Received: 10 August 2023 | Accepted: 30 January 2024

DOI: 10.1111/bjso.12732

ARTICLE

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Intellectual humility as a tool to combat false beliefs: An individual-based approach to belief revision

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Funding information
John Templeton Foundation

Abstract

False beliefs pose significant societal threats, including health risks, political polarization and even violence. In two studies ($N = 884$) we explored the efficacy of an individual-based approach to correcting false beliefs. We examined whether the character virtue of intellectual humility (IH)—an appreciation of one's intellectual boundaries—encourages revising one's false beliefs in response to counter-information. Our research produced encouraging but also mixed findings. Among participants who held false beliefs about the risks of vaccines (Study 1) and the 2020 US Election being rigged (Study 2), those with higher IH explored more information opposing these false beliefs. This exploration of opposing information, in turn, predicted updating away from these inaccurate health and political beliefs. IH did not directly predict updating away from false beliefs, however, suggesting that this effect—if it exists—may not be particularly powerful. Taken together, these results provide moderate support for IH as a character trait that can foster belief revision but, simultaneously, suggest that alternate pathways to combat false beliefs and misinformation may be preferred.

KEYWORDS

belief updating, false beliefs, information search, intellectual humility, misinformation

BACKGROUND

The prevalence of false beliefs poses a major threat to societal welfare (Lewandowsky et al., 2012; Van Bavel et al., 2021). False beliefs about health practices, for instance, are linked to increased viral spread and mortality (Hornik et al., 2021; Loomba et al., 2021). And, in the political domain, false beliefs can

exacerbate polarization and heighten political action, for instance, leading to events such as the January 6th insurrection (Calvillo et al., 2021; Jacobson, 2023; Pennycook & Rand, 2021; Young et al., 2022). Moreover, the negative consequences of false beliefs may even extend to large-scale violence. False allegations of terrorism, illegal immigration and criminal behaviour in Myanmar (Burma) have been linked to the death and displacement of thousands of Rohingya (Mozur, 2018). In an effort to combat such misinformation and false beliefs, we examine whether the character virtue of intellectual humility (IH)—acknowledging one's own knowledge limitations and appreciating others' intellectual contributions (Porter & Schumann, 2018)—can function as an individual-based boosting approach that helps individuals move away from false beliefs and towards accurate ones.

Combating misinformation and false beliefs

How can we combat false beliefs? While misinformation and false beliefs are nothing new, the rapid development of social media has made misinformation more accessible than ever (Hills, 2019; Pierri & Ceri, 2019). For instance, a surprising number of the most-viewed YouTube videos related to COVID-19—over 25%—contain inaccuracies (Li et al., 2020; Mitchell & Oliphant, 2020). Recognizing the magnitude of this issue, researchers have devised computational tools to detect and counteract misinformation (Zhang et al., 2019). However, their implementation can be complex and has been met with significant resistance from media organizations (Hopkins, 2020; Hsu, 2022; Legum, 2018).

Given these circumstances, psychological approaches that support individual users may be the best way to attenuate misinformation and false beliefs. For instance, shifting people's focus towards the accuracy of content effectively increases the quality of information shared (Pennycook et al., 2021). However, these strategies have limitations—they are often overtaken by the rapid evolution of the information landscape and risk encroaching on users' autonomous decision-making (Hertwig & Grüne-Yanoff, 2017). Rather than manipulating the external environment, it may be more beneficial to equip individuals with the capacity to navigate misinformation and false beliefs themselves. Such boosting interventions could involve trainings in media literacy and critical thinking (Guess et al., 2020; Lin et al., 2022) but could also involve identifying and promoting character values or traits that help individuals distinguish between truth and falsehood, adopt true beliefs, and correct false ones.

In the present work, we take an individual-based boosting approach to false beliefs by beginning to examine whether character values or traits can promote false belief revision. Rather than directly targeting the problematic spread of misinformation—a task laden with difficulties—we consider whether character virtues can empower people to autonomously update away from false beliefs. Indeed, as noted by Kelly & Burkell (2024; pg. 1), 'it is not false information per se that is of concern – rather, it is the *false beliefs* that can arise from that information that are the problem'.

In our effort to apply an individual-based approach to false belief revision, we focus on the character virtue known as Intellectual Humility (IH). IH involves acknowledging one's own knowledge limitations and appreciating others' intellectual contributions (Porter & Schumann, 2018). Said another way, this form of humility captures individuals' tendency to have an open intellectual mindset (see Leary, 2022 for an overview). Following this rationale, the current study investigates whether IH helps individuals abandon false beliefs in favour of credible ones when presented with accurate information. Such findings would promote IH as an individual character virtue that can help combat false beliefs in society without overhauling the existing misinformation ecosystem.

Intellectual humility and false belief revision

Numerous psychological factors have been identified as facilitating and maintaining false beliefs (Ecker et al., 2022; Hahn et al., 2018; Newman et al., 2022; Scheffer et al., 2022; Van Bavel et al., 2021). For instance, confirmation bias and cognitive complacency are two prominent variables motivating false

beliefs. These processes prop up false beliefs in that people: (1) pay more attention to information aligning with their prior beliefs, even when this information is false (confirmation bias) (Klayman, 1995; Kelly & Burkell, 2024) and (2) neglect to engage in careful, analytical consideration of information (cognitive complacency) (Bago et al., 2020). Therefore, an effective strategy to combat false beliefs would need to address these phenomena.

The character virtue of IH qualifies as a promising candidate to combat the two primary causes of false beliefs. Regarding confirmation bias, IH is associated with greater open-mindedness towards counter information, spending more time viewing counter information, making attempts to understand epistemic opponents and evaluating new information against one's pre-existing beliefs (Porter & Schumann, 2018; Rodriguez et al., 2019). Additionally, IH has been linked to greater cognitive flexibility, a key variable in counteracting confirmation bias (Zmigrod et al., 2019). Regarding cognitive complacency, IH predicts greater general knowledge, reflective thinking, curiosity, and intellectual openness (Krumrei-Mancuso et al., 2020) (see Porter et al., 2022). Collectively, these characteristics of IH—(1) being more open-minded to counter-evidence and (2) engaging in greater cognitive reflection regarding new information and one's existing beliefs—should help individuals update away from false beliefs.

Past research also more directly supports the efficacy of IH in revising one's false beliefs. For instance, IH has been linked to holding more accurate beliefs. IH predicts being more knowledgeable about general facts (Krumrei-Mancuso et al., 2020; Porter et al., 2022), and a lower likelihood to endorse conspiracy theories and fall for false news (Bowes et al., 2021; Bowes & Tasimi, 2022; Meyer, 2019; Van Bavel et al., 2021). For example, IH is linked to lower susceptibility to COVID-19 misinformation and greater support for public health policies (Meyer et al., 2021; Pärnamets et al., 2022). However, this research primarily focused on relating IH to lower levels of false beliefs. It did not investigate whether IH can help individuals revise away from existing false beliefs towards accurate information. The current work delves deeper into this area, examining IH as a personal virtue that might facilitate the process of correcting pre-existing false beliefs.

Information search as a mechanism

Which processes would underlie a link between IH and false belief revision? IH predicts information-seeking behaviours and searching for information from multiple sources (Gorichanaz, 2022). Additionally, IH predicts open-mindedness towards counter information and spending more time viewing counter information (Porter & Schumann, 2018), as well as greater attempts to understand epistemic opponents (Bowes et al., 2022; Rodriguez et al., 2019; Sgambati & Ayduk, 2022). Moreover, people with higher versus lower IH appear to process information differently; IH predicts a greater ability to discern information as true versus false (Bowes & Tasimi, 2022), better memorization of information (Deffler et al., 2016) and greater deliberation about new information (see Leary, 2022; Porter et al., 2022). Collectively, these information search and processing outcomes should encourage the revision of false beliefs. Following this logic, we propose that IH links to a greater willingness to consider and adopt counter-information—information opposing one's false beliefs—in turn, leading individuals to update away from false beliefs and towards accurate ones.

The present study

The present study investigates IH as a character virtue that can help individuals revise their false beliefs. To test this, we conducted two studies investigating whether IH predicts revising one's false beliefs after an opportunity to explore counter-information. We chose two fairly common false beliefs that are associated with severe harmful consequences: That vaccinations are risky or dangerous (Study 1; see Loomba et al., 2021) and that the 2020 Presidential US Election was rigged in favour of Joe Biden (Study 2; see Jacobson, 2023). In both studies, participants were first screened for holding these false beliefs.

After measuring participants' IH and degree of false belief, we presented participants with the opportunity to read accurate information about these topics. After being exposed to this counter-information opportunity, participants' degree of false belief was again measured. In Study 2, we also assessed participants' belief change after 2 months in a longitudinal follow-up. Across these studies, we hypothesized that IH would predict greater exploration of counter-information and, thus, predict a higher degree of revision away from false beliefs.[1]

STUDY 1: FALSE BELIEFS ABOUT VACCINES

Method

All verbatim materials and data analysis files can be found open-access on OSF. The study was pre-registered here. Informed consent was obtained. For additional details regarding the data collection procedure, see Supporting Information. We confirm that, for all studies, we have reported all measures, conditions, data exclusions and how we determined the recruited sample sizes.

Participants

Participants living in the United States were recruited on Amazon Mechanical Turk (MTurk) and completed the study between 10 and 15 November 2020. Since the study investigated the role of intellectual humility in changing false beliefs, a pre-screen question ensured that participants actually held false beliefs, which in the case of Study 1, meant believing that vaccines are unsafe. Participants responded to: 'Vaccines for diseases such as measles, mumps, and rubella can be unsafe for healthy children'. (1 = *Strongly Disagree* to 7 = *Strongly Agree*). Participants who responded less than four on this scale were excluded and did not complete any other questions. Of the total respondents (2361), 561 responded above three (~24%) and were included in the study. Among these 561 participants, 66 did not pass an attention check, resulting in 495 participants in our final sample (256 female; $M_{age} = 40.4$ years, $SD_{age} = 12.3$). Twenty-seven participants selected 'Asian/Asian American', 69 selected 'Black/African American', 32 selected 'Latino/Hispanic', 354 selected 'White/European American', 8 selected 'Other' and 5 selected 'More than one race'. Participants' political orientation leaned very slightly conservative ($M = 4.29$, $SD = 1.81$; 1 = *Very liberal* to 7 = *Very conservative*).

Data collection procedure

Transparency around data collection procedures is essential to producing high-quality science. The study included two rounds of data collection. The first round of data collection (10–11 November 2020) aimed to collect a total of 215 participants and resulted in a final sample of 179 participants (after exclusions for failing the attention check; see pre-registration here). Because the hypothesized mediation effect was non-significant in this original sample ($p = .13$), we decided *post-hoc* to collect a second round of data (pre-registered here; see OSF and Supporting Information for separate results of the two sub-samples). After exclusions for failing the attention check, the final sample size of the second round of data collection (13–15 November 2020) was 316 participants,[2] resulting in a total of 495 participants in the study.

[1] A third study was conducted. This study overall exhibited consistent results but was excluded due to a lack of face-validity in the outcome measure in terms of measuring false beliefs. The study is shared in the Supporting Information for transparency (see Study S1).

[2] Due to experimenter error, we recruited fewer participants than intended (348 total participants vs. 430 intended; see pre-registration here; see Supporting Information for a detailed description of this experimenter error).

Importantly, multi-step data collection can result in inflated Type I error, and this is especially the case when such data collection is *post-hoc*, as is the case here (Sagarin et al., 2014). To account for this, we applied post-hoc data augmentation methods as outlined by Sagarin et al. (2014). These methods provide researchers with the magnitude of the Type I error inflation resulting from the post-hoc decision to collect additional data, in turn providing context around the reported significance values. The results of the mediation analysis of Study 1 are thus reported according to this method (see Results section).

Power analysis

We conducted a sensitivity power analysis using SIMR based on the total sample ($N = 495$) to calculate the approximate power we had to detect the hypothesized effect (see the IH × Time interaction in the C Path mixed-effects model in the Results section). With 495 participants we had 100% power to detect a coefficient of −5—an increase of 1 on the 1–7 IH scale predicts a change of −5 points in the 1–100 false belief measure from baseline to post counter-information search. This 100% power held until around a coefficient of around −1.7, which revealed ~95% power. These analyses indicate that we were well-powered to detect a change of −1.7 points in the 1–100 false belief scale for every increase of 1 in IH. Given that a change of −1.7, in terms of ecological meaningfulness, is quite a small change in belief revision, we conclude that the study was well-powered to test the hypothesized effect.[3]

Measures

Anti-vaccine attitudes

We included a validated measure of anti-vaccine attitudes (Horne et al., 2015) to help validate our anti-vaccine beliefs measure (i.e. these measures should correlate positively). The scale asked participants to rate five items about vaccines ('The risk of side effects outweighs any protective benefits of vaccines', 'Vaccinating healthy children helps protect others by stopping the spread of disease'; see Verbatim Materials for all items) on a 7-point Likert scale (1 = *Strongly Disagree*, 7 = *Strongly Agree*). Coded so that higher ratings indicate greater anti-vaccine attitudes.

Intellectual humility

We included three validated IH scales (randomized order): The General Intellectual Humility Scale (GIHS; Leary et al., 2017), The Limitations-Owning Intellectual Humility Scale (L-OIHS; Haggard et al., 2018) and The Porter and Schumann Intellectual Humility Scale (PSIHS; Porter & Schumann, 2018). These IH scales are widely used and exhibit good internal consistency and external validity. Additionally, the PSIHS includes reverse-coded items, reducing scale-directed response bias, and the L-OIHS accounts for intellectual servility (in the L-OIHS, IH is measured on a spectrum between intellectual servility and intellectual arrogance). We aggregated across the three scales to create a single IH score for each participant because the scales loaded together ($\omega_t = .81$), theoretically capture the same latent construct, and because doing so increases reliability (for results of the individual IH measures, see Rmarkdown files on OSF). For all IH scales, 7-point Likert scale was used (1 = *Not at all agree*, 7 = *Strongly Agree*; see Verbatim Materials).

Anti-vaccine beliefs

Ten questions assessed participants' beliefs towards vaccines (e.g. 'How dangerous are vaccines?', 'To what extent do you think that vaccines are linked to psychological and health problems [such as autism]',

[3]The power analysis was based on the following metrics. False beliefs: $M = 75.00$, $SD = 15.00$. IH: $M = 5.00$, $SD = 2.50$.

'Vaccines are overwhelmingly safe' [reverse-coded]; see Verbatim Materials for all items). Participants were asked to answer these questions on a scale from 0 to 100 (scale endpoint labels differed depending on item; see Verbatim Materials). Participants' anti-vaccine beliefs were assessed before the counter-information search opportunity. The same items were then assessed again directly after counter-information search.

Counter-information search

Participants read: 'We'd like to give you a chance to hear about pro-vaccine information. Below are several links, each of which explain a different benefit of vaccines. To read the information provided, click on the links below (the information is short and easy to read). If you would rather move on, click the "move on" link. You may read as many posts as you want. All of the links will display unique information regarding the benefits of vaccines'. Underneath this text were five links (labelled 'Vaccine Info 1', 'Vaccine Info 2', etc. and 'Move On'). Each of the links included credible information supporting vaccines (e.g. 'Vaccines are safe: The US has the best post-licensure surveillance system in the world making vaccines extremely safe. There is extraordinarily strong data from many different medical investigators all pointing to the safety of vaccines. In fact, vaccines are among the safest products in all of medicine'; see Verbatim Materials). We quantified counter-information search by the number of links participants clicked on (0–5 links).

Attention check

Participants read: 'People vary in the amount they pay attention to these kinds of surveys. Some take them seriously and read each question, whereas others go very quickly and barely read the questions at all. If you have read this question carefully, please write the word yes in the blank box below labeled other. There is no need for you to respond to the scale below'. Participants who did not respond 'yes' were excluded.

Procedure

Participants completed consent and the prescreen question. Participants then completed the anti-vaccine attitude measure, followed by the three IH scales (randomized order). Next, participants completed the anti-vaccine false beliefs measure (baseline), the counter-information search and then again the anti-vaccine false beliefs measure (post counter-information search) (in that order). Finally, participants completed a social desirability measure (Crowne & Marlowe, 1960) and demographics.[4,5]

Results

See the RMarkdown file on OSF for details of all analyses.

Pre-analysis

Supporting the reliability of our anti-vaccine beliefs measures, general anti-vaccine attitudes (assessed via a previously validated measure; $M = 3.71$, $SD = 1.37$, $\omega_t = .81$) correlated strongly with participants'

[4]A measure of paradoxical knowing (Gollwitzer & Oettingen, 2019; Gollwitzer et al., 2022) was also included for a different project.

[5]Participants also reported how convincing and informative they perceived the counter-information. This measure was not included in the reported analysis due to uninformative/inconclusive results across the studies.

TABLE 1 Results of the generalized multivariate linear models testing the predictive power of IH on counter-information search (the number of pro-vaccine information items participants explored; 0–5 items).

	Path A: Main model			Path A: Saturated model (predictors *z*-score)			Path A: Moderation model (predictors *z*-score)		
Predictors (scale of predictor)	**Incidence rate ratios**	**CIs**	***p***	**Incidence rate ratios**	**CIs**	***p***	**Incidence rate ratios**	**CIs**	***p***
Intercept	0.40	0.24–0.64	**<.001**	1.57	1.46–1.68	**<.001**	1.57	1.46–1.68	**<.001**
Intellectual humility (1–7)	1.30	1.19–1.43	**<.001**	1.21	1.12–1.30	**<.001**	1.21	1.12–1.30	**<.001**
Baseline anti-vaccine beliefs (0–100)				0.96	0.89–1.03	.219	0.96	0.89–1.03	.226
Social desirability (0–1)				0.98	0.91–1.05	.512	0.99	0.92–1.07	.843
Age				1.17	1.09–1.25	**<.001**	1.17	1.09–1.25	**<.001**
Gender (−.5 = *male*; .5 = *female*)				1.07	1.00–1.15	.058	1.07	1.00–1.15	.056
Baseline anti-vaccine beliefs × Intellectual humility							0.97	0.90–1.04	.330
Observations	495			491			491		
R^2 Nagelkerke	.069			.121			.122		

Note: The Main Model includes only IH. The Saturated Model additionally includes control variables. The Moderation Model additionally includes the moderation between anti-vaccine beliefs (at baseline) and IH. Bold values indicate statistically significant values.

anti-vaccine beliefs at baseline as well as with their anti-vaccine beliefs post counter-information search, $r(493) = .85$, $p < .001$ and $r(493) = .83$, $p < .001$ respectively.

Participants' IH (averaged across the three IH scales; $M = 5.24$, $SD = 0.78$, $\omega_t = .81$; 1–7 scale) did not correlate with anti-vaccine beliefs at baseline ($M = 47.64$, $SD = 26.52$, $\omega_t = .95$; 0–100 scale), $r(493) = -.01$, $p = .868$. This finding at first glance opposes past work linking IH to holding accurate beliefs (Bowes & Tasimi, 2022) and, more specifically, to holding pro-vaccine attitudes (Huynh & Senger, 2021; Senger & Huynh, 2021). Note, however, that our sample was constrained to individuals who already hold false beliefs about vaccines. This suggests that while IH and pro-vaccine beliefs may be linked in the general population, this link may not exist among individuals who already hold anti-vaccine beliefs.

A within-participants *t*-test revealed that participants' anti-vaccine beliefs did not change from baseline ($M = 47.64$, $SD = 26.52$, $\omega_t = .95$) to post counter-information search ($M = 47.67$, $SD = 27.39$, $\omega_t = .96$; 0–100 scale), suggesting that the counter-information search opportunity did not alter participants' beliefs, $t(494) = -0.11$, $p = .911$. See RMarkdown on OSF for descriptive and reliability statistics for all variables.

Linking IH to counter-information search (Path A)

To examine whether IH predicted greater counter-information search, we conducted a generalized linear model with IH as the predictor and the number of counter-information (pro-vaccine) items explored as the outcome variable ($M = 1.62$, $SD = 2.12$, between 0 and 5 items selected; Poisson distribution applied due to count data). This Main Model revealed that IH (1–7 scale) predicted examining a greater amount of counter-information, that is, pro-vaccine information (0–5 count scale), $B = 0.26$, incidence rate ratio (IRR) = 1.30, $p < .001$ (see Table 1; Figure 1). Supporting robustness, this result remained, $p < .001$, when adding theoretical control variables to the model (e.g. social desirability, baseline anti-vaccine beliefs; see Saturated Model in Table 1). Additionally, the observed coefficients did not change meaningfully when transforming counter-information search to be binary (0 = *None Selected*, 1 = *Selected One or More*), $B = 0.22$, IRR = 1.24, though technically, IH no longer significantly predicted seeking counter-information, $p = .067$ (see RMarkdown for all statistics). Furthermore, controlling for participants' general vaccine attitudes did not change the results, $p < .001$, and while IH significantly predicted counter-information search, general vaccine attitudes did not, $p = .157$ (see RMarkdown). Finally, IH predicted greater counter-information search across varying degrees of anti-vaccine beliefs at baseline; the observed link between IH and counter-information search was not moderated by participants' baseline anti-vaccine beliefs, $p = .330$ (Table 1).

Linking counter-information search to false belief revision (Path B)

To test whether counter-information search predicted a reduction in anti-vaccine beliefs, we conducted linear mixed-effects models with counter-information search (0–5 items), Time (0 = *Baseline*, 1 = *Post Counter-Information Search*), and the interaction between these two variables as predictors (Path B: Main Model). Anti-vaccine beliefs functioned as the outcome variable. The model revealed that exploring a greater number of counter-information items (pro-vaccine information) predicted a reduction in anti-vaccine beliefs from baseline to post counter-information search—the interaction between counter-information search and Time was significant, $p < .001$ (Table 2; Figure 2). Follow up analyses revealed that participants who explored zero pieces of counter-information exhibited a slight increase in anti-vaccine beliefs from baseline to post counter-information search, $B = 1.13$, $t(489) = 2.87$, $p = .022$; in contrast, participants who explored one or more items of counter-information exhibited a reduction in anti-vaccine beliefs from baseline to post counter-information search, $B = -1.37$, $t(489) = 3.14$, $p = .010$.[6]

[6]Simple effects were calculated in the Saturated Model. The results were consistent across models.

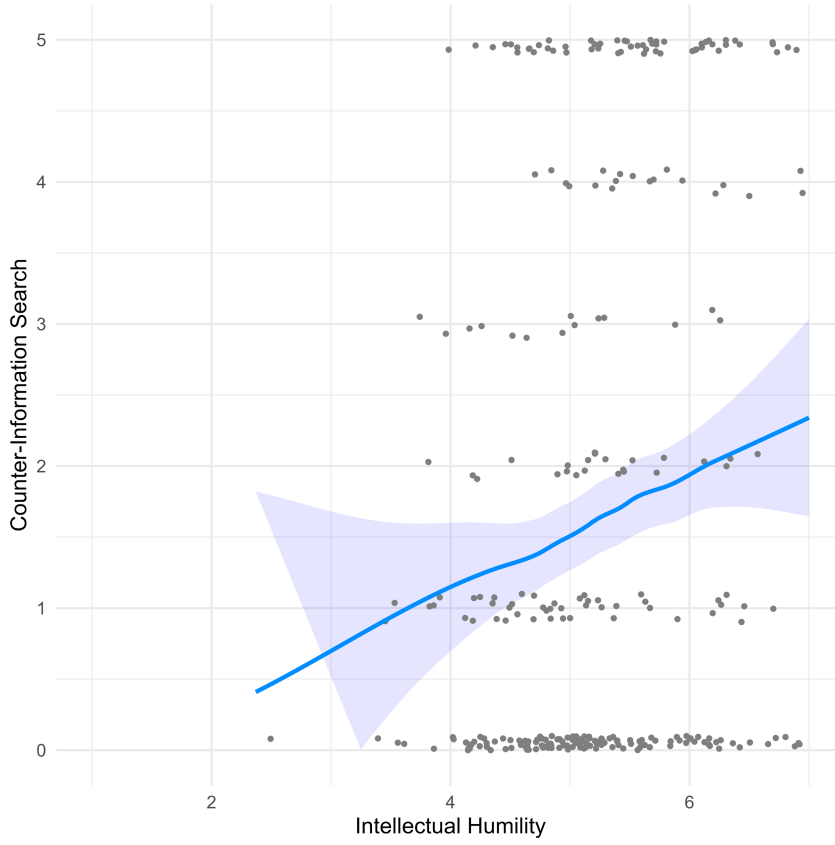

FIGURE 1 IH predicted greater counter-information search—exploring more items of information that vaccines are safe (0–5 items). Loess Plot: Local linear regressions applied. Error bands: 95% CIs.

Supporting robustness of the observed interaction, the interaction remained, $p < .001$, when including theoretical and demographic control variables (e.g. social desirability; Path B: Saturated Model; Table 2).

Linking IH to false belief revision (Path C)

To examine whether IH predicted a reduction in anti-vaccine beliefs after the counter-information search opportunity, we conducted linear mixed-effects models with IH, baseline versus post counter-information search (Time; 0 = *Baseline*, 1 = *Post Counter Information Search*), and the interaction between these two variables as predictors. Anti-vaccine beliefs functioned as the outcome variable. The model revealed that IH did not convincingly predict a change in anti-vaccine beliefs—though the interaction between counter-information search and Time was in the predicted direction, it was not significant, $p = .305$ (Path C: Main Model in Table 3; Figure 3). These results did not meaningfully change when including control variables, $p = .380$ (see Saturated Model in Table 3).

Mediation model

Though IH did not directly predict a reduction in anti-vaccine beliefs after the counter-information search opportunity, an indirect link via counter-information search may exist. The conducted mediation

TABLE 2 Results of the mixed-effects models testing the predictive power of counter-information search (the number of pro-vaccine information items participants explored) on belief-updating away from anti-vaccine beliefs (0–100 scale) from baseline to post counter-information search.

	Path B: Main model			Path B: Saturated model (predictors *z*-score)		
Predictors (scale of predictor)	**Estimates**	**CIs**	***p***	**Estimates**	**CIs**	***p***
Intercept	47.97	44.98 to 50.96	**<.001**	47.71	45.33 to 50.09	**<.001**
Counter-information search (0–5)	−0.21	−1.33 to 0.91	.716	−0.54	−2.95 to 1.87	.661
Time (0 = *baseline*, 1 = *post counter-information search*)	1.07	0.36 to 1.79	**.003**	0.02	−0.56 to 0.59	.958
Counter-information search × Time	−0.64	−0.91 to −0.37	**<.001**	−1.35	−1.92 to −0.78	**<.001**
Social desirability (0–1)				1.43	−0.94 to 3.79	.236
Age				−0.64	−3.03 to 1.76	.601
Gender (−.5 = *male*; .5 = *female*)				1.53	−0.84 to 3.90	.207
Random effects						
σ^2	20.726			20.809		
τ_{00}	705.836_{ID}			703.710_{ID}		
ICC	0.971			0.971		
N	495_{ID}			491_{ID}		
Observations	990			982		
Marginal R^2/conditional R^2	.002/.972			.009/.972		

Note: Bold values indicate statistically significant values.

model included IH as the predictor (1–7 scale), counter-information search as the mediator (0–5 items) and anti-vaccine beliefs (post counter-information search; 0–100 scale) as the outcome variable. We accounted for baseline anti-vaccine beliefs by including it as a control on all paths of the model. The mediation was calculated via the *Mediation* package in R (Imai et al., 2010). Default settings were applied, which involve running 1000 simulations to calculate quasi-Bayesian approximated CIs. We found the Main Mediation Model to be significant, $B = -0.08$, 95% CI [−0.15, −0.02], $p = .008$ (Figure 4). IH predicted greater counter-information search—exploration of information opposing anti-vaccine beliefs, and this in turn predicted a reduction in participants' anti-vaccine beliefs.

We note that the observed mediation should be approached with caution due to the correlational nature of the sample. To help address this weakness, we accounted for common mediation pitfalls (e.g. spurious third-variables) (Bullock et al., 2010). The mediation results remained in a Saturated Mediation Model that included control variables (age, gender and social desirability), $B = -0.07$, 95% CI [−0.15, −0.01], $p = .020$ (see RMarkdown). Additionally, we examined if a moderation (instead of mediation) model better explained the results; a model testing IH as a moderator between counter-information search and anti-vaccine beliefs (baseline vs. post counter-information search) was not significant, $p = .373$ (see RMarkdown).

The observed mediations should be approached with caution for an additional reason. As noted earlier, Study 1 included a *post-hoc* second round of data collection, which likely inflated Type I error (e.g. Sagarin et al., 2014). In the first sub-sample ($n = 177$), the hypothesized mediation effect was non-significant for both the Main Mediation, $p = .13$, and the Saturated Mediation, $p = .14$. In the second sample ($n = 314$) the Main Mediation was significant, $p = .044$, but the Saturated Mediation was not, $p = .056$. When combining the two samples ($n = 495$), both the Main Mediation, $p = .008$ and Saturated Mediation, $p = .020$, were significant. These significant results, however, should be interpreted in line with inflated Type I error given the post-hoc data collection. Following the methods outlined by Sagarin et al. (2014) for post-hoc data augmentation, these p-values should be interpreted under an estimated Type I error rate of around .053 for the Main Mediation and .059 for the Saturated Model, instead of the usual .05 error rate ($p_{\text{augmented}} = [.052, .055]$, and $p_{\text{augmented}} = [.055, .063]$, respectively; see OSF for calculations). While we perceive these as fairly small changes in Type I error, these updated error rates should still be taken into account when considering the reliability of the reported mediations.

Discussion

Study 1 provided preliminary support for IH's potential as an individual-level character virtue that can aid individuals in revising their false beliefs. We found IH to predict a greater exploration of counter-information in the form of pro-vaccine information, and this exploration in turn predicted revising one's anti-vaccine beliefs to become more accurate. While we observed this indirect link, we did not, however, observe a total effect of IH on false belief revision. While these results align with indirect effects being statistically more powerful than total effects (Kenny & Judd, 2014), these non-significant results still indicate that if a link between IH and false belief revision exists, this link may be quite small (given our well-powered sample).

Study 1 also had several significant limitations. For instance, the findings were limited to anti-vaccine beliefs. Additionally, Study 1 included a post-hoc collection of additional data, which inflates Type I error rate. Finally, Study 1 did not examine whether IH has any long-term impacts on false belief revision. To address these limitations, Study 2 aimed to replicate Study 1 in an alternate domain in which collective false beliefs are also common—the political domain. We examined whether IH, following an opportunity to examine counter-information, predicts revising one's false beliefs that the 2020 US Election was rigged against Donald Trump. Additionally, Study 2 included a longitudinal follow-up to examine any long-term relationships between IH, counter-information search, and false belief revision.

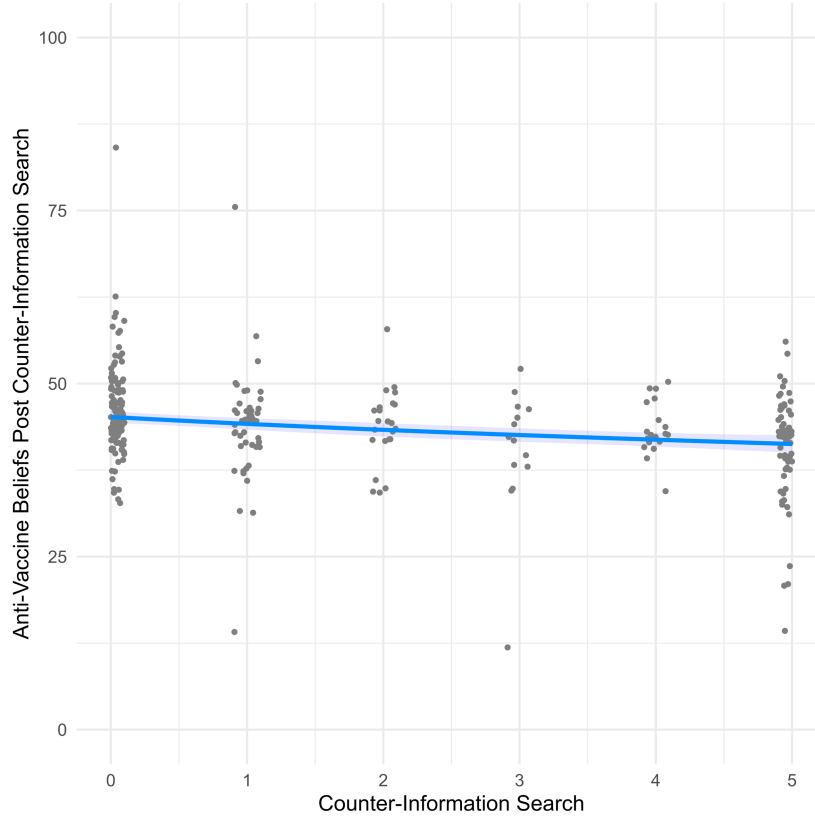

FIGURE 2 Greater counter-information search—the number of pro-vaccine information items participants explored—predicted lower anti-vaccine beliefs post counter-information search. Baseline anti-vaccine beliefs were partialled out. Loess Plot: Local linear regressions applied. Error bands: 95% CIs.

STUDY 2: FALSE BELIEFS ABOUT THE 2020 US ELECTION

Method

Study 2 followed the same paradigm as Study 1 but investigated the false belief that the 2020 US Election was rigged against Donald Trump. Study 2 also included a follow-up approximately 2 months later to examine whether a long-term link between IH, counter-information search, and false belief revision exists.

All verbatim materials and data analysis files can be found open-access on OSF. The study was pre-registered here. Informed consent from participants was obtained.

Participants

As in Study 1, a prescreen question ensured that we included only participants who held false beliefs (about the 2020 Election being rigged). We recruited participants living in the US, who completed the study on 17 November 2020. Participants first responded to: 'The 2020 US Presidential Election was Rigged Against Donald Trump'. (1 = *Not at All Agree* to 7 = *Strongly Agree*). Participants who responded less than three on this scale were excluded and did not complete any other part of the

TABLE 3 Results of the mixed-effects models testing the predictive power of IH on belief-updating away from anti-vaccine beliefs (0–100 scale) from baseline to post counter-information search.

	Path C: Main model			Path C: Saturated model (predictors *z*-score)		
Predictors (scale of predictor)	**Estimates**	**CIs**	***p***	**Estimates**	**CIs**	***p***
Intercept	48.98	32.74 to 65.22	**<.001**	47.71	45.33 to 50.09	**<.001**
Intellectual humility (1–7)	−0.26	−3.32 to 2.81	.870	−0.45	−2.99 to 2.08	.726
Time (0 = *baseline*, 1 = *post counter-information search*)	2.08	−1.88 to 6.04	.303	0.01	−0.57 to 0.59	.972
Intellectual humility × Time	−0.39	−1.14 to 0.36	.305	−0.26	−0.85 to 0.32	.380
Social desirability (0–1)				1.58	−0.88 to 4.04	.208
Age				−0.72	−3.13 to 1.68	.556
Gender (−.5 = *male*, .5 = *female*)				1.49	−0.88 to 3.87	.218
Random effects						
σ^2	21.610			21.692		
τ_{00}	706.532_{ID}			704.418_{ID}		
ICC	0.970			0.970		
N	495_{ID}			491_{ID}		
Observations	990			982		
Marginal R^2/conditional R^2	.000/.970			.007/.970		

Note: Bold values indicate statistically significant values.

study.[7] Of the total respondents (1175; MTurk), 450 responded above two (~38%) and were included in the study. Among these 450 participants, 61 did not pass an attention check, resulting in 389 participants in our final sample (175 female; $M_{age} = 41.8$ years, $SD_{age} = 11.8$). Twenty-one participants selected 'Asian/Asian American', 28 selected 'Black/African American', 19 selected 'Latino/Hispanic', 315 selected 'White/European American', 3 selected 'Other' and 3 selected 'More than one race'. Participants' political orientation leaned conservative ($M = 5.16$, $SD = 1.37$; 1 = *Very liberal* to 7 = *Very conservative*). At Time 2, approximately 2 months later, 198 participants completed the follow-up study (96 female; $M_{age} = 43.7$ years, $SD_{age} = 12.1$). Data collection at Time 2 began on 6 January 2021, and continued until 28 January 2021 (to allow as many participants as possible to complete the follow-up).

Power analysis

The same sensitivity power analysis as in Study 1 was applied. With 389 participants we had 100% power to detect a coefficient of −5—an increase of 1 on the 1–7 IH scale predicts a change of −5 points in the 1–100 false belief measure from baseline to post counter-information search. This 100% power held until around a coefficient of ~−1.8, which revealed around ~95% power. Said another way, we were well-powered to detect a change of −1.8 points in the 1–100 false belief scale for every increase of 1 in IH. We also considered power for the sample at Time 2. One hundred per cent power held until around a coefficient of ~−2.5, which revealed around ~95% power. Given that changes of −1.8 and –2.5 are, in terms of ecological meaningfulness, quite small changes in belief revision, we conclude that the study was well-powered to test the hypothesized effect.[8]

[7]The cut-off for the pre-selection item was changed from Study 1 in line with the change in the scale endpoints: 1 = *Strongly Disagree* was changed to 1 = *Not at All Agree*.

[8]The power analysis was based on the following metrics. False beliefs: $M = 75.00$, $SD = 15.00$. IH: $M = 5.00$, $SD = 2.50$.

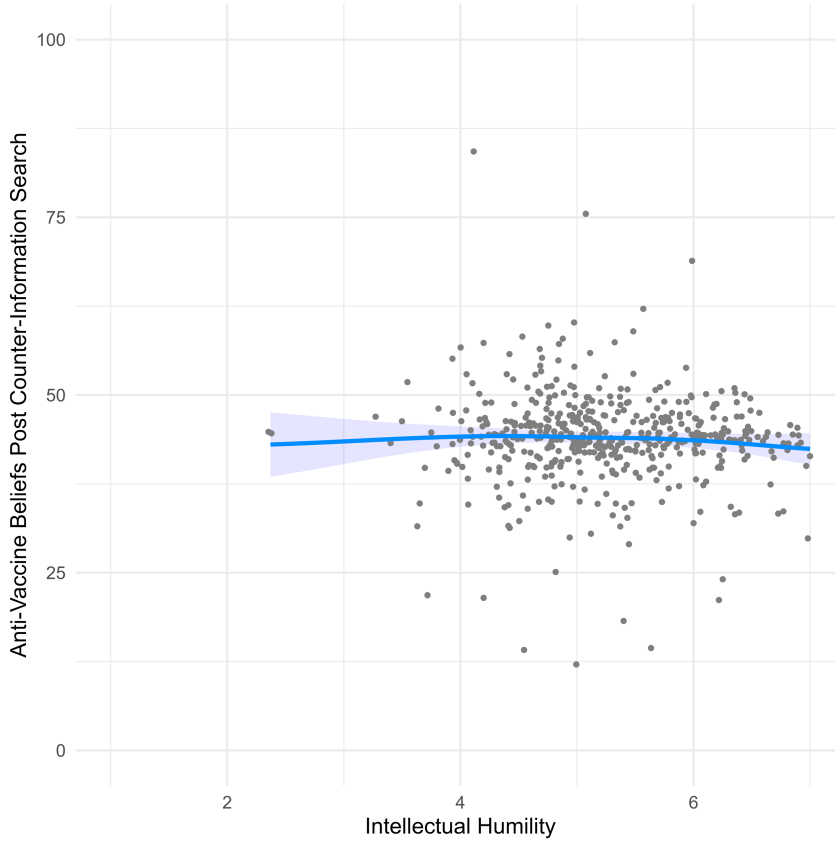

FIGURE 3 IH did not significantly predict a reduction in anti-vaccine beliefs after a counter-information search opportunity. Baseline anti-vaccine beliefs were partialled out. Loess Plot: Local linear regressions applied. Error bands: 95% CIs.

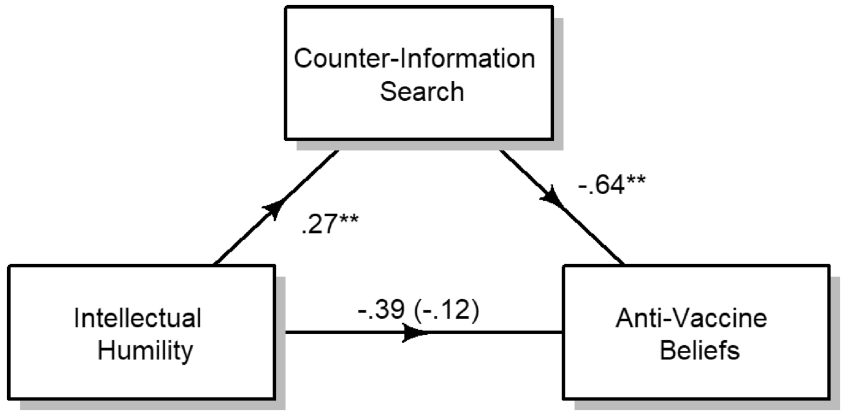

FIGURE 4 Main Mediation Model: The link between IH (1–7 scale) and anti-vaccine beliefs (post counter-information search; 0–100 scale) was mediated by the degree of counter-information search (the number of pro-vaccine items participants explored) (0–5 items). Baseline anti-vaccine beliefs were controlled for on all paths of the model.

Measures

Intellectual humility

IH was measured as in Study 1.

Rigged election beliefs

Nine questions assessed participants' beliefs of the 2020 US Election being rigged (e.g. 'Do you think the 2020 US Presidential Election was rigged?', 'Do you think there was cheating during the 2020 Presidential Election?', 'To what extent do you think that many people voted illegally during the 2020 Presidential Election [e.g., voted twice, voted despite not being a citizen]?'; see Verbatim Materials). Participants were asked to answer these questions on a scale from 0 to 100 (scale endpoints differed depending on item). Participants' rigged election beliefs were assessed before the counter-information search opportunity. The same items were then assessed again directly after counter-information search, and then again at Time 2 (~2 months later).

Counter-information search

Participants read: 'We'd like to give you a chance to hear about information on how Presidential Elections in the United States are fair and secure. Below are several links, each of which explain a different way that the 2020 Presidential Election was fair and secure. To read the information provided, click on the links below (the information is short and easy to read). If you would rather move on, click the "move on" link. You may read as many posts as you want. All of the links will display unique information regarding how the 2020 US Election was fair and secure'. Underneath this text were five links (labelled 'Election Fairness Info 1', 'Election Fairness Info 2', etc. and 'Move On'). Each of the links included credible information supporting the fairness of the 2020 Election (e.g. 'Republican Leaders and Election Officials have said the Election was Fair: Election officials in 45 US states, representing both the Republican and Democratic parties, have said there was no evidence of widespread fraud or irregularities. For instance, Georgia Lt. Gov. Geoff Duncan, a Republican, and Georgia Sec. of State Brad Raffensperger, the official overseeing voting in Georgia (also a Republican), said that there was zero evidence of widespread voter fraud or irregularities in their state'.; see Verbatim Materials). We quantified counter-information search by the number of links participants clicked on.

Procedure

The procedure was identical to Study 1 except that participants' rigged election beliefs were again assessed approximately two months later.

Results

See the RMarkdown file on OSF for details of all analyses.

Pre-analysis

Participants' IH (averaged across the three IH scales; $M = 5.26$, $SD = 0.75$, $\omega_t = .79$; 1–7 scale) unexpectedly correlated positively with rigged election beliefs at baseline ($M = 72.52$, $SD = 21.19$, $\omega_t = .95$; 0–100 scale), $r(387) = .21$, $p < .001$. As in Study 1, however, this finding is constrained to individuals who already holds false beliefs, in the case of Study 2, about the election being rigged (since we restricted our sample to only such participants).

TABLE 4 Results of the generalized linear models in Study 2 testing the predictive power of IH on counter-information search (the number of fair election information items participants explored; 0–5 items).

	Path A: Main model			Path A: Saturated model (predictors *z*-score)			Path A: Moderation model (predictors *z*-score)		
Predictors (scale of predictor)	**Incidence rate ratios**	**CIs**	***p***	**Incidence rate ratios**	**CIs**	***p***	**Incidence rate ratios**	**CIs**	***p***
Intercept	0.46	0.27–0.80	**.006**	1.72	1.59–1.85	**<.001**	1.71	1.58–1.84	**<.001**
Intellectual humility (1–7)	1.28	1.16–1.42	**<.001**	1.18	1.09–1.28	**<.001**	1.18	1.08–1.28	**<.001**
Baseline rigged election beliefs (0–100)				0.99	0.92–1.06	.742	0.99	0.91–1.06	.721
Social desirability (0–1)				1.10	1.02–1.19	**.019**	1.10	1.01–1.19	**.027**
Age				1.01	0.94–1.09	.759	1.01	0.94–1.09	.730
Gender (−.5 = *female*, .5 = *male*)				0.94	0.87–1.02	.124	0.94	0.87–1.01	.115
Baseline rigged election beliefs × Intellectual humility							1.03	0.94–1.12	.561
Observations	389			388			388		
R^2 Nagelkerke	.067			.088			.089		

Note: The Main Model includes only IH. The Saturated Model additionally includes control variables. The Moderation Model additionally includes the moderation between rigged election beliefs (at baseline) and IH. Bold values indicate statistically significant values.

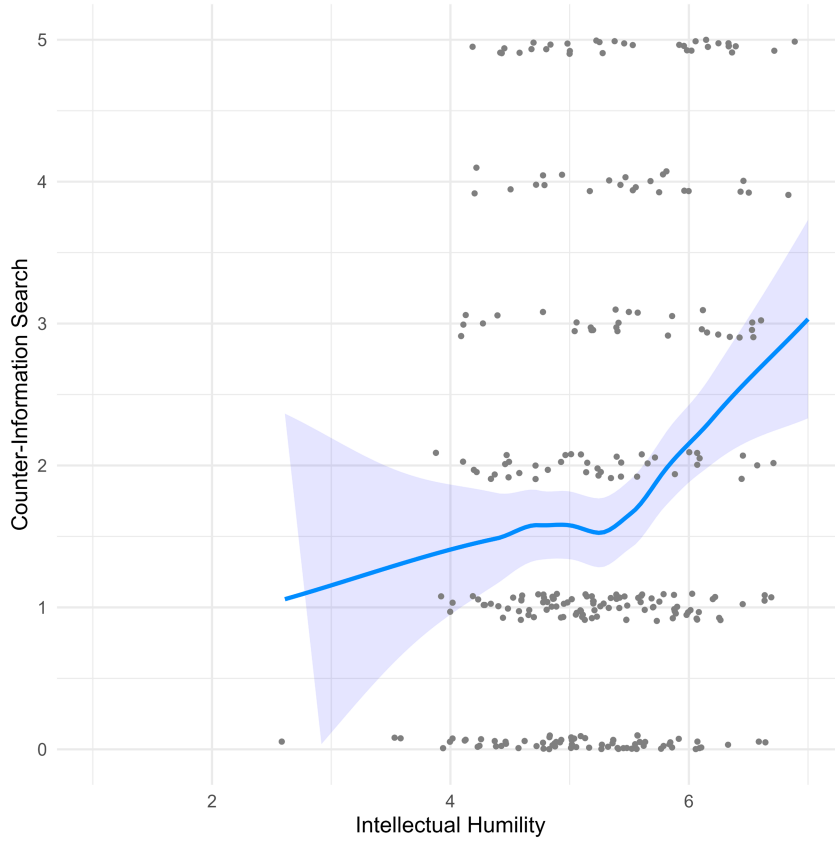

FIGURE 5 Among our sample of individuals holding rigged election beliefs, IH predicted greater counter-information search—exploring more items conveying that the 2020 US Election was fair (0–5 items). Loess Plot: Local linear regressions applied. Error bands: 95% CIs.

Unlike Study 1, and indicating that the counter-information search opportunity impacted participants' false beliefs, a within-participants *t*-test revealed that participants' rigged election beliefs decreased from baseline ($M = 72.52$, $SD = 21.19$, $\omega_t = .95$) to post counter-information search (Time 1; $M = 68.97$, $SD = 25.20$, $\omega_t = .97$; 0–100 scale), and additionally decreased from post counter-information search (Time 1) to when we re-assessed participants' rigged election beliefs approximately 2 months later (Time 2; $M = 65.80$, $SD = 29.67$, $\omega_t = .98$; 0–100 scale), $t(388) = 6.00$, $p < .001$ and $t(197) = 2.41$, $p = .017$ respectively. See RMarkdown on OSF for descriptive and reliability statistics for all variables.

Linking IH to counter-information search (Path A)

The same models as Study 1 were applied. The Main Model revealed that IH (1–7 scale) predicted greater counter-information search—examining a greater amount of information supporting that the 2020 US Election was fair ($M = 1.75$, $SD = 1.84$, 0–5 scale), $p < .001$ (Table 4; Figure 5). These results remained when adding control variables to the model (Saturated Model in Table 4), $p < .001$, and when transforming counter-information search to be binary (0 = *None Selected*, 1 = *Selected One or More*), $p = .004$. Additionally, and conceptually replicating Study 1, the link did not vary across different degrees of participants' baseline rigged election beliefs, $p = .561$ (Table 4).

TABLE 5 Results of the mixed-effects models testing the predictive power of counter-information search (the number of fair election information items participants explored) on belief-updating away from rigged election beliefs (0–100 scale) from baseline to post counter-information search (Time 1).

	Path B: Main model			Path B: Saturated model (predictors *z*-score)		
Predictors (scale of predictor)	**Estimates**	**CIs**	***p***	**Estimates**	**CIs**	***p***
Intercept	69.90	66.71 to 73.09	**<.001**	72.60	70.29 to 74.92	**<.001**
Counter-information search (0–5)	1.49	0.23 to 2.74	**.020**	2.58	0.26 to 4.89	**.029**
Time (0 = *baseline*, 1 = *post counter-information search*)	−0.64	−2.19 to 0.90	.415	−3.58	−4.70 to −2.45	**<.001**
Counter-information search × Time	−1.66	−2.27 to −1.05	**<.001**	−3.03	−4.15 to −1.90	**<.001**
Social desirability (0–1)				0.04	−2.21 to 2.30	.971
Age				1.42	−0.83 to 3.67	.216
Gender (−.5 = *female*, .5 = *male*)				−1.06	−3.32 to 1.20	.358
Random effects						
σ^2	63.579			63.614		
τ_{00}	476.104_{ID}			476.083_{ID}		
ICC	0.882			0.882		
N	389_{ID}			388_{ID}		
Observations	778			776		
Marginal R^2/conditional R^2	.013/.884			.018/.884		

Note: Bold values indicate statistically significant values.

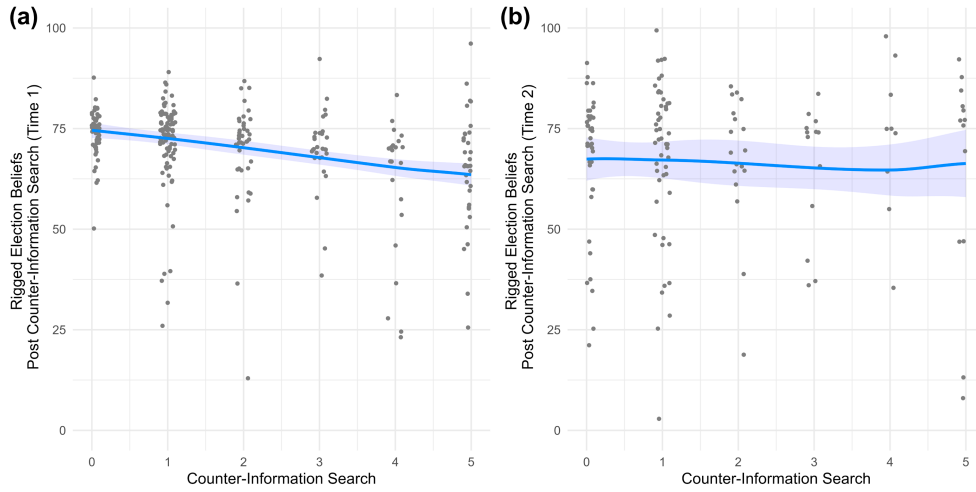

FIGURE 6 Greater counter-information search—the number of fair election information items participants explored—predicted lower anti-vaccine beliefs post counter-information search (a) in the short term (Time 1) but not (b) in the long term (Time 2; ~2 months later). Baseline rigged election beliefs were partialled out. Loess Plot: Local linear regressions applied. Error bands: 95% CIs.

Linking Counter-Information search to false belief revision (Path B)

The same models as in Study 1 were applied, except anti-vaccine beliefs were replaced with rigged election beliefs. Greater counter-information search predicted a reduction in rigged election beliefs from baseline to post counter-information search (Time 1)—the interaction between counter-information search and Time (0 = *Baseline*, 1 = *Post Counter-Information Search*) was significant, $p < .001$ (Table 5; Figure 6). Follow up analyses revealed that participants who explored zero pieces of counter-information did not change their rigged election beliefs, $B = 0.51$, $t(581) = 0.33$, $p = .100$; in contrast, participants who explored one or more pieces of counter-information exhibited a reduction in rigged election beliefs, $B = -5.19$, $t(581) = 4.68$, $p < .001$.[9] Supporting robustness, the observed interaction remained when including control variables $p < .001$ (Path B: Saturated Model; Table 5).

To examine longitudinal efficacy, we also tested whether counter-information search predicted a change in participants' rigged election beliefs from baseline to Time 2 (~2 months later). An interaction between counter-information search and Time (0 = *baseline*, 1 = *post counter-information search [Time 2]*) onto rigged election beliefs was not significant, $p = .755$ (Figure 6). Collectively, these results indicate that though the counter-information search opportunity reduced participants' rigged elections beliefs in the short-term, it did not successfully do so in the long term.

Linking IH to false belief revision (Path C)

The same analyses as in Study 1 were applied, except anti-vaccine beliefs were replaced with rigged election beliefs. IH weakly predicted a reduction in rigged election beliefs from baseline to post counter-information search—the interaction between IH and Time (0 = *baseline*, 1 = *post counter-information search*) was marginal, $p = .068$ (Table 6; Figure 7). These results did not meaningfully change when including control variables, $p = .082$ (see Saturated Model in Table 6). We also examined

[9]Simple effects were calculated in the Saturated Model. The results were consistent across models.

TABLE 6 Results of the mixed-effects models testing the predictive power of IH on belief-updating away from rigged election beliefs (0–100 scale) from baseline to post counter-information search at Time 1.

	Path C: Main model			Path C: Saturated model (predictors *z*-score)		
Predictors (scale of predictor)	**Estimates**	**CIs**	***p***	**Estimates**	**CIs**	***p***
Intercept	41.13	24.96 to 57.30	**<.001**	72.59	70.31 to 74.88	**<.001**
Intellectual humility (0–7)	5.96	2.92 to 9.00	**<.001**	4.48	2.16 to 6.81	**<.001**
Time (0 = *baseline*, 1 = *post counter-information search*)	3.99	−4.20 to 12.18	.340	−3.58	−4.74 to −2.42	**<.001**
Intellectual humility × Time	−1.43	−2.97 to 0.11	.068	−1.03	−2.19 to 0.13	.082
Social desirability (0–1)				−0.58	−2.83 to 1.67	.614
Age				1.37	−0.85 to 3.59	.226
Gender (−.5 = *female*, .5 = *male*)				−1.30	−3.53 to 0.93	.252
Random effects						
σ^2	67.671			67.683		
τ_{00}	459.957_{ID}			459.792_{ID}		
ICC	0.872			0.872		
N	389_{ID}			388_{ID}		
Observations	778			776		
Marginal R^2/conditional R^2	.035/.876			.040/.877		

Note: Bold values indicate statistically significant values.

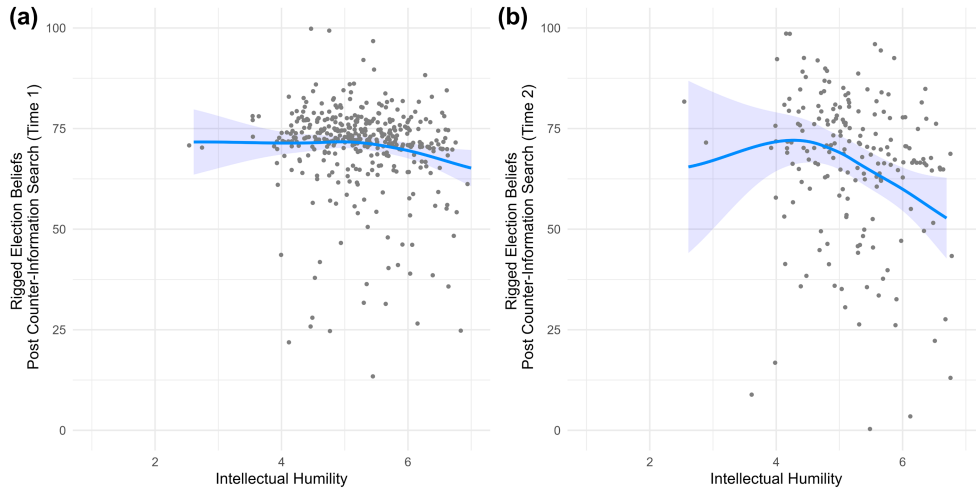

FIGURE 7 IH predicted lower rigged election beliefs post counter-information search marginally (a) in the short term (Time 1), and significantly (b) in the long term (Time 2; ~2 months later). Baseline rigged election beliefs were partialled out. Loess Plot: Local linear regressions applied. Error bands: 95% CIs.

whether IH predicted a reduction in rigged election beliefs from baseline to Time 2 (~2 months later). We found that it convincingly did so—the interaction between IH and Time (0 = *baseline*, 1 = *post counter-information search [Time 2]*) on rigged election beliefs was significant, $p = .003$ (Table 7; Figure 7). This result suggests that—over a 2-month period—IH predicted a reduction in false beliefs that the 2020 US Election was rigged.

Mediation model

The mediation analysis was as in Study 1, except anti-vaccine beliefs were replaced with rigged election beliefs. We found a significant mediation, $B = -0.22$, 95% CI [−0.45, −0.02], $p = .026$ (Main Mediation Model; Figure 8). This mediation remained in a Saturated Mediation Model that included control variables (age, gender and social desirability), $B = -0.21$, 95% CI [−0.43, −0.02], $p = .030$ (see Rmarkdown file). IH predicted exploring a greater number of counter-information opposing one's rigged election beliefs, and this in turn predicted a reduction in rigged election beliefs.

We reconducted the mediation but for participants' rigged election beliefs at Time 2 (~2 months later). Though a total effect of IH on reducing rigged election beliefs was observed, $p = .008$, a significant mediation was not found, $p = .986$. These results indicate that the link between IH and decreased false beliefs at Time 2 was not driven by the counter-information search opportunity in our study. Given the brevity of our study, this is not surprising. Potentially, however, these results are driven by our study being paralleled in the real-world. As time passed (~2 months) and more counter-information emerged opposing the false belief that the 2020 Election was rigged, individuals high in IH may have more closely considered this information, and in turn, reduced their rigged election beliefs.

GENERAL DISCUSSION

We examined whether IH—the ability to acknowledge the limitations of one's knowledge—can help people revise their false beliefs. Study 1 focused on anti-vaccine beliefs, while Study 2 focused on false beliefs that the 2020 US Election was rigged. Across the two studies, we found an indirect link between IH and false belief revision. Participants with greater IH investigated more evidence that contradicted

TABLE 7 Results of the mixed-effects models testing the predictive power of IH on belief-updating away from rigged election beliefs (0–100 scale) from baseline to post counter-information search at Time 2 (~2 months later).

	Path C: Main model (time 2)			Path C: Saturated model (time 2) (predictors *z*-score)		
Predictors (scale of predictor)	**Estimates**	**CIs**	***p***	**Estimates**	**CIs**	***p***
Intercept	41.13	24.29 to 57.96	**<.001**	72.59	70.22 to 74.96	**<.001**
Intellectual humility (0–7)	5.96	2.80 to 9.13	**<.001**	4.53	2.12 to 6.95	**<.001**
Time (0 = *baseline*, 1 = *post counter-information search [Time 2]*)	24.21	3.78 to 44.63	**.020**	−6.94	−9.87 to −4.01	**<.001**
Intellectual humility × Time	−5.93	−9.80 to −2.06	**.003**	−4.58	−7.51 to −1.66	**.002**
Social desirability (0–1)				−1.03	−3.29 to 1.23	.373
Age				1.38	−0.85 to 3.60	.226
Gender (−.5 = *female*, .5 = *male*)				−0.90	−3.14 to 1.34	.430
Random effects						
σ^2	244.612			245.148		
τ_{00}	327.293_{ID}			324.092_{ID}		
ICC	0.572			0.569		
N	389_{ID}			388_{ID}		
Observations	587			585		
Marginal R^2/conditional R^2	.041/.590			.045/.589		

Note: Bold values indicate statistically significant values.

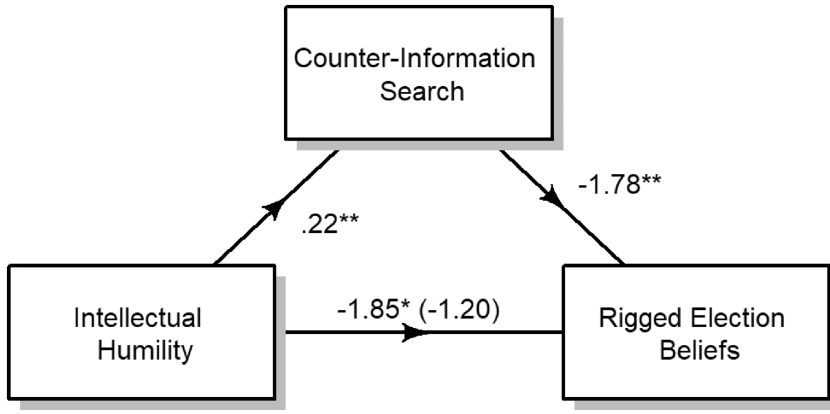

FIGURE 8 Main mediation model: The link between IH (1–7 scale) and rigged election beliefs (post counter-information search; 0–100 scale) was mediated by the degree of counter-information search (the number of fair election items participants explored) (0–5 items). Baseline rigged election beliefs were controlled for on all paths of the model.

their false beliefs—they examined more evidence supporting the safety of vaccines (Study 1) and the fairness of the 2020 election (Study 2). Consequentially, this exploration of counter-information predicted a reduction in false beliefs about the risks of vaccines and the 2020 Election being rigged. While these findings are at first encouraging for the potential of IH at reducing false beliefs, we did not observe a consistent total effect of IH on false belief revision. While these results align with indirect effects being statistically more powerful than total effects (Kenny & Judd, 2014), these non-significant results still indicate that if a link between IH and false belief revision exists, this link may be quite small (given our well-powered samples). As such, while our results suggest that character virtues such as IH may indirectly aid in revising false beliefs towards accurate ones, it is unclear whether this potential link is substantial enough to meaningfully heighten accurate beliefs across society and, moreover, to reduce the negative consequences of false beliefs (e.g. risky decision making, political violence; Jacobson, 2023; Loomba et al., 2021).

Theoretical advances

While past work has linked IH to holding more accurate beliefs (Krumrei-Mancuso et al., 2020; Porter et al., 2022), for instance, in the form of lower endorsement of conspiracy theories (Bowes & Tasimi, 2022), the present work is among the first to examine whether IH is linked to *revising* false beliefs that people already hold. Complementing our findings, Rodriguez et al. (2019) found some support for IH contributing to belief revision; individuals holding IH about their religious beliefs were more likely to revise their religious beliefs after a conversation with someone (of the opposite religious view) as long as they perceived this person as also high in IH. This previous finding may help explain why we did not observe a total effect of IH on belief revision; potentially, this effect only occurs for participants who perceive the counter-information they encounter as originating from an intellectually humble source. If true, this would suggest that an environment perceived as open and collaborative is necessary for IH to predict belief revision. At the same time, however, it is unclear whether the religious beliefs participants revised in Rodriquez et al. (2019) were *false* beliefs or not. As such, the extent to which these past findings apply to the present work is an open question.

The present studies also extend research on false beliefs by examining two major topics in misinformation research—the health domain and the political domain (Jerit & Zhao, 2020; Krumrei-Mancuso & Newman, 2020; Swire-Thompson & Lazer, 2020). Past work in this research area has largely failed to consider the potential of character virtues, such as IH, for attenuating misinformation

and false beliefs. This is no small matter. Misinformation and false beliefs, and in particular the false beliefs we examined, can have severe consequences. False beliefs about health practices, such as vaccines, are linked to increased viral spread and mortality (Loomba et al., 2021), and in the political domain, false beliefs about the 2020 Election more than likely led to the January 6th Insurrection (Jacobson, 2023). Moreover, anti-vaccine and rigged election beliefs are not uncommon. A nationally representative sample conducted in 2022 found that 20% of respondents endorsed at least one COVID-19 vaccine misperception, and 41% believed at least one false statement in the political domain (Ognyanova et al., 2023). Additionally, during the time period of our study, 82% of Republicans believed that Biden had not won the election fairly (Monmouth University Poll, 2020, 2021), suggesting that this false belief was the norm within this ingroup (a 'collective' false belief among Republicans). Taken together, the present work thus raises the possibility that IH can, at least indirectly, alter fairly prevalent false beliefs, and moreover, may even be able to indirectly alter false beliefs that are the norm within a partisan ingroup.

The observed indirect association

The observed indirect association between IH and false belief revision aligns with and extends previous research. First, these findings complement past research linking IH to holding fewer inaccurate beliefs; for instance, IH predicts holding fewer false beliefs about COVID-19 (Huynh & Senger, 2021; Meyer et al., 2021; Pärnamets et al., 2022) and more generally, endorsing fewer conspiracy theories and misinformation (Bowes et al., 2021; Bowes & Tasimi, 2022). Our results may help explain variance underlying these findings. Aside from IH potentially protecting individuals from adopting false beliefs, our results suggest that IH may lead individuals to explore information opposing their false beliefs, in turn leading them to update away from these false beliefs.

Second, the observed link between IH and greater exploration of counter-information (Path A in the mediation model) directly aligns with past research showing that IH predicts greater openness to information opposing one's beliefs (Porter & Schumann, 2018). For instance, when facing persuasive counter evidence, people with high intellectual humility tend to feel less defensive and more willing to consider counterarguments (Porter & Schumann, 2018). Similarly, Gorichanaz (2022) found that people with more IH sought information from multiple sources, mirroring the behaviour of participants in our study, who engaged with a higher number of links presenting counterarguments.

Third, regarding the observed indirect link, the association between counter-information search and belief revision (Path B in the mediation model) did not remain after ~2 months (Study 2). This finding aligns with belief updating often failing to sustain for a long period, due to belief regression—re-endorsing one's original false belief over time (Carey et al., 2022; Newman et al., 2022; Swire-Thompson et al., 2023). Nonetheless, in Study 2, IH—unlike counter-information search—did predict reduced false beliefs at Time 2 (~2 months later; but see Study S1). Potentially, IH did so because our experiment was being 'paralleled' in the real world. As time passed after the 2020 US Election, more convincing evidence that the election was *not* rigged appeared online, accompanied by a decrease of rigged election beliefs. For instance, according to a national poll around the time our study was conducted, the percentage of people who believed Biden won the election fair and square increased from 60% to 65%, and among Republicans, went from 18% to 24% (Monmouth University Poll, 2020, 2021). Following the increasing exposure to accurate information and beliefs, participants in our study with high IH might have encountered this accurate new evidence, and in turn revised their false beliefs about the election. Although this explanation is speculative, if true, it suggests that an environment with accurate information may be necessary for people with high IH to correct their false beliefs.

Limitations of IH in impacting false belief revision

The present research extends past work by uncovering a potential limitation of IH in terms of combating false beliefs. As noted earlier, though the observed indirect links between IH and false belief revision support IH's capability in altering false beliefs, a total effect of IH on false belief revision was not observed. In Study 1, a null link was observed, and in Study 2, this association was marginal (though see Study S1). As such, our results provide mixed evidence for the efficacy of IH in revising false beliefs.

Given that we failed to observe a total effect of IH on belief revision, we considered the observed effect-sizes. The estimated effects of an increase of one in IH on the 1–7 scale was a reduction of 0.39 (Study 1) and 1.43 (Study 2) in false beliefs from Time 1 to Time 2 on the 1–100 scale. These estimates suggest a minimal relationship between IH and belief revision. Given these results, we re-conducted the sensitivity power-analysis with the observed descriptive statistics of Studies 1 and 2. Again, we focused on the potential link between IH and belief revision (the IH × Time interaction in the C Path Models). In Study 1, with 495 participants and the observed descriptive statistics, we had 95% power to detect a coefficient of approximately −7.9. Said another way, the true effect-size of IH predicting belief revision is very likely less than −7.9 per a change of 1 in the IH scale. In Study 2, the calculated value was approximately −8.3. These estimates appear surprisingly large. To understand this, consider the small standard deviation in the IH measure (.78). That is, a change of one in participants' IH on the IH measure is a very large change in IH given the lack of variance. Given this lack of variance in the IH measure, we had quite low power to find *ecologically* meaningful effects of IH on false belief revision. From this analysis, we conclude that a positive link between IH and false belief revision may be a true feature of the world, yet it is difficult to capture this effect given the low amount of variance in the assessed IH measures. We strongly encourage future research to focus on developing IH measures that better capture the assumed variance of IH in the general population (see Costello et al., 2023 for additional critiques of existing IH measures).

Additionally reducing enthusiasm regarding IH and false beliefs revision, in Study 2, participants with higher IH held greater, rather than fewer, false beliefs about the 2020 US Election being rigged at *baseline*. This finding suggests that intellectual humility might—in some cases—lead to higher acceptance of misinformation, a claim that counters previous literature linking IH to reduced false beliefs (Bowes & Tasimi, 2022). We note, however, that our sample was limited to individuals already holding false 2020 Election beliefs. Nonetheless, these findings tentatively suggest that IH may predict being open to any convincing information in one's environment or ingroup (in this case among Republicans), regardless of whether this information is accurate or not (though see Pärnamets et al., 2022). If true, IH may only be a promising tool for reducing false beliefs when an environment provides accurate information.

Limitations

The included studies were correlational; our findings should not be interpreted causally. It remains unclear if manipulating IH, which can be quite difficult, would have any impact on information search or belief revision. We also did not find a total effect between IH and belief revision—we only found an indirect relationship driven by IH's positive link with counter-information search—further suggesting that if a causal link exists, it is fairly weak. Additionally, though we considered some third-variables, like age, gender and social desirability, we did not examine alternate potential confounds of the observed results.

The reported studies have methodological limitations. The cut-offs for the pre-screen items (to constrain the samples to participants who hold false beliefs) were based on our intuition; we aimed to collect participants who held the examined false beliefs while also ensuring that our sample was not 'extremist' in terms of these false beliefs. Given that participants who did not pass these screener items did not complete any other part of the study, it is unclear whether our results would change if these cut-offs had

differed. Additionally, in Study 2, nearly half of participants dropped out at Time 2 (~2 months later). This dropout rate reduces statistical power and may have led to inaccurate estimates. Finally, we assessed intellectual humility before assessing participants' false beliefs, which may have led participants' to under-report their degree of false beliefs.

CONCLUSION

False beliefs have a pervasive and detrimental influence on individuals and society. To address this issue, our research focused on the potential of IH—an individual character virtue capturing people's cognizance of their intellectual boundaries—as a tool to steer individuals away from false beliefs and towards accurate ones. Our findings, however, paint a mixed picture. While IH promoted examining counter-evidence conflicting with individuals' pre-existing false beliefs, and this in turn predicted a shift towards accurate beliefs, we did not observe a total effect of IH on revising one's false beliefs. These results suggest that a potential effect of IH on belief updating—if it exists—is not particularly powerful. Additionally, our analyses tentatively suggest that IH might incentivize individuals to adopt any convincing information, regardless of its veracity. Consequently, the effectiveness of IH may hinge on the availability of accurate information in the surrounding environment. Taken together, while our research provides some support for IH as a character trait to foster belief revision, it simultaneously suggests that other pathways to belief revision should also be considered.

AUTHOR CONTRIBUTIONS

Anton Gollwitzer: Conceptualization; investigation; funding acquisition; writing – original draft; methodology; validation; visualization; writing – review and editing; software; formal analysis; project administration; resources; supervision; data curation. **Evelina Bao:** Writing – original draft; writing – review and editing. **Gabriele Oettingen:** Writing – review and editing; conceptualization; funding acquisition.

ACKNOWLEDGEMENTS

We thank the John Templeton Foundation for funding this research.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in OSF at https://osf.io/yf382/?view_only=e8d279f90c4741fd9f2edeffce5e0c17.

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SUPPORTING INFORMATION

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

How to cite this article: Gollwitzer, A., Bao, E., & Oettingen, G. (2024). Intellectual humility as a tool to combat false beliefs: An individual-based approach to belief revision. *British Journal of Social Psychology*, *00*, 1–29. https://doi.org/10.1111/bjso.12732