretical focus on effects in the current debate about the reproducibility of psychological findings (see Irvine, 2021; Stroebe & Strack, 2014).

In sum, the current research provided conflicting evidence on whether debunking messages negating a state of affairs change responses on implicit measures in a manner intended by the message. Consistent with predictions derived from dual-process learning theories, Experiment 1 found that debunking-via-negation increased responses linking vaccines to autism on implicit measures, although it effectively reduced self-reported judgments linking vaccines to autism on explicit measures. Using the same measures and materials, Experiment 2 found that debunking-via-negation effectively reduced responses linking vaccines to autism on both implicit and explicit measures, consistent with predictions derived from single-process propositional theories. A potential explanation for the conflicting outcomes is that enhanced salience and greater elaboration of vaccine-related issues at the time of Experiment 2 counteracted ironic effects on implicit measures by increasing the likelihood of complete retrieval of stored propositional information. This post-hoc interpretation aligns better with the assumptions of single-process propositional theories than with those of dual-process learning theories. Future research may help to provide deeper insights into the effectiveness of debunking-via-negation by directly manipulating cognitive elaboration during encoding.

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