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Understanding parental vaccine refusal: Implicit and explicit associations about vaccines as potential building blocks of vaccine beliefs and behavior

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ABSTRACT

Objective: A movement of parents refusing vaccines for their children has contributed to increasingly large outbreaks of diseases that are preventable by vaccines. Research has identified multiple factors that relate to parents' vaccination behaviors (i.e., whether not they vaccinate their children), including their beliefs about vaccines' safety and utility and their trust in those who recommend vaccines. Here we examine the role of more fundamental psychological processes that may contribute to multiple vaccine-related beliefs and behaviors: cognitive associations.

Methods: Using a large sample of U.S. parents (pre-COVID-19), we investigated parents' associations between vaccines and helpfulness/harmfulness, as well as between the self and vaccines (vaccine identity), and their relation to parents' beliefs about vaccine safety and utility, trust in authorities' vaccine recommendations, and prior vaccination refusal for their children. To capture a more complete understanding of people's associations, we examined both explicit associations (measured via self-report) and implicit associations (measured by the Implicit Association Test).

Results: Both implicit and explicit associations correlated with beliefs, trust, and vaccination refusal. Results from structural equation models indicated that explicit vaccine-identity and vaccine-helpfulness associations and implicit vaccine helpfulness associations were indirectly related to vaccination refusal via their relation with vaccine beliefs.

Conclusions: Collectively, study findings suggest that vaccine associations—especially those related to helpfulness/harmfulness—may serve as psychological building blocks for parental vaccine beliefs and behaviors.

1. Introduction

The US licensed the measles vaccine for human use in 1963 (Katz, 2009) and by the turn of the 21st century, measles was declared eliminated from the US (Orenstein et al., 2004). Still, from the outset, measles vaccination efforts were met with skepticism by a movement now referred to as the *Anti-Vaccination* or *Anti-Vaxx* movement. Those involved coalesced around beliefs that vaccines were unnatural, poisonous, and could cause major psychobiological problems (Conis, 2019). As the internet and social media websites rose to prominence at the turn of the 21st century, so did the anti-vaccination movement (Hussain et al., 2018; Kata, 2010). The movement was further bolstered by celebrity support (e.g., Jenny McCarthy: Gottlieb, 2016; President Donald Trump: Sharfstein, 2017) and fraudulent scientific and personal claims (Eggertson, 2010). As anti-vaccination narratives became more common, US parents started refusing vaccines for their children more frequently (Meyer et al., 2019). Today more than half of US states (n = 28) fall below the Centers for Disease Control and Prevention vaccination coverage targets of 95% for two doses of the MMR (measles, mumps, and rubella) vaccine by kindergarten (Centers for Disease Control and Prevention, 2019b). As more parents refuse vaccinations, outbreaks of vaccine-preventable disease in children have increased. The case of measles is perhaps the most telling: In 2008, the US experienced its highest level of measles incidence (134 cases) in more than a decade (Parker Fiebelkorn et al., 2010), a spike dwarfed by cases in 2014 and 2015, when 667 measles cases were reported across the US (Clemmons et al., 2015; Zipprich et al., 2015). Then, the largest wave of measles infections in two and a half decades occurred in 2019 with 1282

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cases reported to the Centers for Disease Control and Prevention (2019a).

The MMR vaccine is, of course, only one of the vaccines that people opt not to give their children. Indeed, parents elect to opt out of a host of vaccines for children, including regular-interval vaccines like the annual flu vaccine (e.g., Gilkey et al., 2013; Gust et al., 2008) as well as new and emerging vaccines, like the H1N1 vaccine during the global outbreak in 2009 (Brown et al., 2010), the SARS-CoV-2 (COVID-19) vaccine (Goldman et al., 2020), and the Human Papilloma Virus vaccine (Kester et al., 2013; McRee et al., 2014; Roberto et al., 2011; Rosenthal et al., 2011). Vaccine refusal is a significant problem contributing to the spread of many vaccine-preventable diseases.

1.1. Understanding the factors underlying non-vaccination

Give recent outbreaks of vaccine preventable disease, it is essential to understand what drives parents not to vaccinate their children. Multiple factors appear linked to vaccine hesitancy and refusal (see Dubé et al., 2013 for a review). For example, public policy influences vaccination: Laws requiring vaccinations prior to children entering school dramatically increase vaccination rates (e.g., Averhoff et al., 2004; Orenstein and Hinman, 1999). Research has also identified specific demographic factors that predict vaccination, like socioeconomic status, race, political orientation, religion, and homeschooling (Kennedy and Gust, 2005; Shui et al., 2006; Thorpe et al., 2012). Other research suggests that interpersonal sources religious leaders and healthcare providers (Gargano et al., 2013; Shelton et al., 2013) as well as interactions with other parents on social media (Kata, 2010, 2012; Meyer et al., 2019) can influence willingness to vaccinate.

Parents' beliefs about vaccines and about those recommending vaccinations are also key factors associated with vaccination refusal. For instance, if parents believe that vaccines will cause harm to their children, they are less likely to vaccinate (Freed et al., 2010; Gottlieb, 2016; Hussain et al., 2018; Thorpe et al., 2012). If parents trust providers' and governmental recommendations about vaccination, they are more likely to vaccinate (Larson et al., 2014; Salmon et al., 2005; Thorpe et al., 2012). Parental beliefs also serve as critical mediating variables between many identified factors and vaccine-related behaviors. That is, the path *from* factors like religion, physician recommendations, and social information *to* vaccination behaviors typically flows through parents' perceptions of the safety, efficacy, and trustworthiness of vaccines and opinions about the people recommending vaccination.

1.2. The primacy of associative processes in evaluations

In the present study, we extend the investigation of parental beliefs by examining the possible associative processes—the linking of concepts or stimuli in memory—in vaccine-related beliefs and behaviors. To our knowledge, no study has evaluated vaccine-related associations. Nevertheless, there is reason to suspect that such associations might serve as a fundamental cognitive foundation for broader beliefs about vaccines and those who recommend them, including a large body of evidence linking associative process to everything from intergroup attitudes and behavior (Kurdi et al., 2019) to substance use (Rooke et al., 2008).

Research and theory suggests that evaluations of targets (e.g., vaccines), are based primarily in two automatic cognitive processes: association and proposition (Gawronski and Bodenhausen, 2011). The first process, *association*, happens automatically: People have positive or negative evaluations of a target (e.g., a negative evaluation of vaccines) that come from existing direct or indirect experience with the target or similar targets, and these feelings are strongest for regularly encountered targets. Crucially, associations—that is the general positive or negative evaluations associated with a target—are automatically *activated* when encountering that target. For instance, reading many online testimonies linking vaccines to autism spectrum disorders may create automatically active negative reactions to vaccines based on an association between vaccines and harm.

From there, people translate their initial feeling into a *proposition*—a statement of fact about their evaluations (e.g., "I dislike vaccines"). Finally, they *validate* the proposition by examining whether it is consistent with other relevant and activated propositions (e.g., thoughts about other vaccines). If the proposition is consistent with other relevant cognitions (e.g., "I think flu shots are a scam"), they will endorse the evaluative judgement. If the proposition conflicts with other relevant propositions (e.g., "I believe online testimonies about vaccines are usually false"), they will reject the evaluative judgement (Gawronski and Bodenhausen, 2011). Thus, people's beliefs about vaccines stem proximally from automatically activated associations, which subsequently inform evaluations and, ultimately, specific beliefs. Put succinctly and applying the theory to vaccines: People start to link (associate) vaccines with positive and negative evaluations and ideas based on their experiences, an automatic mental association. They then translate those associations into statements of fact (propositions) about their vaccine beliefs. They compare those statements of fact to their existing beliefs and decide whether to endorse (validate) them.

Similar associative processes can therefore result in different negative beliefs about vaccines. For instance, any two parents who share an association between vaccines and harm, and therefore have a negative evaluation of vaccines, may endorse different specific anti-vaccination beliefs: One parent may believe that vaccines are unnatural and poisonous to the body, another may believe that vaccines actually cause disease. Although these three beliefs differ semantically, they are joined by a common associative process: These parents all mentally link vaccines with harm. Thus, examining this common process may provide an important key to understanding the multitude of factors contributing to the non-vaccination behavior.

1.3. The limitations of self-reporting associations

Theory suggests that people will report negative evaluations regarding vaccines when they both have a negative association and that negative association aligns with their other cognitions. Nevertheless, it is likely that some people hold competing cognitions that are inconsistent with anti-vaccination beliefs. Indeed, the broader literature on *vaccine hesitancy* suggests that parents may be hesitant about vaccination, even when they believe vaccines are important for their children (Dubé et al., 2013; Larson et al., 2014; Leask et al., 2014). Moreover, despite their rising commonality, in some communities anti-vaccination beliefs are often portrayed as fringe and socially unacceptable (Capurro et al., 2018). Thus, even if people have negative associations with vaccines, they might not openly endorse those beliefs to avoid social embarrassment. In these cases, examining only the beliefs that people explicitly endorse misses some people's automatic negative associations. Researchers call the associations that people are willing and able to self-report *explicit* associations. By contrast they call the associations that people are either unwilling or unable to report or cannot control (e.g., because they are automatic or unconscious) *implicit* associations.

A comprehensive evaluation of vaccine associations would employ two measurement techniques. First, it would ask participants *directly* to self-report their associations to capture their *explicit* associations. Second, it would use *indirect* measures—measures wherein participants either do not know what is being measured or cannot easily control their responses—to capture people's automatic, uncontrolled responses, that is, their *implicit* associations (De Houwer, 2006). Although people's implicit and explicit associations are often related, they are independent—for example, one can have a positive explicit association but a negative implicit association (Dovidio et al., 1997; Nosek, 2007). As such, a comprehensive study would also investigate the interaction between these two concepts.

We know of no research that has examined vaccination beliefs using indirect measures, though health psychologists have called for

researchers to do so (Brewer et al., 2017). Nevertheless, the utility of indirect measures is suggested in the health domain (e.g., Howell and Ratliff, 2017; Ratliff and Howell, 2015; Sheeran et al., 2013a). For example, physician's implicit biases affect their care decisions (Green et al., 2007) and can perpetuate healthcare inequities (Chapman et al., 2013). Additionally, research suggests that implicit positivity toward people who tan predicts increased willingness and intention to engage in risky sun behaviors, like tanning (Howell and Ratliff, 2017; Ratliff and Howell, 2015). Indirect measures of attitudes and associations related to alcohol and other drugs have been shown to predict variance in drinking behaviors above and beyond self-report (Lindgren et al., 2018; Stacy and Wiers, 2010). In the domain of health promotion, positive implicit attitudes regarding have been linked to greater exercise rates (Padin et al., 2017) and interventions to improve implicit associations surrounding healthy eating has been linked to healthier food choice (Alblas et al., 2018).

That indirect measures predict unique variance in decision-making and behavior in medical and health behavior domains suggests their potential utility to capture associations that undergird beliefs and behavior related to vaccination. Indeed, doing so may inform the best possible paths for intervention (see Brewer et al., 2017 for additional discussion).

1.4. The present study

We recruited a large sample of parents to examine their associations, beliefs and behaviors related to vaccinating their children. Our primary interest was to understand factors that predict vaccine-related beliefs and refusal, particularly direct and indirect measures of vaccination-related associations, and to assess the unique predictive utility of these associations. We investigated two associations. First, we examined associations between vaccines and helpfulness/harmfulness. We chose to do so because research links positive associations related to a health behavior to engaging in that behavior (Howell and Ratliff, 2017) and because one of the biggest tenets of the anti-vaccination movement is that vaccines cause harm (Kata, 2010). Second, we examined identification with vaccines, that is, the extent to which people associate vaccination with the self. We chose to do so given evidence that personal identification with behavior can be as or more important than other associations (e.g., approach/avoid and/or affect-related associations) in predicting health beliefs and behavior (Lindgren et al., 2013, 2016). The results thus provide an exploratory test of whether personal identification with or general evaluations about vaccines are more important in predicting parents' beliefs and behavior.

2. Methods

2.1. Participants

Participants were 863 adult parents in the US recruited via Project Implicit (www.ProjectImplicit.com) between December 2014 and April 2015 (see Nosek, 2005; Nosek et al., 2007a,b for discussions of the representativeness of Project Implicit samples). Participant demographics appear in Table 1.

Table 1
Participant demographics.

Dimension	*M (SD)* or %
Age	40.6 (13.6)
Oldest Child's Age (note: 36% missing)	17.0 (11.9)
Number of Children	2.8 (1.3)
Gender	
Female	62%
Male	37%
Missing	1%
Expecting a child	
Yes	62%
No	37%
Missing	1%
Education	
High School or Less	3%
High School Degree/Some College/Associates Degree	34%
Bachelors/Some Graduate school	31%
Graduate/Professional degree	32%
Missing	1%
Ethnicity	
Hispanic or Latino	9%
Not Hispanic or Latino	78%
Unknown/Missing	13%
Race	
American Indian/Alaska Native	1%
East Asian	2%
South Asian	3%
Native Hawaiian or other Pacific Islander	1%
Black or African American	8%
White	75%
More than one race	7%
Unknown/Other/Missing	4%
Religiosity	
Not at all Religious	34%
Somewhat Religious	28%
Moderately Religious	25%
Very Religious	10%
Missing	3%
Political Orientation	
Very conservative	3%
Moderately conservative	10%
Slightly conservative	6%
Moderate	29%
Slightly liberal	8%
Moderately liberal	23%
Strongly liberal	18%
Missing	3%
Prior Vaccine Refusal	
Yes	9%
No	90%
Missing	18%

2.2. Procedure and measures

After completing informed consent, participants completed two indirect measures—two variants of the Implicit Association Test (IATs: Greenwald et al., 2009; one assessing vaccine identity; one assessing vaccine helpfulness)—and self-report questionnaires assessing six constructs (explicit vaccine identity, explicit vaccine helpfulness, vaccine beliefs, trust in authority recommendations, prior vaccine refusal, and demographics). Not relevant to the current study, participants also completed an additional IAT assessing associations with the self and helpfulness as well as self-report items about the self and helpfulness. To reduce fatigue, self-report questionnaires and IATs alternated, but the order of the questionnaires and IATs were separately randomized. Upon completion of the study, participants received IAT results and were directed to a debriefing page.

In sum, participants completed measures of implicit and explicit associations (primary predictors), attitudes toward vaccines and trust in authorities that might recommend vaccines (mediators), and prior vaccine refusal (outcome) in addition to basic demographic questions.

2.2.1. Predictors: Implicit Association Tests

The Implicit Association Test (IAT: Greenwald et al., 2009) is a computer-delivered reaction-time-based measure designed to examine mental associations between concepts. In an IAT, participants sort words and images from two sets of contrasting categories (e.g., vaccines and vitals; helpful and harmful) using the 'i' and 'e' computer keys. The IATs used in the study followed the traditional 7-block format (see Greenwald et al., 2009). Participants sort stimuli as quickly as possible, and they correct errors before proceeding to the next trial. For half of the relevant trials, the first category from each set is paired (e.g., 'vaccine' + 'helpful' use the 'e' key) and the second category from each set is paired (e.g.,

'vitals' + 'harmful' use the 'i' key). Participants sort stimuli that appear in the center of their screen into these two bins. For the other half of the IAT, the pairings switch (e.g., 'vitals + 'helpful' use 'e' & 'vaccines' + 'harmful' use 'i'). The order of the pairings is counterbalanced across participants. Stronger implicit associations are assumed to the extent that people categorize stimuli more quickly in one pairing (e.g., 'vitals + 'helpful' & 'vaccines' + 'harmful') relative to the other (e.g., 'vaccines' + 'helpful' & 'vitals' + 'harmful').

Vaccine Helpfulness IAT. We designed this IAT to evaluate the strength of relative associations between vaccines and helpfulness/harmfulness. Participants paired images related to the categories 'vaccines' (e.g., a physician giving a shot into a child's arm) and 'vitals' (e.g., a physician taking blood pressure from a child's arm) with words related to 'helpful' (e.g., good, helpful, beneficial, benefit, useful) and 'harmful' (e.g., bad, harmful, dangerous, damage, risky; (See Supplemental Fig. 1))—stimuli consistent with those used in published health-behavior harmfulness IATs (e.g., Ramirez et al., 2020). We decided to include category 'vitals' to ensure that negative associations were not generally directed at medical situations but were specific to vaccines.

Vaccine Identity IAT. We designed this IAT to evaluate the strength of relative associations between vaccines and the self/others. The vaccine identity IAT included the same 'vaccine' and 'vitals' categories and stimuli as the vaccine helpfulness IAT, and they were paired with words from the categories 'me' (me, mine, self, my) and 'not me' (they, them, theirs, other)—stimuli drawn from published health-behavior identity IATs (e.g., Lindgren et al., 2014).

IAT Scoring. We scored the IATs using the D_1 algorithm described in Greenwald et al. (2003). IATs were scored such that higher scores indicated stronger vaccine-helpfulness and vaccine-self associations. Data were screened consistent with recommendations from Nosek et al. (2007a,b): Participants with more than 10% fast trials (i.e., trials faster than 300 ms) were not included in analyses. Consequently, 11 scores for the vaccine helpfulness IAT and 9 scores for the vaccine identity IAT were not included. The internal consistency of the IATs was evaluated by correlating two D-scores: one for Blocks 3 and 6 and one for Blocks 4 and 7 (see Greenwald et al., 2003). Internal consistencies for the IATs were: vaccine helpfulness $r(614) = 0.65$, $p < .001$, $CI_{95\%} = [0.60, 0.69]$; vaccine identity $r(618) = 0.68$, $p < .001$, $CI_{95\%} = [0.63, 0.72]$.

On average, participants' vaccine helpfulness IAT scores were negative ($M = -0.16$, $SD = 0.51$), indicating faster categorization times when vaccines and harmfulness were paired than when vaccines and helpfulness were paired. By contrast, participants' average vaccine identity IAT scores were positive indicating faster categorization times when vaccines and me were paired than when vaccines and not me were paired ($M = 0.23$, $SD = 0.51$).

2.2.2. Predictors: explicit vaccine associations

We examined explicit vaccine associations using self-report items that matched the IAT constructs: (1) *vaccine helpfulness*–"To what extent do you think vaccines are helpful vs. harmful?" (1 = very harmful; 7 = very helpful), (2) *vaccine identity*–"To what extent do you associate vaccines with yourself vs. others?" (1 = very much associate with others; 7 = very much associate with me). We chose to use these semantic differential scales to match the IAT as is typical and recommended in studies employing IATs (Hofmann et al., 2005).

2.2.3. Outcome and mediator: trust in authority recommendations

Participants reported trust in health recommendations from (1) their "physician/pediatrician/primary care provider," (2) their "school/state health regulations," and (3) "the federal government guidelines" on a six-point scale ranging from 1 = *Completely Distrust* to 6 = *Completely Trust* (Nyhan et al., 2014). We loaded these beliefs onto a single latent index of trust in authority recommendations (α = 0.83).

2.2.4. Outcome and mediator: vaccination beliefs

We measured participants overall beliefs about the utility and safety of vaccines using a 7-item index (adapted from Freed et al., 2010; Nyhan et al., 2014) that included items like, "Generally I do what my doctor recommends about vaccines for my child(ren)" and, "My child(ren) does (do) not need vaccines for diseases that are not common anymore" (reverse coded; scale: 1 = *Strongly Disagree* to 5 = *Strongly Agree;* α = 0.76).

2.2.5. Outcome: vaccine refusal

Vaccine refusal was measured with four questions (adapted from Freed et al., 2010; Nyhan et al., 2014). First, participants indicated whether they had ever "refused a vaccine for [their] child(ren) that a doctor recommended" (*Yes, No*). This served as our primary outcome for vaccine refusal behavior. Participants answering affirmatively then indicated how many vaccines they had refused and then indicated which vaccines those that they had refused in an open-ended format. Finally, participants indicated whether each of 10 reasons for non-vaccination applied to their decision (e.g., "I have read or heard about problems with this vaccine," "This vaccine has not been on the market long enough"). The results for these latter two steps appear the online supplement.

2.3. Analysis

We analyzed the data in three steps. First, we examined vaccination beliefs and behaviors. Second, we examined the raw associations between primary predictor variables (implicit vaccine associations, their explicit measure counterparts, and demographics) and primary outcome variables (vaccine beliefs, trust in authority recommendations, and prior vaccination refusal). Finally, we used Structural Equation Modeling (SEM) to assess the unique predictive utility of the measures of association after controlling for other measures and to assess examine pathways to vaccine refusal. We conducted our SEM analysis in three steps. First, we predicted vaccine beliefs and trust in authority recommendations from the four (grand-mean centered) primary predictors as well as two interactions: 1) implicit by explicit vaccine helpfulness associations and 2) implicit by explicit vaccine identity. Second, we added direct and indirect (via vaccine beliefs and trust in authority recommendations) paths from these six predictors to prior vaccination behavior. Finally, we added in demographic factors to the model controlling for their direct effects on vaccine beliefs, trust in authority recommendations, and behaviors, and the correlation with our predictors. SEM was conducted using R Studio version 1.1.435, R version 3.4.3, and the lavaan package version 0.6–3. We used Full Information Maximum Likelihood estimation to obtain robust estimates for all pathways using all available data. All other analyses used SPSS version 24. Data and analysis scripts are available at https://osf.io/ng89r/.

3. Results

3.1. Description of vaccination beliefs and behaviors

Consistent with the general rarity of vaccine refusal in the population, a minority of participants ($n = 74$; 11% of those responding to the question) indicated that they had refused a vaccine for their child at some point. The most commonly refused vaccines were the flu vaccine (33.8%) and the human papillomavirus (HPV) vaccine (17.6%). Multiple participants also reported refusing Hepatitis (9.5%), Measles/Measles, Mumps, and Rubella (8.1%), Chicken Pox/Varicella (8.1%), and Diphtheria/Pertussis (4.1%) vaccinations. Additionally, 17% of participants fell at or below the midpoint of "neither agree nor disagree" on the measure of pro-vaccine beliefs. Most participants (68.3%) endorsed at least one anti-vaccination belief indicating at least some vaccine hesitancy. Half of these parents (50.0%) endorsed two or more anti-vaccination beliefs. The online supplement provides information about the frequency of vaccine refusal, the vaccines that people indicated they refused, and the reasons they endorsed for refusing them.

3.2. Correlations

Table 2 shows the correlation for all study variables. The online supplement presents correlations at the item-level for all measures. As expected, both types of implicit and explicit associations were associated with higher pro-vaccine beliefs, greater trust in authority recommendations, and lower likelihood of past vaccine refusal.

Consistent with previous findings, people more strongly endorsed pro-vaccine beliefs to the extent that they were politically liberal, educated, older, and less religious. Men also endorsed pro-vaccine beliefs more strongly than did women. Political identity, education, and age were significantly related to trust in authority recommendations such that people trusted authority recommendations regarding vaccinations more to the extent that they were politically liberal, educated, and older. Gender was the only demographic that related to prior vaccine refusal: Men were significantly less likely to have refused vaccines than were women.

3.3. Predictive utility of implicit and explicit associations

Fig. 1 shows the structural equation model used to examine the predictive utility of implicit and explicit associations. Here, we use the first two steps to estimate variance explained in the primary outcomes. Nevertheless, we report the path estimates from the full model. Table 3 shows the results for the primary regression paths at each step. Coefficients for all paths are available at https://osf.io/ng89r/.

3.3.1. Variance explained

Results from Step 1 revealed that implicit and explicit associations (and their interactions) explained 40% of the variance in vaccine beliefs and 26% of the variance in trust in authority recommendations. Results from Step 2 suggested that implicit and explicit associations, pro-vaccine beliefs, and trust in authority recommendations collectively explained 17% of the variance in vaccine refusal.

3.3.2. Associations→Trust in authority Recommendations→Prior vaccine refusal

In the full model, explicit and implicit vaccine helpfulness, but not vaccine identity, predicted trust in authority recommendations. Additionally, greater trust in authority recommendations was related to lower vaccine refusal. There was a negative indirect effect of explicit vaccine helpfulness on vaccine refusal via trust in authority recommendations: greater explicit vaccine helpfulness beliefs related to greater trust in authority recommendations, which, in turn, related to lower vaccine refusal. None of the other indirect effects nor interactions emerged.

3.3.3. Associations→Pro-vaccine Beliefs→Prior vaccine refusal

3.3.3.1. Pro-vaccine beliefs. In the full model, explicit and implicit vaccine helpfulness and explicit vaccine identity predicted pro-vaccine beliefs. Moreover, interactions between both implicit measures and their counterpart explicit measure emerged in predicting pro vaccine beliefs. As such, we examined the between implicit associations and pro-vaccine beliefs at high (+1*SD*) and low (-1*SD*) levels of explicit associations.

When it came to helpfulness associations, implicit vaccine-helpfulness associations were positively related to in positive vaccine beliefs when explicit vaccine-helpfulness associations were low, $b = 0.23$, $SE = 0.07$, $p < .001$, but not high, $b = 0.05$, $SE = 0.06$, $p = .35$. The opposite pattern was true for identification: Implicit identification predicted more positive vaccine beliefs among those high, $b = 0.13$, $SE = 0.06$, $p = .03$, but not low in explicit vaccine identification, $b = -0.04$, $SE = 0.06$, $p = .47$.

3.3.3.2. Prior vaccine refusal. Greater pro-vaccine beliefs related to lower vaccine refusal. Moreover, there was an indirect effect of explicit and implicit vaccine helpfulness and explicit vaccine identity on vaccine refusal via pro-vaccine beliefs: greater implicit and explicit vaccine helpfulness beliefs related to more positive vaccine beliefs, which, in

Table 2
Descriptive statistics and correlations for study variables.

	M (SD)	1	2	3	4	5	6	7
1. Vaccine Beliefs	3.78 (0.74)	–						
2. Vaccine Refusal[a,b]	*n* = 74	**−.35 [-.41, -.29]**	–					
3. Trust in Authority Recs.	4.77 (0.94)	**.51 [.45, .64]**	**−.31 [-.37, -.24]**	–				
4. Implicit-Vaccine Helpfulness	−0.16 (0.51)	**.24 [.16, .33]**	**−.16 [-.24, -.08]**	**.17 [.09, .26]**	–			
5. Implicit-Vaccine Identity	0.02 (0.51)	**.19 [.11, .27]**	**−.11 [-.18, -.02]**	**.10 [.02, .18]**	**.43 [.36, .54]**	–		
6. Explicit-Vaccine Helpfulness	6.44 (1.14)	**.51 [.45, .64]**	**−.29 [-.36, -.22]**	**.46 [.39, .58]**	**.14 [.06, .23]**	**.15 [.07, .24]**	–	
7. Explicit-Vaccine Identity	5.04 (1.74)	**.25 [.17, .33]**	**−.09 [-.17, -.01]**	**.23 [.15, .31]**	**.19 [.11, .27]**	**.14 [.06, .22]**	**.28 [.21, .36]**	–
8. Political Identity	0.78 (1.70)	**.23 [.15, .30]**	−.06 [-.14, .01]	**.13 [.05, .20]**	**.13 [.05, .21]**	.04 [-.04, .12]	**.03 [-.04, .11]**	**.11 [.04, .19]**
9. Education	2.93 (0.88)	**.25 [.18, .33]**	−.06 [-.13, .01]	**.12 [.05, .20]**	.03 [-.05, .11]	.05 [-.03, .13]	**.13 [.06, .21]**	**.11 [.03, .18]**
10. Gender[c]	62% Women	**.11 [.04, .18]**	**−.09 [-.16, -.02]**	.07 [-.01, .14]	.03 [-.05, .11]	−.05 [-.12, .03]	.06 [-.02, .13]	−.07 [-.14, .01]
11. Religiosity	2.12 (1.01)	**−.17 [-.24, -.09]**	.03 [-.04, .10]	−.04 [-.11, .04]	−.01 [-.09, .07]	−.01 [-.09, .07]	−.09 [-.16, −.01]	−.01 [-.08, .07]
12. Age	40.61 (13.62)	**.12 [.04, .19]**	−.05 [-.12, .03]	**.08 [.01, .15]**	−.07 [-.15, .01]	**−.08 [-.16, -.003]**	**.13 [.06, .21]**	.06 [-.01, .14]

Bold indicates $p < .05$.

[a] Vaccine Refusal was coded 0 = no refusals, 1 = any vaccine refusals. All correlations with vaccine refusal represent point-biserial correlations, except for the correlation with gender, which represents a phi correlation.

[b] The number of vaccines refused was positively skewed (skew = 3.21, *SE* = .28), as such we used and report here the non-parametric Spearman's rank order correlation (Spearman's rho) for that outcome.

[c] Gender was coded 0 = Women, 1 = Men.

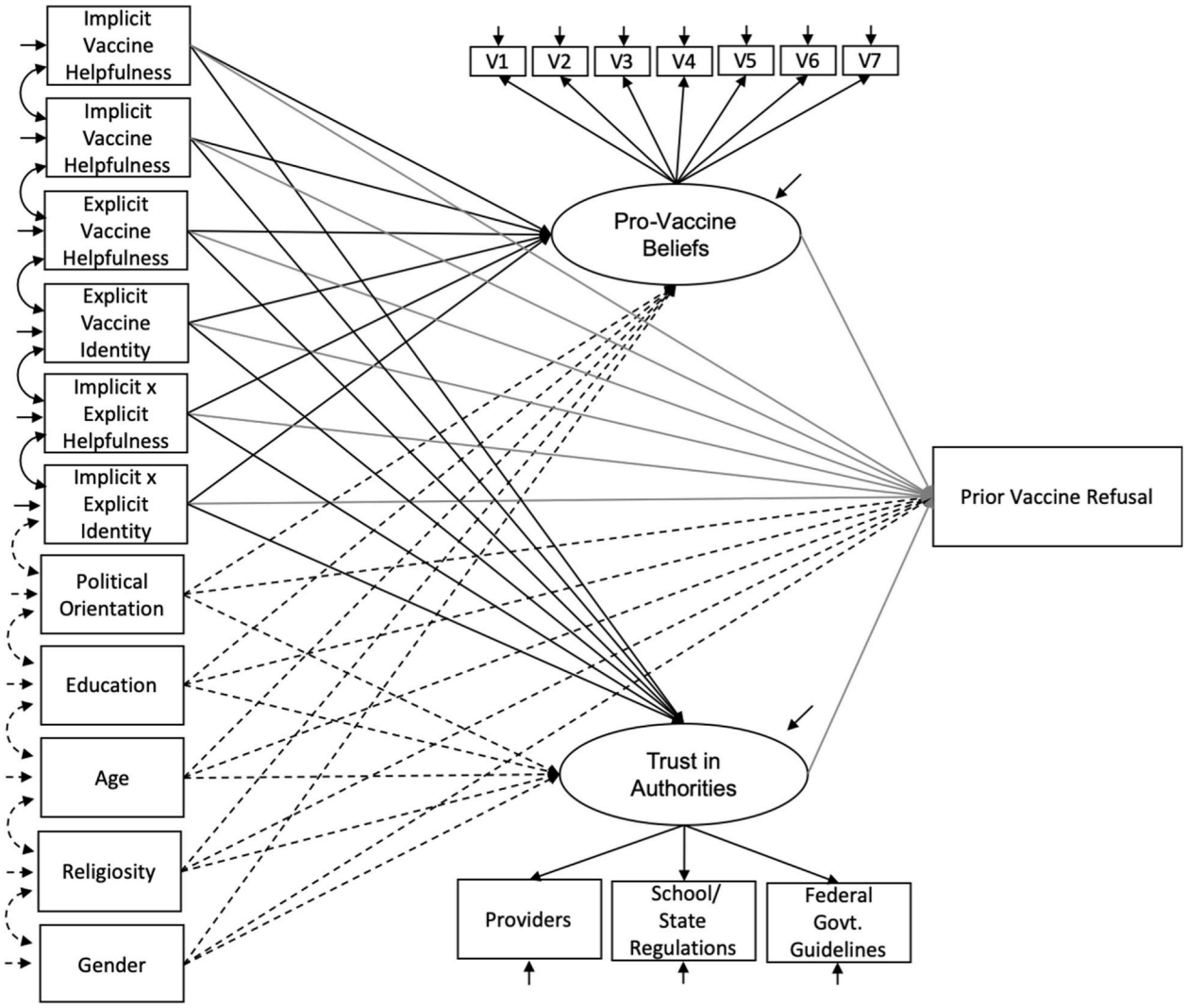

Fig. 1. Three-step structural equation model using implicit and explicit associations and their interactions to predict pro-vaccine beliefs and trust in authority recommendations (Step 1; solid black paths), examining direct and indirect (via pro-vaccine beliefs and trust in authority recommendations) and associations between of these variables and prior vaccine refusal (Step 2; gray lines represent paths added), and finally controlling for demographic variables (Step 3; dashed lines represent paths added). All predictors were correlated; only neighboring correlations are shown, for ease of visualization.

turn, related to lower vaccine refusal.

3.3.4. Demographic predictors in the full model

Only four demographic paths were significant in the final model: Those who were more liberal, more educated, less religious, and men were more likely to report pro-vaccine beliefs. Additionally, those who were more liberal were more likely to trust authority recommendations. Demographic variables explained an additional 11% of the variance in vaccine beliefs and an additional 2% of the variance in both trust in authority recommendations and vaccine refusal.

4. Discussion

We examined parental implicit and explicit vaccine associations, vaccine beliefs, trust in authority' vaccination recommendations and prior refusal of a vaccination for one's child(ren) in a large, online sample of parents. Of those parents, 11% reported prior vaccine refusal. Still, most parents (68.3%) endorsed at least one anti-vaccination belief, indicating some vaccine hesitancy in the majority of our sample. Consistent with previous research, those who were older, more politically liberal, more educated, less religious, and men endorsed more positive vaccine beliefs. Additionally, more politically liberal participants trusted authority recommendations more. Novel to the current study, implicit and explicit vaccine-helpfulness associations and vaccine identity related to greater pro-vaccine beliefs, greater trust in authorities' vaccine recommendations, and lower likelihood of past vaccine refusal.

In a structural equation model, stronger implicit and explicit vaccine-helpfulness associations and stronger explicit self-vaccine associations related independently to greater endorsement of pro-vaccine beliefs and more trust in authority recommendations. Those associations were also related to lower likelihood of prior vaccine refusal indirectly, via pro-vaccine beliefs, even after controlling for demographics. Additionally, explicit, but not implicit vaccine-helpfulness related to lower likelihood of prior vaccine refusal indirectly via trust in authority recommendations even after controlling for demographics.

Interestingly, interactions between implicit and explicit beliefs also emerged and suggested that increased implicit vaccine-helpfulness associations related to more-positive vaccine beliefs when explicit vaccine-helpfulness associations were low or average, but not high. Put another way, implicit associations were most important for those who did not self-report strongly associating vaccines with helpfulness. By contrast, greater implicit vaccine identity related to more-positive vaccine beliefs when explicit vaccine identity was high but not average or

Table 3
Results from three-step structural equation models using implicit and explicit associations to predict pro-vaccine beliefs and trust in authority recommendations (Step 1), as well as prior vaccine refusal both directly and indirectly via pro-vaccine beliefs and trust in authority recommendations (Step 2), then controlling for demographics (Step 3).

	Step 1		Step 2			Step 3				
	Pro-Vaccine Beliefs	Trust in Auth. Recs.	Vaccine Refusal			Pro-Vaccine Beliefs	Trust in Auth. Recs.	Vaccine Refusal		
	Direct	Direct	Direct	Indirect via Pro-Vaccine Beliefs	Indirect via Trust in Auth. Recs.	Direct	Direct	Direct	Indirect via Pro-Vaccine Beliefs	Indirect via Trust in Auth. Recs.
Explicit-Helpfulness	.24 (.03)**	.21 (.02)**	−.01 (.01)	−.04 (.01)**	−.02 (.01)**	.20 (.03)**	.21 (.02)**	−.01 (.01)	−.04 (.01)**	−.02 (.01)**
Explicit- Identity	.04 (.01)**	.03 (.01)*	.01 (.01)	−.01 (.002)**	−.002 (.001)	.04 (.01)**	.02 (.01)	.01 (.01)	−.01 (.002)**	−.002 (.001)
Implicit-Helpfulness	.16 (.05)**	.15 (.05)**	−.03 (.03)	−.03 (.01)**	.004 (.01)	.14 (.05)**	.14 (.05)**	−.03 (.03)	−.03 (.01)**	.004 (.01)
Implicit- Identity	.05 (.05)	−.04 (.05)	−.01 (.03)	−.01 (.01)	.004 (.01)	.04 (.04)	−.04 (.05)	−.01 (.03)	−.01 (.01)	.004 (.01)
Implicit x Explicit-Helpfulness	−.05 (.04)	−.07 (.05)	−.01 (.02)	.01 (.01)	.01 (.004)	−.08 (.04)*	−.08 (.04)	−.01 (.03)	.01 (.01)	.008 (.004)
Implicit x Explicit-Identity	.06 (.03)*	.04 (.03)	−.01 (.02)	−.01 (.01)*	−.01 (.003)*	.05 (.02)*	.04 (.03)	−.01 (.02)	−.01 (.01)	−.005 (.003)
Vaccine Beliefs			−.16 (.04)**					−.18 (.04)**		
Trust			−.10 (.03)**					−.10 (.03)**		
Political Orientation						.05 (.01)**	.04 (.01)**	.00 (.01)		
Education						.12 (.03)**	.02 (.03)	.02 (.01)		
Age						.00 (.001)	.00 (.002)	.00 (.001)		
Gender						.09 (.04)*	.06 (.04)	−.03 (.02)		
Religiosity						−.06 (.02)**	.01 (.02)	−.01 (.01)		
R^2	.40	.26	.17			.51	.28	.17		
χ^2	673.63		774.01			835.74				
RMSEA	.09 [.09, .10]		.10 [.09, .10]			.08 [.07, .08]				

*$p < .05$, **$p < .01$; *Note:* the estimates for the direct effects on predict pro-vaccine beliefs and trust in authority recommendations in Step 1 do not change in Step 2, thus we do not report them in a separate column.

low. Put another way, implicit vaccine identity only mattered for those who self-reported high vaccine identity. Collectively, these findings suggest that associations between vaccines and helpfulness and, to a lesser extent, associations between vaccines and the self might serve as fundamental building blocks for anti-vaccination beliefs and behaviors. Nevertheless, the relationship appears to be nuanced in predicting beliefs—implicit attitudes matter most for those who explicitly identify with vaccines and those who associate vaccines with harmfulness.

4.1. Implications and applications

Despite calls for studies examining implicit processes in vaccine decision-making (Brewer et al., 2017), as far as we know, this study is the first to demonstrate the role of implicit and explicit associations in vaccine-related beliefs and decisions. In so doing, the study adds to the body of work implicating associative processes in health decision-making and behavior: Specifically, the findings suggest that vaccine-related decision-making may be a function of both implicit and explicit associative processes as are behaviors such as alcohol use (Lindgren et al., 2018; Stacy and Wiers, 2010), UV-related behavior (Howell and Ratliff, 2017; Ratliff and Howell, 2015), and exercise (Padin et al., 2017), among others. Additionally they contribute to the broader literature linking implicit processes to physical health (e.g., Avishai and Sheeran, 2020; Chapman et al., 2013; Sheeran et al., 2013b, 2016).

Additionally, this study suggests that understanding the anti-vaccination movement may require more than asking people to report on their thoughts and associations about vaccination directly. Thus, when attempting to understand anti-vaccination beliefs and behaviors, researchers should consider employing indirect measurement approaches, like the IAT, as a companion to direct measurement approaches and consider the interaction between the attitudes captured on these two types of measures.

The IATs developed for this study showed good internal consistency and correlated in expected ways with convergent and divergent factors, suggesting that they are good candidates for future research. Their explicit measure counterparts were also robust predictors of vaccine beliefs, suggesting that they are good candidates for future research as well. Longitudinal research could examine the effects of societal and policy changes related to vaccines on personal- and societal-level changes in implicit and explicit vaccine associations.

Further evidence that implicit and explicit associations are important to consider comes from the weak positive relationships between implicit and explicit vaccine associations and the interactions between them. The modest overlap between these measures is consistent with the larger literature on implicit and explicit associations (Greenwald et al., 2009) and suggests a need to include both indirect and direct measures of vaccine perceptions in future studies. Moreover, the interaction between the two measures suggests that one cannot fully understand vaccine-related beliefs and behaviors without understanding the unique

and joint contributions of implicit and explicit associations.

The present findings also suggest that interventionists wishing to reduce anti-vaccination beliefs and behavior may consider targeting implicit helpfulness/harmfulness associations. Research already suggests that many current interventions—particularly knowledge interventions—often fail to change people's minds or promote vaccination (Nyhan et al., 2014). The present work suggests a possible reason that earlier interventions did not work is that they did not consider implicit processes—that is, the idea that people may be unwilling or unable to report a gut sense that vaccines are harmful. Although implicit associations can be quite difficult to change (Lai et al., 2013, 2016), interventions might aim to disrupt the role of implicit processes in vaccine decision making broadly.

Other research on broadly disrupting implicit processes in behavior suggests that there are three possible levels that interventionists can target to improve vaccine uptake (Lai and Banaji, 2019). First, interventionists can change the situation in which decision are made via policy. For instance, reducing exemptions to vaccine requirements for school entry can increase vaccine uptake, regardless of parents beliefs (Orenstein and Hinman, 1999). Second, interventionists can work on disrupting associations by reducing exposure to false information (e.g., by shutting down anti-vaccination social media groups that communicate false scientific information) and increasing exposure to more accurate scientific information. Finally, becoming aware of one's implicit vaccine-harmfulness associations, particularly if one explicitly endorses pro-vaccine beliefs, can allow greater control over one's behavior and lessen the influence of implicit beliefs.

One final striking finding was that over 68% of parents endorsed at least one anti-vaccination belief. This finding suggests that people may be experiencing some vaccine hesitancy that may be primed to affect later behavior (e.g., allowing one's child to get a new and important vaccine like the COVID-19 vaccine during the COVID-19 pandemic). In so doing, it lends additional credence to the notion that people may have conflicting propositional beliefs (Gawronski and Bodenhausen, 2011), making indirect measures all the more important to consider in addition to direct measures. The observation of conflicting explicit beliefs is consistent with the literature on vaccine hesitancy (Dubé et al., 2013; Larson et al., 2014; Leask et al., 2014), which suggests that people sometimes hold only a few negative beliefs regarding vaccines and their effectiveness and that those mixed beliefs can make them hesitant to vaccinate. This finding further highlights the need to examine and identify fundamental cognitive processes that might underlie multiple different anti-vaccination beliefs.

4.2. Limitations and future directions

The present study is limited in at least four ways that can be addressed in future research. First, behavior in the study (i.e., vaccination refusal) was self-reported and retrospective. It is possible that parents who refused vaccinations prior simply forgot that they had done so. Indeed, vaccine coverage for the flu is only around 60% suggesting that there are perhaps more than 11% of parents refusing the vaccine (Centers for Disease Control and Prevention, 2021). Future research should more directly observe vaccination-related behavior, for instance by reviewing children's medical records. Another limitation is the study's retrospective correlational nature. Because participants completed all measures at a single time point, we cannot draw conclusions about directionality or third variable influences. Our hope was to provide an initial proof of concept, establishing that (1) it is possible to measure implicit vaccine associations and (2) that those associations offer predictive value beyond self-reported associations. The obvious next step in this work is to invest in a longitudinal assessment of these associations and vaccine-related beliefs and behavior. Doing so will allow researchers to more directly examine whether vaccine associations precede the formation of anti-vaccination attitudes and behaviors, and changes that occur as a consequence of any law or policy efforts to increase vaccination. Relatedly, the present data were collected during the 2014 and 2015 measles outbreak that preceded the record-breaking measles outbreak of 2019 and, ongoing as of writing of this article, the COVID-19 pandemic. We think the same basic processes likely apply today, but research is needed with a contemporary cohort and considering new and emerging vaccines. Relatedly, the sample was disproportionally White, offering a clear constraint on generalizability to non-White populations, who might face specific and different disease burden from vaccine-preventable diseases (Roberts et al., 2020). Future research targeting non-white samples is essential.

Third, both our implicit and explicit measures were based in a dichotomy (e.g., comparing vaccines-harmful vs. vaccines-helpful). This bipolar differential is inherent in the standard IAT. As such, we also chose to use it in our explicit measures—to ensure they were capturing the same implicit/explicit construct. Nevertheless, it is possible that people are conflicted regarding vaccines—they may find them both helpful and harmful. Our measures were not sensitive to such ambiguity. As such, we recommend that future studies employ unipolar scales and implicit measures that allow for the detection of more ambiguity in responses (e.g., single-category and single-target IATs). Relatedly, the IAT is one of several measurement approaches to assessing implicit attitudes (see Gawronski and Hahn, 2019); however, its psychometric properties are among the strongest (Bar-Anan and Nosek, 2014). Future studies might consider using other types of measures (e.g., the extrinsic affective Simon task, De Houwer, 2006; the Affect Misattribution Procedure, Payne et al., 2005), or multiple measures in concert, to fully assess implicit attitudes.

Fourth, in an effort to reduce participant burden, we were only able to assess two implicit vaccination associations. It is possible that other factors, like implicit trust in healthcare providers might provide additional explanatory utility. As such, we recommend that future work examine other types of implicit vaccine-related associations. Finally, given the relative rarity vaccine refusal (here 11%) replication with a larger sample is warranted.

5. Conclusions

This study provides novel insight into the role of implicit and explicit associations in parents' vaccine-related beliefs and behaviors. The findings particularly implicate vaccine-helpfulness/harmfulness associations in predicting vaccine beliefs and behavior. Study results add to an emerging literature implicating implicit and explicit processes as partners in health decision-making and suggest that interventionists should consider implicit and explicit processes. Although further investigation in a larger and more socio-demographically diverse longitudinal sample will provide a richer picture of the role of implicit attitudes in vaccine beliefs and behavior, ultimately, the present findings suggest the utility of considering basic cognitive processes when seeking to understand the anti-vaccination movement and resultant vaccine-preventable disease outbreaks.

CRediT statement

Jennifer Howell: Conceptualization, Data curation, Formal Analysis, Writing-Original Draft, Visualization. **Melissa Gasser:** Conceptualization, Writing- Review & Editing, Investigation, Software. **Debra Kaysen:** Conceptualization, Writing- Review & Editing. **Kristen Lindgren:** Conceptualization, Methodology, Software, Formal Analysis-Secondary, Investigation, Data curation, Supervision, Writing- Review & Editing, Resources.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2022.115275.

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