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A little shot of humility: Intellectual humility predicts vaccination attitudes and intention to vaccinate against COVID-19

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Abstract

Vaccinations remain a critical, albeit surprisingly controversial, health behavior, especially with the promise of widely available COVID-19 vaccine. Intellectual humility, a virtue characterized by nonjudgmental recognition of one's own intellectual fallibility, may counter rigidity associated with anti-vaccination attitudes and help promote vaccine-related behaviors. This study investigated whether intellectual humility is related to anti-vaccination attitudes and intentions to vaccinate against COVID-19, and whether intellectual humility can predict unique variance in these outcomes beyond participant demographic and personal factors. Participants ($N = 351$, 57.23% male, mean age = 37.41 years, $SD = 11.51$) completed a multidimensional measure for intellectual humility, the anti-vaccination attitudes (VAX) scale, and a two-item COVID-19 vaccination intention scale. Bivariate correlations demonstrated that intellectual humility was negatively related with anti-vaccination attitudes overall, $r(349) = -.46$, $p < .001$, and positively related to intentions to vaccinate against COVID-19, $r(349) = .20$, $p < .001$. Hierarchical multiple regression revealed that intellectual humility predicted all four types anti-vaccination attitudes, overall anti-vaccination attitudes, and COVID-19 vaccination intentions above and beyond demographic and personal factors (i.e., sex, race/ethnicity, age, education, socioeconomic status, and political orientation), ΔR^2 between .08 and .18, $ps < .001$. These results bolster intellectual humility as a malleable psychological factor to consider in efforts to combat anti-vaccination attitudes and promote COVID-19 vaccination uptake.

1 | INTRODUCTION

Vaccines are effective at curbing infectious diseases; however, a resurgence of anti-vaccination attitudes may worsen vaccine uptake at exactly the wrong time—during a global pandemic (Bertin et al., 2020; Smith & Reiss, 2020). For example, researchers have noted drastic increases in social media activity relating to anti-vaccination sentiment and COVID-19 (e.g., Burki, 2020; Puri et al., 2020). As of the beginning of December 2020, there have been more than 14.5 million cases of COVID-19, resulting in more than 280,000 deaths in the United States (Centers for Disease Control and Prevention [CDCP],

2020b). Thus, efforts to combat the pandemic may require parallel efforts to discover factors that may counter anti-vaccination attitudes and promote vaccination uptake, alongside the logistics of distributing the vaccines.

Vaccination attitudes are positive, negative, or neutral evaluations of vaccines (Eagly & Chaiken, 1993; Martin & Petrie, 2017). According to functional theories of attitudes (Katz, 1960; Shavitt, 1989), attitudes perform specific functions for the individual, functions related to knowledge and ego-defense may explain the persistence of anti-vaccination attitudes. Regarding knowledge, attitudes help people organize and structure the external world and

provide consistency as they evaluate new information (Katz, 1960; Shavitt, 1989). Thus, the existence of certain anti-vaccination attitudes may lead people to reject new information about vaccine effectiveness or new vaccines themselves (e.g., a COVID-19 vaccine) because they are inconsistent with their existing attitudes. Regarding ego-defense, attitudes help people cope with anxieties related to internal or external conflicts (Katz, 1960; Shavitt, 1989). For example, picking a side of the controversial debate about vaccines (i.e., settling on certain anti-vaccination attitudes) may quell the persistent apprehension surrounding vaccines. Thus, researchers should look to identify psychological factors that may mitigate these inflexible attitudes, which function to validate rigid knowledge structures and ego-defensive positions.

Intellectual humility, a virtue characterized by having a "non-threatening awareness of one's intellectual fallibility" (Krumrei-Mancuso & Rouse, 2016, p. 210), may refute people's inaccurate and dogmatic perceptions of vaccinations. Intellectual humility directly addresses the need to have flexibility in one's pursuit of knowledge and the need to form hypo-egoic positions (Banker & Leary, 2020). To our knowledge, there is only one study that has directly examined the relationship between intellectual humility and anti-vaccination attitudes (Senger & Huynh, 2020). Thus, a critical evaluation of their findings is imperative to the current study. First, the reported association was quite weak (i.e., $r(237) = -.14$, $p = .04$) and the researchers' presentation of bivariate correlations failed to highlight intellectual humility's unique role as a predictor. Thus, research is needed to demonstrate intellectual humility's ability to predict anti-vaccination attitudes above and beyond other factors (e.g., demographics). Senger and Huynh (2020) also found that intellectual humility was unrelated to intentions to vaccinate against the seasonal flu. Because this study was conducted prior to the COVID-19 era, it may have potentially failed to capture the essence of the pervasive anti-vaccination tide (Burki, 2020), and thus, unintentionally undersold intellectual humility's value in predicting anti-vaccination attitudes. Additionally, as noted in their limitations section, although their study focused on the seasonal flu, their data collection occurred outside of peak flu season (CDCP, 2018). Thus, concerns about the flu were not as prevalent. In contrast, this study examines intellectual humility's relationship with anti-vaccination attitudes and intention to vaccinate against COVID-19 in the midst of the crisis, when disease severity and susceptibility may be elevated (e.g., health beliefs model; Rosenstock, 1974). Moreover, this study employs hierarchical regression, in addition to bivariate correlations, to examine intellectual humility's unique ability to predict anti-vaccination attitudes and intentions, while accounting for other factors' contributions.

1.1 | Intellectual humility

Various definitions of intellectual humility exist (e.g., Davis et al., 2016; Hoyle et al., 2016; Samuelson et al., 2015), but for the current study, we subscribed to a four-facet conceptualization of intellectual humility (Krumrei-Mancuso & Rouse, 2016). The first facet,

Independence of Intellect and Ego, allows a person to be secure in their own opinions. In the context of contentious debates, such as whether or not individuals should vaccinate, this facet may manifest as perceiving a challenge to one's opinion non-threateningly. Second, Openness to Revising One's Viewpoint allows one to shift their opinion when faced with substantial alternative evidence. For example, someone displaying this facet may change their anti-vaccination attitudes to that of pro-vaccination when faced with convincing evidence of vaccine effectiveness. Third, Respect for Other's Viewpoints facilitates civil discourse to occur, despite holding a conflicting view. An example of an individual displaying this facet might be a person calmly discussing their anti-vaccination or pro-vaccination beliefs with someone of the opposite viewpoint. Finally, Lack of Intellectual Overconfidence helps one sidestep intellectual arrogance. An individual showcasing this facet might be willing to admit either directly or indirectly that they do not know all there is to know about vaccinations.

Intellectual humility can help be helpful when discussing contentious topics such as religion and politics (Hoyle et al., 2016; Leary et al., 2017; Porter & Schumann, 2018). For example, people who are high in intellectual humility are less willing to perceive their religious views as superior and are more likely to label essays arguing opposing religious views as accurate (Leary et al., 2017). Additionally, intellectually humble pastors were found to be more tolerant of diverse religious views (Hook et al., 2017). Moreover, intellectually humble people were more likely to seek knowledge that disavow their views rather than confirming it (Porter & Schumann, 2018). Thus, it is possible that intellectually humble people may be more likely to reassess their position on vaccinations and be more tolerant of alternative positions.

Furthermore, intellectual humility is also linked to memory and knowledge (Deffler et al., 2016; Krumrei-Mancuso et al., 2020). In a memory task, people high in intellectual humility were better able to distinguish between what they have seen before and new items indicating better memory (Deffler et al., 2016). Additionally, one study found that people lacking intellectual humility overestimated their performance on cognitive tests (Krumrei-Mancuso et al., 2020). Furthermore, intellectual humility has a positive association with general knowledge, intelligence, and cognitive flexibility (Krumrei-Mancuso et al., 2020; Zmigrod et al., 2019). Intellectual humility's association with these particular constructs may be relevant to vaccination attitudes and intentions due to the knowledge needed to evaluate the benefits and risks of health behavior (i.e., theory of planned behavior; Ajzen, 1991).

Recently, intellectual humility was studied within the contentious topic of vaccinations (Senger & Huynh, 2020). Using an online sample, the researchers found that intellectual humility negatively (but weakly) correlated with anti-vaccination attitudes. They demonstrated that this relationship was mostly driven by the association between anti-vaccination attitudes and the facets of Openness to Revising One's Viewpoint and Lack of Intellectual Overconfidence. However, they found that intellectual humility was unrelated to seasonal flu vaccination intention.

1.2 | Vaccination attitudes

Anti-vaccination attitudes can be conceptualized as a multidimensional construct with four facets (Martin & Petrie, 2017; Martinez-Berman et al., 2020). The first facet, Mistrust of Vaccine Benefit, highlights people's incredulity in vaccines' ability to safeguard against infectious diseases. For example, someone who holds anti-vaccination attitudes would not trust in a vaccine's ability to protect against a specific disease. The second facet, Worries about Vaccine's Unforeseen Future Effects, illustrates people's concern about potential side effects of vaccines. The third facet, Concerns about Commercial Profiteering, encapsulates people's wariness about the influence of the powerful pharmaceutical companies in the development and deployment of vaccines. People who hold this subset of anti-vaccination attitudes may have concerns about potentially imprecise vaccines because of pharmaceutical companies' profit-focused drive for its development. Finally, the fourth facet is Preference for Natural Immunity (Martin & Petrie, 2017). This facet reflects the mistaken belief that natural immunity is superior to vaccinations. Together, the facets reflect the varied representations of anti-vaccination attitudes. The critical element that bonds these anti-vaccination attitudes may be people's dogmatic subscription to them (Martin & Petrie, 2017). Intellectual humility, marked by its flexible approach to knowledge (Zmigrod et al., 2019), may negate these obstinate anti-vaccination attitudes by allowing people to objectively evaluate the evidence for vaccinations and adjust their positions accordingly.

1.3 | Vaccine intentions

Intention to vaccinate or vaccine intention is commonly used to predict vaccination rates (e.g., Barnack et al., 2010; Dhalla et al., 2012). Vaccine intentions are particularly important to measure because a COVID-19 vaccine does not exist yet; therefore, it is critical to predict how the vaccine will be received. Vaccine intentions are an important component in predicting and determining health behavior, especially when measured in conjunction with attitudes (i.e., theory of planned behavior; Ajzen, 1991; Kahn et al., 2003). Vaccine intentions may be predicted by vaccination attitudes, which are associated with health benefits, such as the reduction of disease-related complications and a reduced need for medical attention (Myers & Goodwin, 2011). Additionally, knowledge of vaccines is a known predictor of vaccine uptake further illustrating the construct's utility in public health (Betsch & Wicker, 2012). Because knowledge of vaccinations is an important predictor of vaccine uptake, intellectual humility could potentially support efforts to increase vaccination against COVID-19 by opening people to scientific knowledge about vaccines, which they may not have considered otherwise.

1.4 | Demographic and personal factors

Various demographic factors are related to vaccine uptake and intentions and should be considered in a model examining such outcomes.

For example, vaccination uptake was significantly higher in men than women during the 2009 H1N1 pandemic and age positively predicted vaccination uptake (Rodríguez-Rieiro et al., 2011). Considering that COVID-19 disproportionately affects older people (CDCP, 2020a), age should be considered a predictor in the model. In addition, race/ethnicity should receive strong consideration because COVID-19 disproportionately affects certain ethnic/racial minority groups (Alsan et al., 2020; CDCP, 2020c). Additionally, socioeconomic status and educational attainment have been shown to be associated with intentions to vaccinate for pandemic influenza (Maurer, 2016), and COVID-19 has exacerbated issues related to income inequity (Oronce et al., 2020). Finally, people's political orientation (left-right; liberal-conservative) may be related to intentions to vaccinate against COVID-19 and anti-vaccination attitudes due to reduced perceptions of risk and susceptibility to fake news (e.g., Calvillo et al., 2020); more conservative orientation has been shown to predict stronger anti-vaccination attitudes and lower vaccination uptake (Baumgaertner et al., 2018). Political orientation is particularly important to consider because of the polarized political climate in the United States.

1.5 | Summary and hypotheses

We examined the relationship between intellectual humility and anti-vaccination attitudes and COVID-19 vaccination intention in the midst of the COVID-19 pandemic. We hypothesized that intellectually humility would be negatively related to anti-vaccination attitudes. We also hypothesized that intellectual humility would be positively related to intention to vaccinate against COVID-19. Additionally, we hypothesized that intellectual humility would predict anti-vaccination attitudes and COVID-19 vaccination intentions above and beyond demographic and personal factors.

2 | MATERIALS AND METHODS

2.1 | Sample size

G*Power 3.1.9.2 (Faul et al., 2009) was used to estimate the necessary sample size under specified parameters. Considering previous research (Senger & Huynh, 2020), an effect $r = .14$ was estimated, alpha was set to be at .05 and power at .80. Under these parameters, 311 participants are necessary. However, our budget allowed us to collect data from additional participants for this project. We felt that a larger sample size would allow us some flexibility around our estimate and enable us to preemptively address anticipated data loss due to online data collection (Aguinis et al., 2020; Oppenheimer et al., 2009).

2.2 | Participants

Participants were recruited from Amazon Mechanical Turk (MTurk), a popular source for participants in the social sciences (for review and

recommendations, see Aguinis et al., 2020). A pilot version of the study was conducted to determine the average completion time. Participants were compensated at the rate of $10 USD/hour, based on this established average completion time. Because of our focus on vaccine attitudes in the United States of America (USA), we limited participation to people 18 years old or older and whose residence is in the USA. A total of 392 people attempted the study, 21 people did not complete the study and did not provide sufficient information for us to determine whether their failed participation systematically differed from those who completed the study. Because "bot" responses and data farms are significant concerns for data collected through MTurk, we followed the common/simplest recommendation by experts to include a validity indicator of asking participants to provide an answer to an open-ended question (e.g., Chmielewski & Kucker, 2020; Dennis et al., 2018). We asked participants to name their favorite celebrity then examined those responses to determine whether they came from "bots." For example, bot responses to open-ended questions appear as if the response was copied from the results of a Google search query or parts of the question is simply pasted into the response text box (Chmielewski & Kucker, 2020). After eliminating nonresponses, nonsensical and suspicious responses, our final sample composed of 351 participants (89.54% of all attempts). See Table 1 for a summary of participant demographics.

2.3 | Measures

2.3.1 | Intellectual humility

We used the Comprehensive Intellectual Humility Scale (Krumrei-Mancuso & Rouse, 2016) to measure intellectual humility. The scale consists of four subscales: Independence of Intellect and Ego; Openness to Revising One's Viewpoint; Respect for Other's Viewpoints; and Lack of Intellectual Overconfidence. Participants used a Likert scale to indicate their (dis)agreement with 22 statements, with (1) = *strongly disagree* to (5) = *strongly agree* as anchors. Higher scores indicate higher intellectual humility.

2.3.2 | Anti-vaccination attitudes

We used the Vaccine Attitudes Examination (VAX) Scale (Martin & Petrie, 2017) to measure anti-vaccination attitudes. The VAX scale has four subscales: Mistrust of Vaccine Benefit, Worries about Unforeseen Future Effects, Concerns about Commercial Profiteering, and Preference for Natural Immunity. Participants indicated their (dis)agreement with 12 statements using a 6-point Likert scale (1) = *strongly disagree* and (6) = *strongly agree*. Higher scores indicate stronger anti-vaccination attitudes.

2.3.3 | Vaccination intentions

COVID-19 vaccine intentions were measured using a two-item measure adapted from the flu vaccine intention scale (Sar &

TABLE 1 Summary of participant demographics (N = 351)

Variable	Frequency	Percent
Sex		
Male	198	56.40
Female	148	42.20
Other/prefer not to say	5	1.40
Highest level of education		
High school graduate (high school diploma or equivalent including GED)	34	9.70
Some college but no degree	51	14.50
Associate degree in college (2-year)	31	8.80
Bachelor's degree in college (4-year)	177	50.40
Master's degree	53	15.10
Doctoral degree	1	0.30
Professional degree (JD, MD)	4	1.10
Race/ethnicity		
White/Caucasian	261	74.40
Black/African American	32	9.10
Native American	6	1.70
Asian/Pacific Islander	16	4.60
Hispanic/Latino	22	6.30
Mix	11	3.10

Rodriguez, 2019). The items were: 1) "How likely is it that you would get a Corona Virus (COVID-19) shot if one were available?"; and 2) "If you were faced with the decision to get a Corona Virus (COVID-19) shot today, how likely is it that you would do so if one were available?" Participants indicated their intentions by using a 7-point Likert scale (1) = *not at all* and (7) = *extremely likely*. See Table 2 for means, standard deviations, and Cronbach's alphas for all measures.

2.3.4 | Demographic and personal factors

Participants indicated their sex (male, female, prefer not to say, and other), race/ethnicity (White/Caucasian, Black/African American, Native American, Asian/Pacific Islander, Hispanic/Latino, and Mixed), highest level of education (from high school to doctorate/professional degree), and provided their age (open-ended). Socioeconomic status (SES) was measured using the MacArthur Scale of Subjective Social Status (Singh-Manoux et al., 2005). Participants rated their own social status by selecting a step on a ladder with 10 steps that they think best describes their own status relative to others; 1 = worst off relative to others, 10 = best off relative to others. Research has demonstrated that subjective SES may be a better predictor of psychological functioning than objective measures of SES (Rabin & Charro, 2009; Singh-Manoux et al., 2005). Finally, we used a one-item measure of political orientation (Kroh, 2007): "How would you describe your overall political ideology?" Participants indicated their political orientation by selecting a number from 1 to 11; 1 = completely liberal, 11 = completely conservative.

TABLE 2 Summary of possible ranges, cronbach's alphas, means, standard deviations, and percentile scores for each scale and subscale

Scale/subscale	Possible range	α	Mean	SD	Percentiles 5	10	25	50	75	90	95
Intellectual Humility overall	1–5	.87	3.48	0.59	2.78	2.87	3.01	3.36	3.93	4.34	4.57
Independence of intellect and ego	–	.91	3.09	1.11	1.60	1.60	2.20	3.00	4.00	4.80	5.00
Openness to revising one's viewpoint	–	.83	3.96	0.74	2.80	3.00	3.60	4.00	4.60	5.00	5.00
Respect for other's viewpoints	–	.84	3.97	0.73	2.67	3.00	3.50	4.00	4.50	5.00	5.00
Lack of intellectual overconfidence	–	.85	2.92	0.89	1.50	1.83	2.33	2.83	3.50	4.13	4.50
VAX scale overall	1–6	.92	3.06	1.11	1.08	1.35	2.17	3.25	3.92	4.42	4.58
Mistrust of vaccine benefit	–	.84	2.37	1.06	1.00	1.00	1.67	2.00	3.00	3.93	4.67
Worries—Unforeseen future effects	–	.82	3.55	1.32	1.00	1.67	2.67	3.67	4.67	5.00	5.47
Concerns—Commercial profiteering	–	.89	3.10	1.50	1.00	1.00	1.67	3.00	4.33	5.27	5.67
Preference for natural immunity	–	.88	3.21	1.47	1.00	1.00	2.00	3.33	4.33	5.00	5.67
COVID–19 Vaccine Intentions	1–7	.87	5.44	1.60	2.00	3.00	4.50	6.00	7.00	7.00	7.00

Note: N = 351.

2.4 | Procedure

All study materials and procedures were approved by the authors' Institutional Review Board. Participants clicked on a link to the online study hosted on Qualtrics, a survey management system. Following consent procedures, participants completed the study measures and provided demographic information. To control for potential order effects, the main study measures were presented in random order; demographics were provided last. After participants completed the study measures, they read a debriefing statement and were thanked for their participation.

2.5 | Data analysis plan

In order to provide an overview of the associations between study variables and to directly compare our results to Senger and Huynh's (2020) results, we conducted a series of bivariate correlations. In addition, to fully assess intellectual humility's ability to predict anti-vaccination attitudes and vaccination intentions, we conducted a series of hierarchical multiple regression analyses. This approach allowed us to examine the unique contribution of intellectual humility in predicting anti-vaccination attitudes, above and beyond the effects of demographic predictors. In hierarchical multiple regression, we entered the predictor variables in two steps: 1) demographic and personal factors (i.e., sex, race/ethnicity, age, education, socioeconomic status, and political orientation); 2) the four facets of intellectual humility (Independence of Intellect and Ego; Openness to

Revising One's Viewpoint; Respect for Other's Viewpoints; and Lack of Intellectual Overconfidence). We ran separate models for each outcome (the four types of anti-vaccination attitudes, overall anti-vaccination attitudes, and COVID-19 vaccination intentions).

3 | RESULTS

3.1 | Bivariate correlations

We found that overall intellectual humility and overall anti-vaccination attitudes were negatively associated, $r(349) = -.46$, $p < .001$. Using Fisher's r to z transformational, we compared this correlation to the one reported in Senger and Huynh (2020), $r(237) = -.14$, $p = .04$. We found that the correlation reported in this study is significantly larger, $Z_{observed} = 4.19$, $p < .001$.

Additionally, all four subscales of the Comprehensive Intellectual Humility Scale were related to overall anti-vaccination attitudes, as measured by the Vaccine Attitudes Examination (VAX) Scale. The strongest relationships with overall anti-vaccination attitudes were Lack of Intellectual Overconfidence, $r(349) = -.43$, $p < .001$, and Independence of Intellect and Ego, $r(349) = -.34$, $p < .001$. Overall intellectual humility correlated most strongly to the VAX subscales of Concerns about Commercial Profiteering, $r(349) = -.52$, $p < .001$, Preference for Natural Immunity, $r(349) = -.45$, $p < .001$, and Worries about Unforeseen Future Effects, $r(349) = -.32$, $p < .001$. Overall intellectual humility was weakly correlated with Mistrust of Vaccine Benefits, $r(349) = -.15$, $p = .005$, albeit it is still a significant correlation.

Overall intellectual humility and COVID-19 vaccine intentions were positively associated, $r(349) = .20$, $p < .001$. The strongest relationship with COVID-19 vaccine intentions was Openness to Revising One's Viewpoint, $r(349) = .26$, $p < .001$. Additionally, COVID-19 vaccine intentions were negatively correlated with overall anti-vaccination attitudes, $r(349) = −.50$, $p < .001$. Mistrust of Vaccine Benefits had the strongest relationship with COVID-19 vaccination intentions, $r(349) = −.63$, $p < .001$.

See Table 3 for correlations between study measures.

3.2 | Hierarchical multiple regression

We organized the main findings by dependent variable below. See Table 4 for a summary of the findings, including βs and variance accounted for (R^2 and ΔR^2). Because the four facets of intellectual humility were correlated, we tested to see whether multicollinearity was an issue. The highest variance inflation factor (VIF) value was 1.94, which is lower than the conservative benchmark of 5 (Tab achnick & Fidell, 2007), suggesting that multicollinearity was not an issue. Additionally, the histogram of standardized residuals, P–P plots, and residual scatter plots supported normality, linearity, and homoscedasticity assumptions. The range for Cook's Distance scores (0–.33) indicated that there were no outliers. Moreover, we performed a post hoc power analysis for the regression analyses because these analyses were considered after data collection. Using the following parameters, effect size $f^2 = .13$, which is based on the

smallest R^2 value across all the models, alpha = .05, a total sample size of 347, and 10 predictors, the achieved power was well over .99.

3.2.1 | Mistrust of vaccine benefits

Results from step 1 indicated that demographic factors significantly predicted Mistrust of Vaccine Benefits, $F_{(6, 340)} = 7.30$, $p < .001$; significant variables were education, $\beta = −.15$, $p = .005$, SES, $\beta = −.17$, $p < .001$, and political orientation, $\beta = .27$, $p < .001$. In step 2, intellectual humility accounted for additional variance in Mistrust of Vaccine Benefits, $F_{(4, 336)} = 7.84$, $p < .001$. Age, SES, and political orientation remained significant predictors, $\beta s = −.16$ to .25, $p s < .01$. The intellectual humility facet of Openness to Revising One's Viewpoint negatively predicted Mistrust of Vaccine Benefits, $\beta = −.21$, $p = .002$.

3.2.2 | Worries about unforeseen future effects

Results from step 1 indicated that demographic factors significantly predicted Worries about Unforeseen Future Effects, $F_{(6, 340)} = 11.82$, $p < .001$. Significant variables included: race/ethnicity (identifying as White/Caucasian relative to other groups), $\beta = −.17$, $p = .001$, and political orientation, $\beta = .34$, $p < .001$. In step 2, intellectual humility accounted for additional variance in Worries about Unforeseen Future Effects, $F_{(4, 336)} = 8.58$, $p < .001$. Race/ethnicity and political orientation remained significant predictors, $\beta = −.16$,

TABLE 3 Summary of correlations

Variable	1	2	3	4	5	6	7	8	9	10
1. Intellectual humility overall										
2. Independence of intellect and ego	.71**									
3. Openness to revising one's viewpoint	.62**	.07								
4. Respect for other's viewpoints	.67**	.17**	.67**							
5. Lack of intellectual overconfidence	.69**	.43**	.16**	.18**						
6. VAX scale overall	−.46**	−.34**	−.25**	−.18**	−.43**					
7. Mistrust of vaccine benefit	−.15**	−.01	−.28**	−.21**	.01	.55**				
8. Worries—Unforeseen future effects	−.32**	−.27**	−.15**	−.07	−.34**	.88**	.37**			
9. Concerns—Commercial profiteering	−.52**	−.42**	−.22**	−.18**	−.52**	.91**	.31**	.75**		
10. Preference for natural immunity	−.45**	−.36**	−.21**	−.14*	−.46**	.90**	.30**	.72**	.82**	
11. COVID–19 Vaccine Intentions	.20**	.05	.26**	.15**	.11*	−.50**	−.63**	−.39**	−.38**	−.31**

Note: $N = 351$.

*Correlations are significant with $p < .05$.

**Correlations are significant with $p < .01$

TABLE 4 Summary of hierarchical regression analyses

	Mistrust of vaccine benefit	Worries about unforeseen future effects	Concerns about commercial profiteering	Preference for natural immunity	Overall anti-vaccination attitudes	COVID-19 vaccination intentions
Step 1: Demographic and personal factors						
Sex	−.06	−.04	.05	.04	.01	.05
Race/ethnicity	−.05	−.16**	−.14**	−.15**	−.16**	.04
Age	−.06	.07	−.002	.04	.020	.06
Education	−.16**	−.06	−.002	−.09	−.08	.09
SES	−.18**	.01	.08	.08	.013	.07
Political orientation	.24***	.25***	.24***	.26***	.30***	−.20***
R^2	.11***	.17***	.26***	.23***	.24***	.07**
Step 2: Intellectual humility						
Ind. of intellect and ego	.01	−.15**	−.23***	−.21***	−.19***	−.004
openness to rev. viewpoints	−.21**	−.13*	−.15**	−.16**	−.19**	.25***
Respect for other's viewpoints	−.10	.09	.05	.08	.05	−.03
Lack of intell. overconfidence	.06	−.19**	−.29***	−.24***	−.22***	.04
R^2	.19	.35	.44	.37	.37	.12
ΔR^2	.08***	.08***	.18***	.13***	.13***	.05***

Note: All standardized regression coefficients are from the final step of the analyses; $N = 347$.

*$p < .05$; **$p < .01$; ***$p < .001$.

$p = .001$ and $\beta = .25$, $p < .001$, respectively. The intellectual humility facets of Independence of Intellect and Ego, $\beta = −.15$, $p = .006$, Openness to Revising One's Viewpoint, $\beta = −.13$, $p = .048$, Lack of Intellectual Overconfidence, $\beta = −.19$, $p = .001$, negatively predicted Worries about Unforeseen Future Effects.

3.2.3 | Concerns about commercial profiteering

Results from step 1 indicated that demographic factors significantly predicted Concerns about Commercial Profiteering, $F_{(6, 340)} = 19.87$, $p < .001$. Significant variables included: race/ethnicity (identifying as White/Caucasian relative to other groups), $\beta = −.15$, $p = .001$, SES, $\beta = .21$, $p < .001$, and political orientation, $\beta = .37$, $p < .001$. In step 2, intellectual humility accounted for additional variance in Concerns about Commercial Profiteering, $F_{(4, 336)} = 26.57$, $p < .001$. Race/ethnicity, $\beta = −.14$, $p = .001$, and political orientation, $\beta = .24$, $p < .001$, remained significant predictors. The intellectual humility facets of Independence of Intellect and Ego, $\beta = −.23$, $p < .001$, Openness to Revising One's Viewpoint, $\beta = −.15$, $p = .008$, and Lack of Intellectual Overconfidence, $\beta = −.29$, $p < .001$, negatively predicted Concerns about Commercial Profiteering.

3.2.4 | Preference for natural immunity

Results from step 1 indicated that demographic factors significantly predicted Preference for Natural Immunity, $F_{(6, 340)} = 17.20$, $p < .001$.

Significant variables included: race/ethnicity (identifying as White/Caucasian relative to other groups), $\beta = −.16$, $p = .001$, SES, $\beta = .19$, $p < .001$, and political orientation, $\beta = .37$, $p < .001$.

In step 2, intellectual humility accounted for additional variance in Preference for Natural Immunity, $F_{(4, 336)} = 17.80$, $p < .001$. Race/ethnicity, $\beta = −.15$, $p = .001$, political orientation, $\beta = .26$, $p < .001$, remained significant predictors. The intellectual humility facets of Independence of Intellect and Ego, $\beta = −.21$, $p < .001$, Openness to Revising One's Viewpoint, $\beta = −.16$, $p = .008$, and Lack of Intellectual Overconfidence, $\beta = −.24$, $p < .001$, negatively predicted Preference for Natural Immunity.

3.2.5 | Overall anti-vaccination attitudes

Results from step 1 indicated that demographic factors significantly predicted Overall Anti-Vaccination Attitudes, $F_{(6, 340)} = 17.58$, $p < .001$. Significant variables included: race/ethnicity (identifying as White/Caucasian relative to other groups), $\beta = −.16$, $p = .001$, SES, $\beta = .12$, $p = .02$, and political orientation, $\beta = .41$, $p < .001$.

In step 2, intellectual humility accounted for additional variance in Overall Anti-Vaccination Attitudes, $F_{(4, 336)} = 17.67$, $p < .001$. Race/ethnicity, $\beta = −.16$, $p < .001$, and political orientation, $\beta = .30$, $p < .001$, remained significant predictors. The intellectual humility facets of Independence of Intellect and Ego, $\beta = −.19$, $p < .001$, Openness to Revising One's Viewpoint, $\beta = −.19$, $p = .001$, and Lack of Intellectual Overconfidence, $\beta = −.22$, $p < .001$, negatively predicted Overall Anti-Vaccination Attitudes.

3.2.6 | COVID-19 vaccination intentions

Results from step 1 indicated that demographic factors significantly predicted COVID-19 Vaccination Intentions, $F_{(6, 340)} = 4.06$, $p = .001$. The only significant variable was political orientation, $\beta = -.25$, $p < .001$. In step 2, intellectual humility accounted for additional variance in COVID-19 Vaccination Intentions, $F_{(4, 336)} = 5.18$, $p < .001$. Political orientation remained a significant predictor, $\beta = -.20$, $p < .001$. The intellectual humility facet of Openness to Revising One's Viewpoint predicted COVID-19 Vaccination Intentions, $\beta = .25$, $p < .001$.

4 | DISCUSSION

We found that intellectual humility was negatively associated with anti-vaccination attitudes and positively correlated with intentions to vaccinate against COVID-19. Additionally, we found that intellectual humility predicted anti-vaccination attitudes and COVID-19 vaccination intentions above and beyond demographic and personal factors. Overall, these results supported our hypotheses and align with the current literature regarding intellectual humility's overarching benefits.

The finding that anti-vaccination attitudes are inversely associated with intellectual humility corresponds with Senger and Huynh's (2020) findings; however, the associations are much stronger in this study. Additionally, we demonstrated that intellectual humility predicted additional variance in anti-vaccination attitudes above important factors such as SES, race/ethnicity, age, and political orientation. Due to the ongoing pandemic, COVID-19 may provide a more salient threat to elicit stronger attitudes about vaccinations, especially with the conjecture surrounding its origin and the promise of a vaccine for it (Goodman & Carmichael, 2020). Moreover, whereas Senger and Huynh (2020) found that Openness to Revising One's Viewpoint was a main driver of this relationship, we found that Independence of Intellect and Ego largely drove the current study's associations (in addition to the Lack of Intellectual Overconfidence, which both studies had in common). This difference may be due to an evolution of vaccination attitudes. That is, vaccination attitudes during the pandemic maybe be imbued with personal sensitivity, such that it may be more difficulty to separate one's knowledge (or intellect) and one's self-worth (ego) for people who lack intellectual humility.

Moreover, the relations between intellectual humility and anti-vaccination attitudes may be due to the fact that people who are unafraid of being challenged or have an accurate understanding of their own knowledge may seek out new information about vaccines without being concerned about being wrong. For instance, prior research demonstrates that humility has the power to mitigate anxiety (Kesebir, 2014). Thus, it is possible that people high in intellectual humility understand their knowledge on vaccines may be limited and do not treat potentially new information as threatening. Therefore, possessing high levels of intellectual humility may quiet any anxieties associated with information about vaccines or vaccines themselves.

Additionally, although anti-vaccination attitudes are considered more general (Martin & Petrie, 2017), compared to more specific indicators such as vaccination intentions, there is growing evidence to suggest that some anti-vaccination attitudes are growing or are becoming stronger alongside the persistence of COVID-19 (e.g., Burki, 2020; Huynh, 2020). In line with functional theories of attitudes (Katz, 1960; Shavitt, 1989), increases in attitudinal valence would strengthen the need for intellectual humility to combat these rigid knowledge structures and egocentric positions. However, more research is needed to determine whether the increases in the relationship between intellectual humility and anti-vaccination attitudes may be due to other factors beyond the COVID-19 pandemic.

The predictive relationship between intellectual humility and intentions to vaccinate against COVID-19 is noteworthy. Intentions are critical for predicting behaviors (Ajzen, 1991), and currently, intentions are the best measure for potential uptake of a COVID-19 vaccine because a vaccine has yet to be made widely available to everyone. This predictive relationship suggests that intellectually humble people are more likely to vaccinate against the virus. Therefore, intellectual humility may play a significant role in promoting public health and flattening the curve.

Given the associations found among intellectual humility, vaccination attitudes, and vaccine intentions, this study adds further evidence for intellectual humility's potential as a health promotion factor. The particular benefit of humility is that there are known experimental interventions to increase its levels via writing prompts, gratitude, or experiences of awe (Kesebir, 2014; Kruse et al., 2014; Stellar et al., 2018). Future research can examine how the promotion of intellectual humility can potentially counter anti-vaccination attitudes. This evidence would be critical to showing humility's potential causal role in influencing vaccination attitudes. However, this study establishes the correlational and predictive link between intellectual humility and vaccine attitudes and intentions and demonstrates how these relationships maybe change dependent on context (e.g., disease severity, susceptibility).

4.1 | Limitations and future directions

A limitation of the study is the fact that our participants came from MTurk, which has recently seen an increase in low-quality responses from data farms or "bots" (Chmielewski & Kucker, 2020). Although we followed the simplest and frequently recommended solution of screening responses to an open-ended question to ensure data quality (e.g., Chmielewski & Kucker, 2020; Dennis et al., 2018), it may lack the thoroughness of other approaches. For example, other practices to screen data include adding "attention check" items, although this approach may alter participants' responses in subsequent parts of the survey (Clifford & Jerit, 2015). Other approaches include screening participants' IP addresses (Kennedy et al., 2020) or response time (for a review of issues and recommendations for working with MTurk, see Aguinis et al., 2020). Future research may take efforts to

include other data screening measures in addition to or in place of our approach to ensure data quality.

The current study sought to examine intellectual humility's relationship and specific role in predicting anti-vaccination attitudes and COVID-19 vaccination intentions. Therefore, we sought to statistically account for the influential roles of race/ethnicity and political orientation. However, these factors should not be overlooked. For example, in our study, White/Caucasian participants expressed lower anti-vaccination attitudes relative to other groups. These results suggest that anti-vaccination attitudes may exacerbate the already disproportional impact of COVID-19 on ethnic/racial minority communities and socioeconomically disadvantaged communities (Alsan et al., 2020; CDCP, 2020c; Oronce et al., 2020). Relatedly, a significant limitation of our study is that our sample does not reflect people who are most at risk for contracting and suffering from the full impact of COVID-19. Future studies should examine intellectual humility and these outcomes by stratifying recruitment to sample people from ethnic/racial minority communities and socioeconomically disadvantaged communities, who are most likely to be affected by COVID-19 (Oronce et al., 2020). Additionally, beyond controlling for political orientation, which significantly predicted all four types of anti-vaccination attitudes and COVID-19 vaccination intentions, future research should clarify the interplay between these variables. For example, researchers should examine whether intellectual humility can suppress relationship between political orientation and anti-vaccination attitudes.

Other limitations of the study included the study's specific focus on COVID-19 vaccination intention and correlational design. Given the anxiety surrounding the pandemic, the current environment may have inflated intentions compared to other diseases such as the flu. Vaccine attitudes (i.e., vaccine hesitancy) vary from vaccine to vaccine (MacDonald, 2015); thus, caution should be exercised when generalizing the results of this study to other vaccines. When it comes to COVID-19, health behaviors may depend on various social and psychological factors (e.g., social contacts, Moussaoui et al., 2020; perceived control, Zheng et al., 2020). More generally, important medical decisions likely depend on other important factors such as patients' emotional state (e.g., Legg et al., 2015) and relationships between the patient and their care provider (e.g., Huynh et al., ,,2018, 2020; Huynh & Dicke-Bohmann, 2020; Huynh & Sweeny, 2014). Finally, the current study is correlational in nature. Although we used both bivariate correlations and hierarchical multiple regression to examine intellectual humility's relationship with and unique role in predicting anti-vaccination attitudes and COVID-19 vaccination intentions, these approaches cannot overcome the limited nature of the cross-sectional, survey-based design. Additional evidence, particularly through experiments, would still be needed to determine causality.

Future studies should examine whether intellectual humility can be engendered and employed to alter vaccine attitudes, intentions, and uptake. For example, researchers can apply the experimental medicine framework (Field et al., 2020; Sheeran et al., 2017) to intellectual humility. The framework suggests four steps in evaluating interventions: 1) identify a malleable psychological factor that is associated with a problematic attitude/behavior; 2) manipulate the psychological factor to examine its causal influence on the attitude/behavior; 3) evaluate and refine manipulations; 4) conduct randomized control trials to examine whether the intervention would affect behavior change in the real world. This study provides evidence for step 1, intellectual humility is associated with anti-vaccination attitudes and COVID-19 vaccination intentions. To address step 2, researchers can adapt strategies from previous works to manipulate humility to examine its causal role in changing anti-vaccination attitudes and intentions. For example, researchers can use a writing prompt that asks participants to recall a time when they experienced intellectual humility (adapted from Kesebir, 2014) to engender intellectual humility and measure any resulting changes in vaccine attitudes and intentions. Then, researchers can compare those changes to fluctuations resulting from a control prompt, such as asking participants to recall a time when they experienced humidity (Kesebir, 2014). In step 3, researchers can reexamine the effectiveness of the writing prompts and consider making adjustments to them to ensure that they address intellectual humility. Because the use of intellectual humility to address anti-vaccination attitudes and vaccination intentions are novel, researchers may want to devote particular attention to this step to ensure that intellectual humility's influence can be maximized. Finally, researchers should conduct randomized control trials to examine whether intellectual humility can be effective in changing vaccination intentions and uptake. For example, a demographically representative sample from the community can be randomly assigned to write about intellectual humility or a control, then, immediately answer questions about their vaccination attitudes and intentions. Then, researchers can follow-up with them anywhere from 30 days to 1 year as in previous studies investigating vaccine uptake (Cassidy et al., 2014; Kaoiean et al., 2019) to assess whether the intellectual humility manipulation affected vaccine uptake. By employing the experimental medicine framework, researchers can more effectively evaluate the potential benefits of intellectual humility in a methodical and systematic way.

4.2 | Conclusion

COVID-19 vaccinations may be an important part of public health in the years ahead and combatting anti-vaccination attitudes may support such efforts. Our study provides evidence for intellectual humility's ability to predict anti-vaccination attitudes and intention to vaccinate against COVID-19. With further research, intellectual humility may be leveraged into a public health strategy to support increased vaccine uptake.

CONFLICT OF INTEREST
The authors certify that they have no affiliations with or involvement in any organization or entity with any financial or nonfinancial interest in the subject matter or materials discussed in this manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available upon reasonable request from the corresponding author. The data are not publicly available because they contain information that could compromise the privacy of research participants.

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