Countering antivaccination attitudes

Zachary Horne[a,1,2], Derek Powell[b,1], John E. Hummel[a], and Keith J. Holyoak[b]

[a]Department of Psychology, University of Illinois at Urbana–Champaign, Champaign, IL 61802; and [b]Department of Psychology, University of California, Los Angeles, CA 90095

Edited by Susan Gelman, University of Michigan, Ann Arbor, MI, and approved June 11, 2015 (received for review February 26, 2015)

Three times as many cases of measles were reported in the United States in 2014 as in 2013. The reemergence of measles has been linked to a dangerous trend: parents refusing vaccinations for their children. Efforts have been made to counter people's antivaccination attitudes by providing scientific evidence refuting vaccination myths, but these interventions have proven ineffective. This study shows that highlighting factual information about the dangers of communicable diseases can positively impact people's attitudes to vaccination. This method outperformed alternative interventions aimed at undercutting vaccination myths.

vaccination | belief revision | attitude change | science education

In 2014, there were 644 cases of measles reported in the United States—three times as many cases as were reported the year before (1). In 2000, measles was thought to have been eradicated in the United States (1). The reemergence of measles has been linked to an increase in the number of parents refusing to vaccinate their children. Parents who refuse vaccines cite fears that vaccinations may have harmful side effects because of now discredited research (2, 3) that claimed there was a causal link between certain vaccinations and a child's risk for autism (4). Despite efforts by the Centers for Disease Control and Prevention (CDC) (1) to undermine vaccination myths and almost universal support for vaccinations among healthcare providers, vaccination rates have declined. We need effective provaccine messages to reverse this dangerous trend by persuading people—both vaccine skeptics and vaccine-hesitant parents (5)—to vaccinate their children.

Ideally, doctors and health organizations would be able to reassure parents about the safety of vaccines through direct scientific education. However, recent findings have led researchers to question whether direct provaccine messages are efficacious, even raising the possibility that they may be harmful (6, 7). Nyhan et al. (6) and Nyhan and Reifler (7) presented parents with provaccine information from the CDC website, but these provaccine messages failed to improve their attitudes toward vaccination. In fact, these studies reported a "backfire effect": vaccine skeptics formed even stronger negative opinions about vaccinations after being given information intended to undermine the supposed connection between vaccinations and autism (a similar effect is discussed in the work in ref. 8).

Despite these failures, we suspect that a stronger direct message holds promise for influencing parents' vaccine attitudes. A normative analysis of vaccination decisions implies that parents' decisions to accept or refuse vaccinations for their children should depend on not only the risks associated with vaccinating, but also the risks of not vaccinating. This reasoning suggests another avenue by which people's attitudes might be influenced. Rather than attempting to overcome vaccination myths by convincing parents of the safety of vaccines, provaccine messages might be more effective if they work to convince parents of the dangers of failing to vaccinate their children. In terms of expected utility (9), a parent's decision to vaccinate should be governed by

$$U(\text{vaccination}) = P(\text{prevention})P(\text{illness})U^{+}(\text{remain healthy}) + P(\text{side effect})U^{-}(\text{side effect}).$$

The expected utility of vaccinating can be increased by either decreasing estimates of the probability of negative side effects (the second term in the equation above) or increasing estimates of positive effects of vaccines (the first term in the equation).

Efforts to directly counter vaccination myths often take aim at the second term. However, we know that parents who oppose vaccinations have strong beliefs about the side effects of vaccines—presumably, these beliefs are the reason that they do not vaccinate their children. Since attempts to influence attitudes are often thwarted by people's tendency to discount or ignore evidence contrary to their existing attitudes [a phenomenon known as confirmation bias (10)], such manipulations may be largely ineffective. Indeed, it is known that direct attempts to dispel myths risk perpetuating those myths through their repetition, as this repetition breeds familiarity and may strengthen people's memory for incorrect information (11, 12). Moreover, it is difficult, even in principle, to provide compelling evidence for the absence of risk (13). For these reasons, it is often easier to replace an existing belief with an alternative belief rather than attempting to directly counter it (11).

These considerations led us to consider an alternative approach to using scientific information to change attitudes: convincing parents that the probability of disease contraction is high if they do not vaccinate their children and that the consequences of getting these illnesses are severe. This approach is analogous to that taken by researchers who have effectively corrected participants' erroneous beliefs not by refuting incorrect elements of these beliefs, but rather by replacing those elements with new information (11).

In this study, we succeeded in altering people's vaccination attitudes by drawing attention to the consequences of not vaccinating their children. Participants were randomly assigned to the disease risk intervention, the autism correction intervention, or a control intervention (in a between-subjects design). Participants assigned to the disease risk condition read three pieces of information taken from the CDC website in randomized order: (*i*) a paragraph written from a mother's perspective about her child contracting measles, (*ii*) a picture of a child with measles, a

Significance

Myths about the safety of vaccinations have led to a decline in vaccination rates and the reemergence of measles in the United States, calling for effective provaccine messages to curb this dangerous trend. Prior research on vaccine attitude change suggests that it is difficult to persuade vaccination skeptics and that direct attempts to do so can even backfire. Here, we successfully countered people's antivaccination attitudes by making them appreciate the consequences of failing to vaccinate their children (using information provided by the Centers for Disease Control and Prevention). This intervention outperformed another that aimed to undermine widespread vaccination myths.

Author contributions: Z.H., D.P., J.E.H., and K.J.H. designed research; Z.H. and D.P. performed research; Z.H. and D.P. analyzed data; and Z.H., D.P., J.E.H., and K.J.H. wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

[1]Z.H. and D.P. contributed equally to this work.

[2]To whom correspondence should be addressed. Email: horne2@illinois.edu.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1504019112/-/DCSupplemental.

MEDICAL SCIENCES

PSYCHOLOGICAL AND COGNITIVE SCIENCES

child with mumps, and an infant with rubella, and (*iii*) three short warnings about how important it is for people to vaccinate their children. Participants assigned to the autism correction condition read information taken from the CDC website summarizing recent research showing that vaccines do not increase the risk of autism in children. Participants assigned to a control condition read an unrelated vignette about a scientific topic.

Participants' vaccine attitudes were compared before and after these interventions in a two-phase design (Fig. 1). Both parents and nonparents shared similar attitudes toward vaccines at pretest and both groups' attitudes were very similarly affected by our interventions (*Intervention Results*; see Fig. 4). Therefore, we pooled across parents and nonparents in our analyses. We found that the disease risk intervention yielded a positive shift in participants' attitudes toward vaccines, even among those participants who were initially most skeptical (Fig. 2).

This finding suggests that education about the risks posed by failing to vaccinate can have meaningful effects on vaccination attitudes. Moreover, this intervention was significantly more effective than corrective information aimed at dispelling myths about vaccines and autism. Despite a slight reduction in participants' erroneous beliefs that vaccines cause autism and a strong negative relationship between provaccination attitudes and the belief that vaccines cause autism (r = −0.70), the autism correction intervention did not significantly influence general attitudes toward vaccines compared with the control condition. We did not observe any backfire effect (6, 7) when participants' attitudes were examined immediately after the autism correction intervention; however, these effects may be more likely to emerge after a delay (11, 14).

Future research should examine the effects of these types of interventions after a delay. Indeed, many vaccination decisions will not be made immediately after exposure to educational interventions, calling for additional research to assess the risk of backfire effects and to evaluate the longevity and robustness of the improvements in vaccine attitudes that we observed. Still, even a temporary improvement in parents' vaccination attitudes could increase vaccination rates if such interventions were incorporated into doctor–parent interactions (5).

Effective educational messages are needed to overcome parents' misplaced skepticism toward vaccines and convince them to vaccinate their children. Failure to overcome this skepticism places the lives of thousands of children at risk. This study offers a potential solution based on scientifically grounded education. Rather than attempting to dispel myths about the dangers of vaccinations, we recommend that the very real dangers posed by serious diseases, like measles, mumps, and rubella, be emphasized. This approach would allow media reports and health professionals to improve vaccine attitudes by communicating accurate information about disease risks without repeating inaccurate information that may further fuel antivaccination attitudes (11, 14). Our results suggest that parents are likely to be responsive to warnings (in the form of graphic pictures and anecdotes) of the severity of these diseases, and that heightened awareness of the risks associated with failure to take preventive action will improve attitudes toward vaccinations.

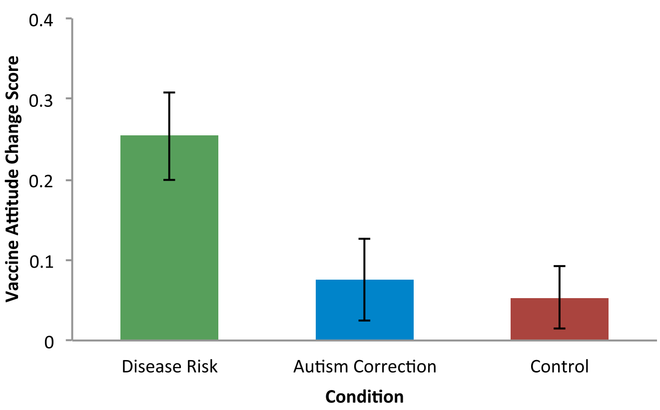

Fig. 1. Vaccine attitude change scores across conditions (posttest – pretest). A one-way ANOVA revealed a significant difference between the three conditions [$F(2,312) = 5.287$, $P = 0.006$]. This effect was driven by the disease risk condition, which led to larger changes in vaccination attitudes than either the control [$t(212) = 3.04$, $P = 0.003$, $d = 0.41$, 95% highest density interval (HDI; a Bayesian estimate of the most credible values of the difference) (15) = 0.058, 0.292] or the autism correction condition [$t(203) = 2.41$, $P = 0.017$, $d = 0.33$, 95% HDI of the difference = 0.009, 0.269]. The effect of the autism correction condition was no greater than that observed in the control condition [$t(209) = 0.358$, $P = 0.721$, $d = 0.05$, 95% HDI of the difference = −0.066, 0.138].

Experiment

Vaccine Scale. We developed a five-item vaccine attitude scale intended to measure people's general attitudes toward vaccines (*SI Appendix*). Examples of scale response items are, "The risk of side effects outweighs any potential benefits of vaccines" (reverse coded) and "I plan to vaccinate my children." The scale was highly reliable ($\alpha = 0.84$) and found to correlate with past vaccine behaviors and intentions to vaccinate, supporting its validity. Among parents (n = 137), pretest vaccination attitude scores predicted whether parents had ever refused a vaccination recommended for their children ($r = -0.453$, $P < 0.001$) and whether they had elected to have their children vaccinated for the flu in the past year ($r = 0.340$, $P < 0.001$). In addition, attitude scores also predicted whether participants had themselves elected to receive the flu vaccine in the past year ($r = 0.252$, $P < 0.001$; $n = 314$).

Participants. In the first part of this study, we recruited 811 participants through the Amazon Mechanical Turk work distribution website. This research was approved by the University of California, Los Angeles Institutional Review Board (IRB#12-000063) and participants were presented with consent information at the beginning of the study. Based on their responses to attention check questions, 720 of 811 were invited to return for the second half of the study. On day 2, 341 participants returned, and 315 participants passed attention check questions (160 female, 155 male; mean age = 35.44 y old, SD = 11.60). Pretest vaccine attitude scores did not differ between participants who completed the study ($n = 341$, mean = 4.86, SD = 1.04) and those eligible participants who did not return [$n = 379$, mean = 4.84, SD = 1.03; $t(718) = -0.306$, $P = 0.76$, $d = 0.02$, 95% highest density interval of the difference = −0.108, 0.181]. Fig. 3 shows the distribution of pretest vaccine attitudes among the 315 participants who passed attention checks on day 2 and composed the final sample for the study. The distribution is strongly peaked at the maximum score of six, although there is a long tail, indicating that many participants held less favorable attitudes.

Materials and Procedure. On day 1, participants were presented with the vaccine attitudes scale and asked to rate their agreement with each item on a six-point scale ranging from "strongly disagree" to "strongly agree." Participants also responded to an additional question about the link between vaccinations and autism (autism link question). Participants then answered questions about their beliefs on several different moral issues, such as abortion and euthanasia. These additional questions were meant to serve as distractors to prevent participants from identifying the purpose of the study on day 1 and prevent selection effects for participants returning for day 2 of the study. Finally, attention check questions were embedded within each of these scales to ensure that participants were properly attending to the task. For example, one attention question stated, "We just want to make sure you are paying attention. Select 'somewhat disagree' from the options below to pass this attention check."

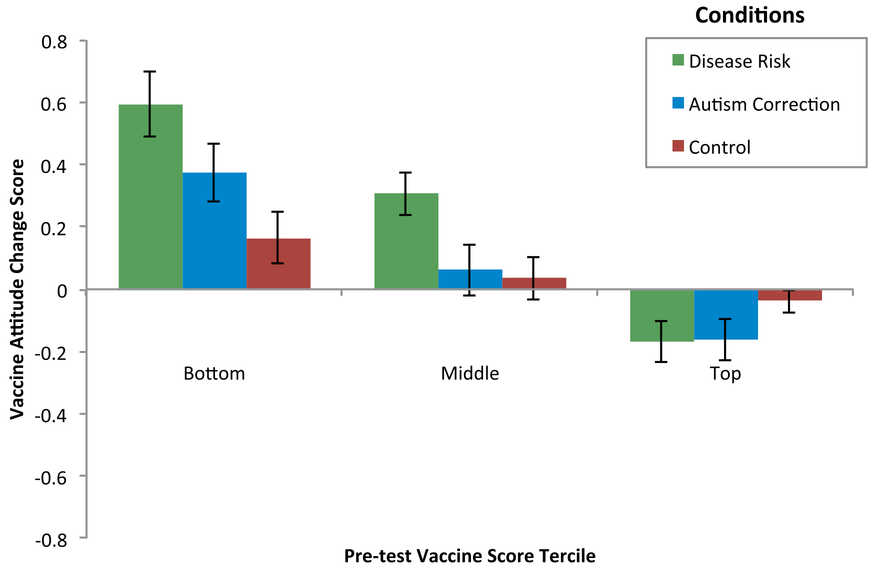

Fig. 2. Vaccine attitude change scores across conditions (posttest − pretest) divided into terciles based on pretest score. A 3 × 3 factorial ANOVA compared conditions among each tercile and revealed significant main effects of condition [$F(2,306) = 5.362$, $P = 0.005$, $\eta^2 = 0.034$] and tercile [$F(2,306) = 32.10$, $P < 0.001$, $\eta^2 = 0.173$]. A significant interaction was also observed between these two factors [$F(4,306) = 3.735$, $P = 0.006$, $\eta^2 = 0.047$], indicating that condition differences were greatest among participants in the bottom tercile. Change scores were significantly larger in the disease risk condition compared with the control condition among participants in the bottom [$t(65) = 3.23$, $P = 0.002$, $d = 0.79$, 95% highest density interval (HDI) of the difference = 0.126, 0.682] and middle [$t(77) = 2.76$, $P = 0.007$, $d = 0.62$, 95% HDI of the difference = 0.094, 0.473] terciles. Finally, in the top tercile, change scores were slightly negative for all three conditions, which might be expected because of both ceiling effects and regression to the mean. Change scores tended to be more negative for the disease risk condition than for the control condition, although this difference was not statistically significant [$t(66) = -1.79$, $P = 0.077$, $d = 0.44$, 95% HDI of the difference = −0.030, 0.020]. The weak regressive trend did not outweigh the overall positive effects of the disease risk intervention on vaccination attitudes for more skeptical participants.

At the end of their participation on day 1, participants who passed attention check questions were invited to return for the second part of the experiment on the following day (day 2). They were required to wait until the next day at 9:00 AM Pacific Standard Time before they could complete the second part of the study. Access to the study was closed at 8:00 PM Pacific Standard Time that day.

On day 2, participants were randomly assigned to read the information contained in the disease risk, autism correction, or control interventions. Participants assigned to the disease risk condition read three pieces of information in randomized order: (*i*) a paragraph written from a mother's perspective about her child contracting measles, (*ii*) a picture of a child with measles, a child with mumps, and an infant with rubella, and (*iii*) three short warnings about how important it is for people to vaccinate their children. Participants assigned to the autism correction condition read information summarizing recent research showing that vaccines do not increase the risk of autism in children. The materials presented in these two conditions were adapted from those used in a prior study (6) and were originally compiled from information from pages on the CDC website (www.cdc.gov). Participants assigned to the control condition read an unrelated vignette about a scientific topic (also used in a prior study) (6). For all three conditions, timing controls ensured that participants spent a sufficient amount of time reading the materials provided to them. After reading their assigned materials, participants were again asked to complete the vaccine attitude scale followed by the same distractor questions as on day 1. Finally, participants were asked several questions about their past vaccine behaviors and their intentions

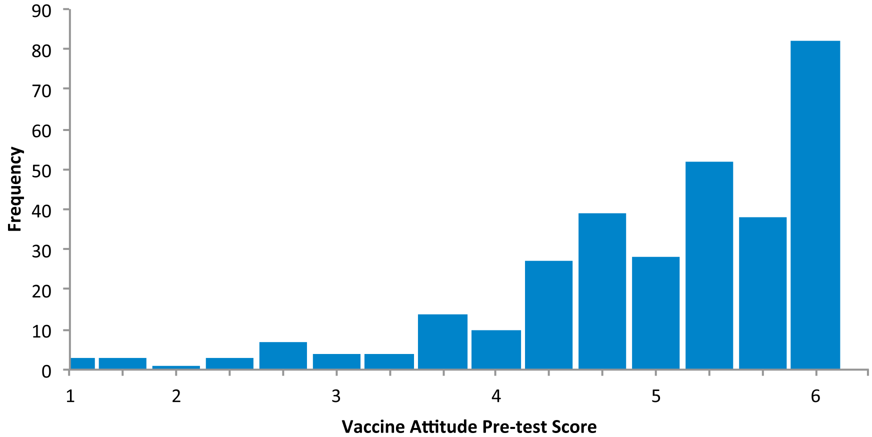

Fig. 3. Frequency of pretest vaccine attitudes.

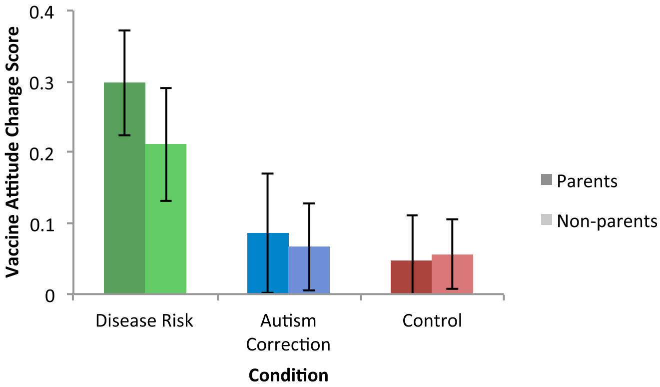

Fig. 4. Vaccine attitude change scores by condition for parents and nonparents.

to vaccinate their children in the future, and were asked to provide basic demographic information.

Intervention Results

We created a vaccination attitude change score, which was computed as the difference between participants' posttest and pretest vaccination attitude scores. As shown in Fig. 1, the disease risk condition led to larger changes in vaccination attitudes than the control condition. Attitude change scores were also more positive in the disease risk condition than the autism correction condition. In contrast, the autism correction condition had no greater effect on people's vaccination attitudes than did the control condition. Although presenting participants with evidence that there is no link between vaccinations and autism did not lead people to form even stronger antivaccination attitudes (6), this manipulation did not meaningfully alter people's existing attitudes about vaccinations.

To ensure that these findings hold equally for both parents and nonparents, vaccination attitude change scores were also analyzed across conditions for parents and nonparents (Fig. 4) using a two-way (condition × parenthood) ANOVA. As in the one-way ANOVA summarized in Fig. 1, the main effect of condition was significant [$F(2,309) = 5.219$, $P = 0.006$]. However, there was no main effect of parenthood [$F(1,309) = 0.338$, $P = 0.561$] nor any interaction between parenthood and condition [$F(2,309) = 0.254$, $P = 0.776$], indicating that parents and nonparents were similarly affected by our interventions. In addition, there were no pretest differences between parents' (mean = 4.89, SD = 0.969) and nonparents' (mean = 4.80, SD = 1.107) vaccine attitudes [$t(313) = 0.749$, $P = 0.454$].

Another concern might be that direct interventions are effective for people who already have positive attitudes toward vaccines but will introduce backfire effects or remain ineffective for vaccine skeptics or those with less favorable attitudes toward vaccines (6, 7). To test this possibility, we split participants into terciles based on their pretest vaccine attitudes and performed a 3 × 3 factorial ANOVA comparing conditions among each tercile (summarized in Fig. 2). This analysis revealed significant main effects of condition as well as a significant interaction between these factors, indicating that condition differences were greatest among participants in the bottom tercile. Change scores were significantly larger in the disease risk condition compared with the control condition among participants in the bottom tercile (Fig. 2). The disease risk intervention produced effects of a similar size for the bottom and middle terciles in an earlier pilot study (d values > 0.5), suggesting that these positive findings are both robust and replicable.

1. Centers for Disease Control and Prevention (2015) *Measles in the US*. Available at www.cdc.gov/media/releases/2015/t0129-measles-in-us.html. Accessed February 12, 2015.
2. Taylor LE, Swerdfeger AL, Eslick GD (2014) Vaccines are not associated with autism: An evidence-based meta-analysis of case-control and cohort studies. *Vaccine* 32(29):3623–3629.
3. Taylor B, et al. (1999) Autism and measles, mumps, and rubella vaccine: No epidemiological evidence for a causal association. *Lancet* 353(9169):2026–2029.
4. Wakefield AJ, et al. (1998) Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children. *Lancet* 351(9103):637–641.
5. Opel DJ, et al. (2013) The architecture of provider-parent vaccine discussions at health supervision visits. *Pediatrics* 132(6):1037–1046.
6. Nyhan B, Reifler J, Richey S, Freed GL (2014) Effective messages in vaccine promotion: A randomized trial. *Pediatrics* 133(4):e835–e842.
7. Nyhan B, Reifler J (2015) Does correcting myths about the flu vaccine work? An experimental evaluation of the effects of corrective information. *Vaccine* 33(3):459–464.
8. Lord CG, Ross L, Lepper MR (1979) Biased assimilation and attitude polarization: The effects of prior theories on subsequently considered evidence. *J Pers Soc Psychol* 37(11):2098–2109.
9. Von Neumann J, Morgenstern O (2007) *Theory of Games and Economic Behavior* (Princeton Univ Press, Princeton).
10. Nickerson RS (1998) Confirmation bias: A ubiquitous phenomenon in many guises. *Rev Gen Psychol* 2(2):175–220.
11. Lewandowsky S, Ecker UK, Seifert CM, Schwarz N, Cook J (2012) Misinformation and its correction: Continued influence and successful debiasing. *Psychol Sci Public Interest* 13(3):106–131.
12. Mayo R, Schul Y, Burnstein E (2004) "I am not guilty" vs "I am innocent": Successful negation may depend on the schema used for its encoding. *J Exp Soc Psychol* 40(4):433–449.
13. Popper K (2014) *Conjectures and Refutations: The Growth of Scientific Knowledge* (Routledge, London).
14. Schwarz N, Sanna LJ, Skurnik I, Yoon C (2007) Metacognitive experiences and the intricacies of setting people straight: Implications for debiasing and public information campaigns. *Adv Exp Soc Psychol* 39:127–161.
15. Kruschke JK (2013) Bayesian estimation supersedes the *t* test. *J Exp Psychol Gen* 142(2):573–603.