

How is analytical thinking related to religious belief? A test of three theoretical models

Abstract

Research has identified a negative association between analytical thinking style and belief in God. However, the replicability and theoretical importance of this correlation has been debated. Moreover, the literature has not examined distinct psychological accounts of this relationship. In Study 1, we tested the replicability of the correlation in a large sample ($N = 5284$; undergraduate students at a Canadian university, and broader samples of Canadians, Americans and Indians); while testing three accounts of how cognitive style comes to be related to belief in God, in karma, and in witchcraft, and to the belief that religion is necessary for morality. The first, *the dual process model*, posits that analytical thinking is inversely related to all supernatural beliefs. The second, *the expressive rationality model*, posits that analytical thinking is recruited in supporting already-held beliefs in an identity-protective manner. And the third, *the counter-normativity rationality model*, posits that analytical thinking is recruited to question beliefs supported by prevailing cultural norms. We tested predictions from these theoretical models in a Bayesian framework. In Study 2, we tested the replicability of our results in a re-analysis of published data. The association between analytic thinking style and various religious beliefs was replicated. We conclude that whereas the counter-normativity rationality model was contradicted by the data, both the dual process and expressive rationality models received varying degrees of empirical support, but neither model fully accounted for all the patterns in the data.

Keywords

Religion; belief; analytical thinking; intuition

48 minutes to make 5 widgets, how many minutes would it take 100 machines to make 100
49 widgets?") to which there is an intuitively compelling but wrong answer (i.e., 100 minutes), and
50 a correct answer (i.e., 5 minutes). Although simple in its design, this measure is reported to
51 reliably differentiate between those who tend to go with their 'gut' response and those who are
52 willing to reflect and override their 'gut' response (i.e., reason analytically) about the questions -
53 even over time and repeated tests, and controlling for cognitive ability (Stagnaro, Pennycook, &
54 Rand, 2018). And in support of the hypothesis that religious belief is related to intuitive thinking
55 styles, a meta-analysis of 31 studies consisting of mostly North American participants ($N =$
56 15078), found that CRT scores were inversely related to religious beliefs ($r = -.18$, $.95\text{CI} = [-.21,$
57 $-.16]$; Pennycook, Ross, Koehler, & Fugelsang, 2016).

58 *The dual-process model of religious belief*

59 This correlational evidence forms the core of what can be called the *dual process model of*
60 *religious belief* (e.g., Norenzayan & Gervais, 2013; Pennycook, Ross, et al., 2016; Shenhav et al.,
61 2012). In this perspective, the human tendency for religious thinking emerges from the everyday
62 functioning of intuitive cognitive systems, whose output is constrained by careful, effortful
63 reasoning (for this distinction, see Evans & Stanovich, 2013). In its strong version, this model
64 proposes that deliberation and questioning of human intuitions should consistently lead to the
65 rejection of belief. Thus, a core prediction of this model is that, all else being equal, it should be
66 more common that individuals reason their way out of their religious beliefs than it is for
67 individuals to reason their way into them.

68 However, one need not look deeply into the theological and philosophical record of treatises
69 on religious belief to realize that many a religious scholar have deeply reasoned their way into their
70 religious beliefs. Dating back to the 4th and 5th century, the careful and deeply analytical works of

71 St. Augustine of Hippo, for example, remain a cornerstone of Christian philosophically-reasoned
72 arguments *for* believing in God (e.g., see De Cruz & De Smedt, 2017). This raises an important
73 question as to whether there are reliably detectable circumstances under which analytical thinking
74 can promote religious belief rather than dampen it.

75 *The expressive rationality model of religious belief*

76 Much like Augustine – who spent a great deal of time coming up with reasoned arguments
77 defending his conversion to Christianity (Jacoby, 2017) – individuals can be deeply motivated to
78 justify their previously-held commitments and beliefs and sometimes go to incredible lengths to
79 confirm their preconceptions (Nickerson, 1998). Although overriding one’s intuitions might be a
80 good way to reason through all the available evidence, an alternative account suggests that
81 analytical thinkers might be even better than intuitive thinkers at finding ways to confirm their
82 biases *regardless* of the evidence. Indeed, the *expressive rationality model* holds that individuals
83 deploy their analytical thinking to justify previously-held beliefs and that they do so most
84 dramatically when these beliefs are strong indicators of their social affiliations (Kahan, 2017).

85 That is, rationality can be deployed to confirm already held beliefs as an identity-protective
86 strategy. For example, Kahan & Stanovich (2016) demonstrated that belief in evolution in
87 religious and non-religious Americans is most different (i.e., polarized) amongst analytical
88 thinkers from either camp. In this view, while analytical thinking might lead nonreligious
89 individuals to question their core intuitions that the design of nature implies supernatural agency
90 (Kelemen, 2004; Kelemen et al., 2013; Rottman et al., 2016), the same analytical tendency leads
91 religious individuals to endorse supernatural agency with even greater conviction. Indeed, already-
92 devoted analytical thinkers – like Augustine – might prove to be the deepest believers, or at the
93 very least no more or less believing than their intuitive and devoted counterparts. No work – yet –

has directly tested whether and how this model applies to belief in God.

The counter-normative rationality model

Moreover, an important limitation of the bulk of the research on the relationship between analytical thinking and religious belief is that it has been conducted with mostly North American and specifically majority Christian samples (with some important exceptions; e.g., studies of Turkish Muslims found results of similar size and magnitude to those reported from American samples; Yilmaz & Saribay, 2016). To test the dual process model of religious belief cross-culturally, Gervais et al. (2017) deployed the CRT and a measure of belief in God in 13 religiously-diverse samples (e.g., Buddhists in Singapore, Hindus in Mauritius, Muslims in the United Arab Emirates, and in secularized nations such as the Czech Republic). In aggregate, Gervais et al. (2017) observed a relationship between analytical thinking and belief in God in the direction predicted by the dual process model of belief; however, the average magnitude of the effect was very small (i.e., an estimated average 2-point decrease on a 100-point scale of belief in God with each additional correct answer on the CRT). While providing some cross-cultural support for the dual process model of religious belief, the observed relationship between CRT and belief was also found to be more strongly negative in more religious countries, and in a few places – such as the UK, the observed relationship was reversed.

From this, Gervais et al. (2017) proposed a third possible account, which can be called the *counter-normative rationality model*. This model says that the *contents* of our intuitions are not just the output of evolved cognitive systems but also (at least in part) the output of culturally-learned norms (Henrich, 2015). And thus, it may be that the observed effect of analytical thinking on religious beliefs is an expression of questioning the prevailing norm of religiosity in majority-religiously affiliated cultures (i.e., where most of this research is conducted). In highly secularized

117 cultural contexts – questioning the norms might predict higher religious belief. In line with this,
118 Gervais et al.’s (2017) found that analytical thinking was weakly but *positively* related to belief in
119 God in a sample of students in the United Kingdom. However, Stagnaro, Ross, Pennycook, &
120 Rand (2019), failed to replicate Gervais et al.’s positive association – in fact, they found the
121 typically sized negative correlation between CRT and belief in God in the United Kingdom in a
122 larger and broader sample of British adults. This additional data, however, does not necessarily
123 rule out the counter-normative rationality’s account of the fluctuating magnitude of the
124 relationship as a function of varying levels of normative religiosity. Given the differences in
125 British populations sampled in Gervais et al.’s (2017; university students) and Stagnaro et al.
126 (2019; broader sample of the British public), these results may just be representative of the
127 different populations they were drawn from. And, assuming that the student sample was relatively
128 less religious than the broader sample of the British public, these differing results may provide
129 further indication that normative levels of religiosity moderates the relationship between cognitive
130 style and belief.

131 *Testing the three models*

132 The growing record of a robust negative correlation between analytical thinking and
133 religious belief has so far not adequately investigated the cognitive processes that account for this
134 relationship. Moreover, given recent failures to replicate the *causal* (i.e., experimental) effect of
135 induced analytical thinking on disbelief in God in high powered samples and preregistered designs
136 (Sanchez et al., 2017; Saribay et al., 2020; Camerer et al., 2018 failing to replicate Gervais &
137 Norenzayan, 2012, Study 2) there is all the more reason to aim for a better theoretical
138 understanding of the underlying psychological processes and moderators of the association
139 between cognitive style and religious beliefs. Based on these considerations, Study 1 had several

goals.

140 First, we tested the dual process model of religious belief by assessing the replicability and
141 magnitude of the correlation between belief in God and cognitive style (measured in two
142 complementary ways – tendencies to think analytically and one’s self-reported faith in intuition).
143 In addition, and going beyond existing research, we examined whether the effect of cognitive style
144 extends to other types of religious and supernatural beliefs (i.e., the belief that religion is necessary
145 for morality, belief in karma, and belief in witchcraft). This is important, because the dual process
146 model predicts that all types of supernatural beliefs will be negatively correlated with analytic
147 cognitive style, whereas the expressive rationality and counter-normative rationality models do
148 not.

149 Second, we tested predictions from the expressive rationality model by examining the
150 interaction between cognitive style and political orientation in predicting varied beliefs.
151 Specifically, this model predicts that the relationship between analytical thinking and *identity-*
152 *relevant beliefs* such as belief in God and the belief that religion is necessary for morality will be
153 moderated by political orientation. These beliefs are both considered a hallmark of political
154 conservatism in North America (e.g., Haidt, 2012) and are more strongly endorsed by the
155 ideological right in many countries (Pew Research Center, 2020). The expressive rationality model
156 predicts that analytical thinking will be *positively* associated with these beliefs amongst politically
157 conservative individuals, but *negatively* associated with these beliefs among politically liberal
158 individuals – as analytical thinking is employed to strengthen existing commitments to identity-
159 relevant beliefs. This interaction thus resulting in widening differences in belief between liberals
160 and conservatives with increasing tendencies for analytical thinking. Otherwise, the expressive
161 rationality model really makes no clear predictions as to whether the relationship between
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163 analytical thinking and *non-identity-relevant* supernatural beliefs (e.g., karma/witchcraft beliefs
164 among North Americans) will be similarly moderated by political orientation. Indeed, if the
165 relationship between analytical thinking and supernatural beliefs results *entirely* from the
166 dynamics of identity-protective motivated reasoning as would be proposed by a strong version of
167 the expressive rationality model, then analytical thinking would be unrelated to non-identity-
168 relevant supernatural beliefs. We test for all these possibilities in Study 1.

169 Third, we tested the counter-normative rationality model in a novel way, by examining the
170 direction of the correlation between cognitive style and belief in *counter-normative* supernatural
171 beliefs - in karma and in witchcraft in samples where these beliefs have markedly different
172 normative status. Specifically, we tested the predictions of counter-normative rationality model
173 that: (1) among majority Hindu Indians (where karmic belief is more normative¹) analytical
174 thinking should be *negatively* related to karma beliefs; but, (2) among North Americans (where
175 karmic belief is less normative), analytical thinking should be *positively* related to karma beliefs.
176 Witchcraft beliefs, however, being less normative in both samples, are predicted by this model to
177 be *positively* (or less strongly negatively) related to analytical thinking. In sharp contrast, the dual
178 process model predicts that these associations will be consistently *negative*.

179 Finally, in Study 2, we tested the replicability of the some of the focal results obtained in
180 Study 1 in data that was not collected by our team, through a re-analysis of two previously
181 published and openly-accessible datasets (Gervais et al., 2017; Stagnaro et al., 2019).

¹ The Indian participants in Study 1 were roughly 75% Hindu (the rest of participants were mostly Christian or Muslim); and although karmic beliefs are more strongly endorsed by Indian Hindus than other Indian subpopulations, they are still commonly endorsed by Indian Christians and Muslims (White, Norenzayan & Schaller, 2019).

182 In both studies, the hypotheses are compared and contrasted in a Bayesian framework that
183 enabled us to determine the relative probabilities with which the data provide evidence in support
184 (or against) the specific predictions of these three models. In doing so, we (1) provide further tests
185 of the replicability of the association between analytical thinking and religious beliefs, in terms of
186 its magnitude and association in previously studied and understudied cultural contexts, and (2) also
187 move beyond documenting the association, to test three distinct psychological accounts of the
188 association between cognitive style and religious beliefs.

189 Study 1

190 In Study 1, we tested the predictions of three psychological accounts of the relationship
191 between analytical thinking and religious beliefs in four samples (undergraduate students at a
192 Canadian university, and broader non-student samples of Canadians, Americans, and Indians).
193 The dual process model of belief predicts that analytical thinking (i.e., greater cognitive
194 reflection and less faith in intuition) will be negatively related to all forms of supernatural beliefs
195 across all samples. The expressive rationality model of belief predicts that (1) the relationship
196 between analytical thinking and identity-relevant supernatural beliefs (e.g., belief in God, and
197 belief that religion is necessary for morality) will be moderated by political orientation (i.e., such
198 that the association is negative for liberals and positive for conservatives), (2) that political
199 orientation will not moderate these associations in the case of non-identity relevant supernatural
200 beliefs and/or that analytical cognitive style will be unrelated to endorsement of non-identity
201 relevant beliefs. The counter-normative rationality model, on the other hand, predicts that
202 analytical thinking will be *positively* related to endorsement of counter-normative supernatural
203 beliefs.

Methods

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Sample

To test these predictions, we identified datasets that we had previously collected which included the relevant variables to examine the association between cognitive style and varied religious/supernatural beliefs. A total of 9 datasets were identified ($N = 5284$; see Table S1 for sample details of each dataset). Participants were: undergraduate students sampled from the University of British Columbia Psychology Department's Human Subject Pool; a national sample of Canadians; two samples of majority Hindu Indians (one sample recruited from Amazon's Mechanical Turk and a broader national sample recruited by an online market research company), and a broad sample of majority Christian Americans (recruited from Amazon's Mechanical Turk). All measures, data analytic choices, and data exclusions are fully disclosed in this article; and materials, data and analysis scripts are available at <https://osf.io/hpw38/>.

Materials

The presence/absence of the focal measures in each data set are presented in Table S2. Summary statistics of all focal measures are presented in Table S3 and correlations by sample in Table S4.

Measures of belief

Across the datasets, belief in God was measured on different response scales (5- and 7-point scales). To allow for comparison across response scales, belief in God was linearly recoded to a 0 (minimum belief) to 100 (maximum belief) scale. This type of rescaling was beneficial for two reasons. First, it had the benefit of making all effect size estimates across Study 1 and Study 2 directly comparable (as all examined datasets now employed a 0 to 100 response scale to measure

226 belief endorsement). Second, alternative rescaling strategies like standardizing responses within
227 datasets would cancel out between dataset mean differences, effectively eliminating the benefits of
228 partial pooling that result from generating estimates and predictions using mixed-effect regression
229 models as do in our analyses.

230 In four of the datasets, the belief that religion is necessary for morality was assessed. This 5
231 -item scale asked participants to rate the extent to which they agree with items such as, “Generally
232 speaking, people need religion to be morally good”, and “An individual who does not believe in
233 God cannot lead a moral life” ($\alpha = .96$; full scale included in supplemental, Table S5). Across
234 datasets, responses were coded on varying response scales (6- and 7- point scales). As above,
235 responses were recoded on to a 100-point scale. The belief that religion is necessary for morality is
236 prevalent across cultures (Pew Research Center, 2020) and known to be particularly polarizing
237 between North American conservatives and liberals (Pew Research Center, 2014).

238 Belief in karma was assessed using either the 16-item or 4-item version of a karmic belief
239 scale (White, Norenzayan, & Schaller, 2019). This scale assesses belief in karma with items such
240 as, “Karma is a force that influences the events that happen in my life”, and “When people
241 experience good fortune, they have brought it upon themselves by behaviour in a past life”. This
242 scale showed good internal consistency across samples ($\alpha s = .90-.93$).

243 Belief in witchcraft was assessed using a 7-item scale ($\alpha s = .84-.91$ across samples; e.g.,
244 “People can harm others with supernatural power, e.g., by cursing or casting spells on people”, and
245 “If other people have had bad thoughts towards you, it can make you sick”). These items have
246 some overlap with (but are not identical to) previously examined measures of paranormal beliefs
247 that have been reported to be negatively correlated with analytical thinking (Pennycook et al.,
248 2012).

Measures of cognitive style

249 The Cognitive Reflection Test (Frederick, 2005) is a three-item measure ($\alpha = .75$ across
250 samples) designed to assess capacities and general tendencies for inhibiting intuitive responses and
251 thinking more analytically. The test's three questions have an intuitively compelling (but wrong)
252 answer (e.g., "If a bat and a ball cost \$1.10, and the bat costs \$1.00 more than the ball, how much
253 does the ball cost?"). Individuals who tend *not* to reflect often give the answer "10 cents" (the
254 modal response). Individuals who do make the effort to reflect are more likely to arrive at the
255 correct answer, "5 cents". Correct responses are summed, and the total score serves as an index of
256 analytical thinking. This test is commonly used in assessing the association between analytical
257 thinking and religious belief (e.g., Pennycook, Ross, Koehler, & Fugelsang, 2016).

258 The Faith in Intuition subscale of the Rational Experiential Inventory (Pacini & Epstein,
259 1999) was included in these datasets as a measure of intuitive cognitive style. This 20-item self-
260 report measure ($\alpha = .96$) asks participants to indicate their agreement with a series of statements
261 reflecting an explicit preference for *not* overthinking and trusting in one's intuitions (e.g., "I like to
262 rely on my intuitive impressions", and "I believe in trusting my hunches"). The inclusion of this
263 measure of intuitive thinking style allowed us to test the robustness of the hypothesized association
264 between cognitive style and religious belief. Responses were on varied response scales (5- and 7-
265 point scales) and were first rescaled on to a 0 to 1 scale for comparison and then *reverse* scored
266 such that higher scores indicated *less* faith in intuition to ease comparisons between this measure
267 and the CRT.

Political Orientation

270 Political orientation was measured across all datasets with a single item that asked
271 participants to indicate whether they were very liberal (1) to very conservative (7) on a Likert-
272 scale.

273 Results

274 *Analytical Strategy and Predictions*

275 Our analytical strategy was not pre-registered. As such, our focal regressions include only
276 variables that are directly relevant to testing the predictions of the dual process, expressive
277 rationality and counter-normative rationality models of religious beliefs (i.e., measures of belief,
278 political orientation, and identifiers for sample and dataset). The publicly available datasets
279 include additional demographic variables (age and sex); and we note that the pattern of results
280 reported here remain unchanged when demographic controls are added to the models. We actively
281 encourage those interested in considering the relationship between these additional variables and
282 our focal predictors to make use of our compiled data.

283 All analyses were conducted in *R* (R Core Team, 2017). Bayesian mixed-effect linear
284 regression models were executed using the *brms* (Bürkner, 2017) compiler for *RStan* (Stan
285 Development Team, 2017). Model summary tables were generated with *sjPlot* (Lüdtke, 2018).
286 Beliefs were modelled with a random-intercept for dataset (unless data was only available from a
287 single source, in which case no random-intercept was included). Priors were set as weakly-
288 regularizing: fixed effects \sim Normal(0,1); and for variance components for varying effects \sim
289 Exponential(1); which help to minimize overfitting the model to the data in the estimation process
290 (McElreath, 2015, p. 393; Purzycki, Pisor, et al., 2018).

291 As beliefs were recorded on differing response scales between datasets, all belief measures
292 were rescaled from their original form to a 0 (minimum belief) to 100 (maximum belief) response
293 format. All predictions were tested in models that took one of two forms. The first examined the
294 main effect of analytical thinking on beliefs within each sample by including an interaction term
295 between sample and the measure of analytical thinking (CRT or reverse coded faith in intuition).
296 The second tested for the moderating effect of political orientation (1 = very liberal, 7 = very
297 conservative; standardized) on the relationship between analytical thinking on belief in each
298 sample. The four belief outcomes (belief in God, belief that religion is necessary for morality,
299 belief in karma and belief in witchcraft), two measures of cognitive style (CRT and faith in
300 intuition), and two model forms resulted in 14 model specifications all of which were run for 2000
301 iterations (1000 warmup) across four sampling chains that converged across all specifications (R_s
302 < 1.01). For interested readers, the summaries of all 14 regressions are presented in the
303 supplemental materials: belief in God (CRT - Table S6; Intuition - Table S7), belief that religion is
304 necessary for morality (Table S8), belief in karma (CRT - Table S9; Intuition - Table S10) and
305 belief in witchcraft (CRT - Table S11; Intuition - Table S12). In the main text, we summarize the
306 results of these models by extrapolating and making predictions from the posterior distributions of
307 the estimated contributions of analytical thinking to belief.

308 In what follows, the reported regression coefficients are the means of the posterior
309 distributions for each parameter estimated by the Bayesian models and can be interpreted as one
310 would a regression coefficient in a frequentist framework. The uncertainty around these point
311 estimates are described by the highest density intervals (95% HDIs). These intervals indicate the
312 range of values that make up the 95% most credible estimates of the parameter in the posterior

313 distribution. By more closely examining the posterior distributions of the model estimated
314 associations of analytical cognitive style and supernatural beliefs in varied contexts (between
315 samples; and within samples in more or less politically conservative individuals), we assessed
316 the extent to which these data support the predictions of the dual process, expressive rationality,
317 and counter-normativity rationality models of belief. Put simply and to summarize:

- 318 1. The dual process model parsimoniously predicts that all associations between analytical
319 cognitive style and supernatural beliefs will be negative.
- 320 2. The expressive rationality model predicts that:
 - 321 a. The association between analytical cognitive style and identity-relevant
322 supernatural beliefs (i.e., belief in God and belief that religion is necessary for
323 morality) will be moderated by political orientation such that the association will
324 be positive in more conservative individuals and negative in more liberal
325 individuals.
 - 326 b. The association between analytical cognitive style and *non*-identity relevant
327 supernatural beliefs (i.e., belief in karma and belief in witchcraft among North
328 Americans) will not be moderated by political orientation - and that the main
329 effect of analytical cognitive style on these beliefs will be largely zero.
- 330 3. The counter-normative rationality model predicts a positive association between
331 analytical thinking and supernatural beliefs that are counter-normative (e.g., belief in
332 karma/witchcraft in the North American samples).

333 *Bayesian regression model evaluations*

334 As a first step to assessing which of these models better accounts for the data - we
335 evaluated our regressions with the *loo* package to estimate out-of-sample prediction accuracy

336 using ‘leave-one-out’ (loo) cross-validation (Vehtari et al., 2017). The results (see Table 1)
337 suggest that by and large the regressions that included the analytical thinking by political
338 conservatism interaction (in line with the expressive rationality model) had greater predictive
339 performance than regressions that predicted belief only from cognitive style in each sample (i.e.,
340 those in line with the dual process model). This indicates that when predicting religious and
341 supernatural beliefs, cognitive style alone is a relatively poorer input than knowing one’s
342 political orientation *and* tendencies for analytical thinking. Importantly, these evaluations adjust
343 for differences in the number of parameters between models. Thus, these results indicate that the
344 better predictive performance of the regressions in line with the expressive rationality model is
345 not owed to there being more predictors in the regressions testing the interaction. However, these
346 evaluations do *not* test for the predicted differences regarding the directionality of the estimated
347 association between cognitive style and belief. Given the relatively greater performance of the
348 regressions that included the expressive rationality model’s predicted interaction, we next
349 employed the parameter estimates from these regressions to specifically test the directional
350 predictions of the three focal models.

351 *Analysis 1: Dual Process Model*

352 Figure 1 presents the estimated posterior distributions of the association between
353 analytical thinking (CRT and reverse-scored faith in intuition) and beliefs in all samples at (1)
354 average political orientation, (2) in more liberal (-1 SD) and (3) in more conservative individuals
355 (+1 SD). For the most part, the estimated association is robustly negative for both measures of
356 analytical thinking, varied kinds of belief, in different samples, and at different levels of political
357 orientation. This provides consistent and clear support for the dual process model. Indeed, the
358 posterior probability that at average liberalism-conservatism (i.e., ‘controlling for political

orientation') analytical thinking is negatively associated with belief drops below .98 (i.e., highly probable) only in a single case (the association between witchcraft beliefs and intuition in Indians where the posterior probability = .87, which still mostly supports the dual process model; see Table 2).

Analysis 2: Expressive-rationality model

Returning to Figure 1, the magnitude of the association between analytical thinking and belief is observably moderated by political orientation, but not in the way that the expressive rationality model necessarily predicts (for precise estimates and intervals see Table 2). When comparing more liberal individuals (-1 SD) to more conservative individuals (+1 SD) we do not find that the estimated associations reverse directions for identity-relevant beliefs (belief in God/belief that religion is necessary for morality). Moreover, as already noted, we do not find that analytical thinking is *unrelated* to *non-identity* relevant belief sets (belief in karma and witchcraft). In stark contrast to the model's predictions, it is a non-identity relevant belief that shows the greatest probability of being positively associated with analytical thinking (belief in witchcraft in Americans, and also Indians; with most of the more conservative distribution crossing the dashed zero line). However, what we do find is that the magnitude of the associations are more often than not reduced in more conservative as compared to more liberal individuals. Indeed, in all but two cases², the posterior probabilities that the association is stronger in more liberal-leaning individuals than it is in more conservative-leaning individuals are greater than .94 (see Table 2).

² These are the same two cases in which LOO model evaluation indicated no evidence for difference in predictive performance between regressions with and without the conservatism by analytical cognitive style interactions.

379 To follow this up and further unpack the analytical thinking by political orientation
380 interaction, we generated and plotted the predictions made by our regressions at each level of
381 political orientation (Figure 2). In so doing, we find that although we see little support for the
382 prediction of the expressive rationality model that there will be a *positive* association with belief
383 among conservatives (as summarized in Figure 1 and Table 2), we do find that the patterns of
384 belief are at least somewhat in line with the expressive rationality model. Indeed, the predicted
385 *spreading interaction* resulting from a positive association of belief and analytical thinking in
386 more conservative individuals and a negative association in more liberal individuals is evident in
387 a few instances (e.g., belief in God in Students) but a spreading interaction also appeared in what
388 we had considered non-identity relevant supernatural beliefs (e.g., belief in witchcraft among
389 Americans). And although this spreading interaction was not consistent across beliefs or
390 samples, it was reliably the case that variance in predicted belief is greater at *high* analytical
391 thinking than at *low* analytical thinking (i.e., the regression lines are more tightly clustered
392 together at low analytical thinking than at high analytical thinking). What this suggests is that
393 without knowing one's political orientation, the extent of one's analytical thinking tendencies is
394 a relatively poor predictor of supernatural beliefs. This provides some further indication as to
395 why the regression models that included the analytical thinking by political orientation
396 interaction made more accurate predictions than models of just the main effect of analytical
397 thinking in each sample (Table 1). Moreover, Figure 2 clearly demonstrates that the negative
398 association between analytical thinking and varied beliefs is strongest in the most liberal
399 participants (with the steepest slopes), and the weakest (but only rarely positive) in the most
400 conservative participants. While these results do not exactly match the predictions of the

401 expressive rationality model, they nonetheless suggest that identity-protective processes are a
402 factor; thus it is important for future research to avoid simply averaging across political
403 orientations.

404 *Analysis 3: Counter-normative rationality model*

405 The identified clear support for the dual process model effectively demonstrates that the
406 predictions of the counter-normative rationality model are *not* supported in this data. We did not
407 find that endorsement of counter-normative supernatural beliefs were positively related to
408 analytical thinking (i.e., belief in karma and witchcraft were negatively associated with analytical
409 thinking in both the North American and the Indian samples, despite cultural differences in
410 karma's normativity).

411 **Discussion**

412 The results of Study 1 replicate previously reported findings that analytical thinking is
413 negatively correlated with religious and supernatural beliefs in a large and diverse sample. Our
414 results provide further evidence that this association, despite its small magnitude, extends to
415 several types of religious and supernatural beliefs. Moreover, tendencies for analytical thinking (as
416 measured by the Cognitive Reflection Test) and placing faith in one's intuition (as measured in a
417 self-report scale) converged in predicting religious and supernatural beliefs. Taken together, this
418 provides evidence that the association between cognitive style and religious belief is robust to two
419 different cognitive measures. Indeed, while the CRT reliably measures tendencies for overriding
420 one's intuitions, it has somewhat surprisingly been demonstrated to be a relatively poor indicator
421 of individual differences in reliance on intuitions (Pennycook, Cheyne, et al., 2016). And thus, the
422 growing body of work that employs the CRT in examining the relationship between analytical
423 thinking that and belief in God is better understood as documenting the *negative* association of

analytical thinking and belief, and not necessarily the complementary *positive* association of
424 intuition. Here, the consistently observed negative relationships of (reverse scored) self-reported
425 faith in intuition speaks to this inverse relationship – that a reliance on one’s intuitions is likewise
426 related to belief.

427 In addition to this complementary relationship between intuition and analytical thinking in
428 predicting belief in God, our results provide evidence that these relationships extend to other types
429 of religious and supernatural beliefs. Analytical thinking was found to be *negatively* related to
430 belief in karma and witchcraft across samples that varied considerably on whether these beliefs are
431 culturally normative, and even to cross-culturally prevalent beliefs that religion is necessary for
432 morality. These consistently negative associations disconfirm the predictions of the counter-
433 normative rationality model that analytical thinking might be employed to question culturally
434 normative beliefs – and provide additional clear support for the dual process model of belief.

435 While the dual process model of belief was tested in various ways and received support, the
436 results revealed an important limitation of this model in explaining belief. Across diverse belief
437 types and samples, the negative association between analytical thinking and belief was found to be
438 weaker in more conservative individuals. The dual-process model is silent about this pattern, and it
439 is particularly striking and non-obvious, given that more politically conservative individuals are
440 reported to rely more heavily on their intuitions, and are generally more religious (Deppe et al.,
441 2015; Haidt, 2012; Nail et al., 2009; Pew Research Center, 2017). Given that the relationship
442 between analytical thinking and belief in God, for example, is reported to be greater in more
443 religious nations (Gervais et al., 2017), it might be expected that the association *within*-samples
444 would be greater amongst more religious sub-samples (i.e., more conservative-leaning
445 individuals) than less religious sub-samples (i.e., liberal-leaning individuals). And thus, if
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447 anything, the dual process model, with some extra tweaking, would make the prediction that, *if*
448 there was going to be a difference in the association amongst conservative and liberal individuals,
449 it would be larger (not smaller or reversed) amongst conservatives – a pattern that was not found in
450 our data.

451 Some, but not all, of our results can instead be accounted for by the expressive rationality
452 model, which argues that analytical thinking is employed not to override intuitions but rather to
453 engage in identity-confirming motivated reasoning (Kahan & Stanovich, 2016). While some of the
454 predictions made from our regression models do generate the spreading interaction predicted by
455 the expressive rationality model for identity-relevant beliefs (e.g., belief in God predicted by the
456 CRT in an undergraduate student sample), we also see some evidence of this spreading interaction
457 in predictions of *non*-identity relevant beliefs (e.g., belief in witchcraft as predicted by faith in
458 intuition in Americans and Indians). This latter result not being directly predicted by the
459 expressive rationality model as formulated here. That being said, our data cannot directly address
460 whether witchcraft beliefs are identity-relevant to conservatives and liberals in India or the USA.
461 Even though we see evidence of the spreading interaction in both samples in Figure 2, witchcraft
462 beliefs are more strongly correlated with political conservatism in Indians ($r = .34$) than in
463 Americans ($r = .06$); suggesting that different processes may be at play here in these two samples,
464 or even that these results have little to do with identity-protective cognitions. And yet more
465 consistently, what we find is not a spreading interaction resulting from a positive association
466 between analytical thinking and belief in more conservative individuals and a negative association
467 in more liberal individuals but rather a reduction in the magnitude of the association in more
468 conservative as compared to more liberal individuals.

469 If there is one thing that is abundantly clear in our data, it is that we find no support for the
470 predictions of the counter-normative rationality model. Otherwise, our data support the dual
471 process model, but with the important caveat that the magnitude of the association between
472 analytical thinking and diverse supernatural beliefs are consistently reduced (and in some
473 instances reversed in direction) amongst more conservative individuals than amongst more liberal
474 individuals. Before considering whether this provides evidence for the expressive rationality
475 model, we turn first, in Study 2, to testing the expressive rationality model in two additional
476 datasets in which only the main effect of analytical thinking has been previously reported. The
477 results of Study 1 provide sufficient impetus for researchers to look more closely at the association
478 between cognitive style and belief at different levels of political orientation, rather than merely
479 controlling for it.

480 **Study 2**

481 In Study 2, we tested the predictions of the *expressive rationality model* of religious belief
482 in two additional openly-accessible datasets from recently published papers testing the dual
483 process model of belief in diverse samples. The first dataset (Gervais et al., 2017) examined the
484 relationship between belief in God and scores on the Cognitive Reflection Test in 13 samples.
485 Their results demonstrated that the relationship between belief in God and CRT scores is (1) *small*;
486 (2) *variable* across cultures; and (3) that the magnitude of the effect is reduced in less religious
487 nations. Interestingly, these authors reported a surprising reversal: a small *positive* correlation
488 between belief in God and analytical thinking in the United Kingdom. The second dataset
489 (Stagnaro, Ross, Pennycook, & Rand, 2019) examined the relationship between belief in God,
490 supernatural beliefs (measured more broadly) and the Cognitive Reflection Test in India and the

491 United Kingdom, controlling for political orientation (as a direct attempt to replicate the surprising
492 reversal reported by Gervais et al., 2017). In India and the United Kingdom (speaking to the non-
493 replicability of the reported reversal from Gervais et al. 2017), Stagnaro et al. (2019) reported a
494 negative correlation between belief in God and analytical thinking that was comparable in size to
495 that expected by the meta-analytic estimates of the relationship. Neither of these papers, however,
496 considered the potential *moderating* effect of political orientation in the relationship between
497 analytical thinking and religious belief. Using their openly accessible data, we tested the
498 predictions of the expressive rationality model of belief in the samples from these datasets where
499 political orientation was assessed (Gervais et al., 2017: Australia, China, Czech Republic, India,
500 Mauritius, Netherlands, and Singapore; and Stagnaro et al., 2019: United Kingdom). Critically, we
501 treat these analyses as an entirely exploratory attempt to replicate the focal results in Study 1 in a
502 broader sample. We made no strong or specific a priori claims as to having insight into the
503 dynamics linking political orientation and religious belief in these diverse cultural settings.

504 **Methods**

505 The published datasets were retrieved from the Open Science Framework: Gervais et al.
506 (2017) - <https://osf.io/v53c4/>; Stagnaro et al. (2019) - <https://osf.io/jb2mr/>). For full sample details,
507 interested readers should refer to their published papers. In both datasets, not all samples included
508 a measure of political orientation and thus we selected only those samples that did. These
509 exclusions left us with 1192 individuals from 7 countries (Australia, China, Czech Republic, India,
510 Mauritius, Netherlands, and Singapore) from the Gervais et al. (2017) dataset; and 523 individuals
511 from the United Kingdom from Stagnaro et al. (2019). Our scripts for the re-analysis of these
512 datasets are available at <https://osf.io/hpw38/>.

513 *Measures*

514 In Gervais et al. (2017), belief in God was measured on a 0 to 100 (max belief) scale,
515 analytical thinking was assessed using the 3-item Cognitive Reflection Test (Frederick, 2005), and
516 political orientation was assessed with a single item (“Would you consider yourself more liberal or
517 conservative? [1 = very liberal; 7 = very conservative]. In Stagnaro et al. (2019), belief in God was
518 measured on a 0 to 100 (max belief) scale, analytical thinking was assessed using a 7-item
519 Cognitive Reflection Test (Thomson & Oppenheimer, 2016), and political orientation was
520 assessed with two items: “On social issues I am...” and “On economic issues I am...” [1 = strongly
521 liberal to 5 = strongly conservative]. These two items were strongly positively correlated, $r(521) =$
522 $.73$ [.69, .77], $p < .001$ and we took their average as an index of political conservatism. Stagnaro et
523 al. (2019) also measured supernatural belief using the 6-item revised-Supernatural Belief Scale
524 (Jong & Halberstadt, 2016). For all analyses, political orientation was centered (negative values =
525 more liberal; positive values = more conservative).

526 *Analytical Models*

527 Analyses were conducted using the same software as in Study 1. Beliefs were modelled
528 using Bayesian mixed-effect linear regressions as conducted in Study 1. For the re-analysis of the
529 Gervais et al. (2017) dataset a random intercept for sample was included (7 countries) in addition
530 to a random slope by country for the effects of CRT, political orientation and their interaction – to
531 allow all effects to vary across samples. The UK data from Stagnaro et al (2019) were modelled
532 using Bayesian linear regressions (i.e., with no random effects). Priors were set as uninformative
533 and weakly-regularizing: fixed effects \sim Normal(0,1); variance components for varying effects \sim
534 Exponential(1); and for the covariance structure of varying effects \sim LKJ(4); (McElreath, 2015, p.
535 393; Purzycki, Pisor, et al., 2018).

Results

536 Reproducing the focal results and support for the dual process model reported by Gervais
537 et al. (2017) and Stagnaro et al. (2019), across all models, analytical thinking (CRT) was
538 negatively related to religious belief controlling for political orientation (model summaries
539 presented in the supplemental materials; Table S13). When holding political orientation constant
540 at zero (i.e., amongst political centrists), these models predict varying magnitudes of belief
541 reduction amongst those who respond correctly to *all* CRT items: 3.93 points out of 100 (Gervais
542 et al. data; belief in God), 10.92 points (Stagnaro et al. data; belief in God), and 16.02 points
543 (Stagnaro et al. data; supernatural belief).

544 As observed in Study 1, however, the estimated effect of CRT on belief was moderated by
545 political orientation across models. The posterior distributions of regression coefficients at varied
546 levels of political orientation are plotted in Figure 3 (and precise estimates presented in Table 3). In
547 all three cases, we find that the association is more strongly negative in more liberal leaning
548 participants than in more conservative leaning participant. That being said, the magnitude of the
549 effect remains small, and is less clearly differentiated in Gervais et al.'s (2017) more broadly cross
550 -cultural dataset. Moreover, we again find only a slight indication of a reversal of the direction of
551 the association in the conservative leaning individuals as predicted by the expressive rationality
552 model - and rather that the posterior distributions of the estimated association are more closely
553 centered around zero. As in Study 1, this analysis provides evidence that the predictions of the dual
554 process model of belief holds more for liberals than conservatives. And as in Study 1, although we
555 find no clear support for the expressive rationality models' predicted *reversal* of the association in
556 conservatives; we do find that the already small negative association approaches 0 in more
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conservative individuals.

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Discussion

In Study 2, we further tested the predictions of the expressive rationality model of belief in two additional cross-cultural datasets. We find that in both of these datasets – the negative relationship between CRT and religious belief predicted by the dual process model of belief was to some extent stronger in increasingly liberal-leaning individuals. However, contrary to the prediction of the expressive rationality model, the association between analytic thinking and religious belief in conservative-leaning individuals was largely flat – it was not positive. These results provide further evidence that the contributions of CRT to religious belief can sometimes be just as “fickle” (Gervais et al., 2017) within cultures as they may be between them. While Stagnaro et al. (2019) demonstrated a negative relationship *controlling* for political orientation, our analyses demonstrate that the relationship is largely reduced to zero with greater political conservatism. And while this result does not provide strong evidence for the expressive rationality model of belief, in the general discussion we consider this evidence, in tandem with the results of Study 1, by returning to our focal question of “how” is analytical thinking related to religious and supernatural beliefs.

General Discussion

How is analytical thinking related to religious belief? To answer this question, in two studies we tested competing predictions derived from three accounts about the contributions of cognitive style to religious belief (one of which, the counter-normative rationality model, went completely unsupported). As predicted by the dual process model of religious belief, we found that analytical thinking is robustly related to religious belief in the predicted negative direction, in large culturally diverse samples, for two distinct measures of analytic thinking (cognitive reflection and

581 faith in intuition), and for several types of religious beliefs (i.e., belief in God, that religion is
582 necessary for morality, in karma, in witchcraft). Nevertheless, the dual process model's limitations
583 in accounting for religious belief were apparent in the estimated small effect size and the
584 consistently observed interaction of analytical thinking and political ideology, which is not
585 obviously predicted by this model. And thus, the pattern of our results also fit to some extent with
586 the predictions of an alternative account - the expressive rationality model of belief - that holds that
587 analytical thinking is employed to sustain one's already held commitments, particularly those
588 emblematic of social identities. However, this model had its limitations too; from the perspective
589 of the expressive rationality model, (1) the negative association between analytic thinking and
590 religious belief should reverse for political conservatives, (2) the main association should
591 disappear once the interaction with political ideology is taken into account, and (3) analytical
592 thinking should only be associated with identity-relevant supernatural beliefs. These predictions
593 received inconsistent support. The main effect often remained even after accounting for the
594 interaction with political ideology; moreover, the predicted reversal (to a positive relationship
595 between analytic thinking and religious/supernatural belief) for conservatives did not materialize
596 in most of our samples. Instead, we consistently observed that rather than reversing in direction,
597 the size of the association weakened or became zero among conservatives. And contrary to the
598 expressive rationality model, we find that this weakening of the effect in more conservative
599 participants compared to more liberal participants occurred in both identity-relevant (belief in
600 God, belief that religion is necessary for morality) and *not*-obviously identity-relevant beliefs
601 (belief in witchcraft in both Americans and Indians).

602 One way to interpret these results is to take them as evidence for a "weak" version of the
603 expressive rationality model that makes the prediction that analytical thinking will only be

604 negatively correlated with religious beliefs amongst more politically liberal individuals, while
605 being largely unrelated to belief amongst more politically conservative individuals. But it is not
606 directly obvious why identity-protective cognitions would be less involved in maintaining
607 religious and supernatural beliefs in the typically more religious sub-samples of our datasets (i.e.,
608 conservative-leaning individuals). Another way to explain these results might be to make the
609 prediction that if we had more data from the *most* liberal and *most* conservative individuals, we
610 might have observed stronger evidence for the predicted reversal and the spreading interaction.
611 Testing this prediction is one clear way forward for research of this kind. But yet, an altogether
612 different explanation arises from considering the relative contributions of ‘cognition’ and
613 ‘culture’ in predicting religious and supernatural beliefs.

614 A recent review of the empirical evidence (White et al., 2021) and a pre-print of a study
615 that employs a nationally-representative sample of Americans (Gervais et al., 2019) provide
616 evidence that analytical cognitive style is a robustly weaker predictor of religious and
617 supernatural beliefs than is growing up with caregivers who consistently demonstrated their
618 religious commitment (i.e., religious credibility enhancing displays; Lanman & Buhrmester,
619 2016). What our results might suggest is that high enough cultural exposure to religion - as might
620 be more likely in more conservative individuals than in liberals - leaves little room for cognitive
621 style to have sway over the extent to which one endorses religious and supernatural beliefs. This
622 perhaps explains the fairly consistent reduction in the association between analytical thinking
623 and belief in politically conservative individuals. If this is the case, then the dynamics at play
624 might have little to do with identity-protective cognition; instead, political orientation in our
625 datasets is perhaps acting as a proxy-measure for cultural exposure to religion. In support of this
626 view, Gervais et al. (2019) found that analytical thinking only predicted supernatural beliefs in in

627 those with relatively lower cultural exposure to religion. That being said, this alternative
628 explanation does little to account for the cases, particularly at the extremes of political
629 orientation, in which some of our models do indeed predict patterns in line with the expressive
630 rationality model.

631 Taken together, it is clear that neither the dual process nor the expressive rationality model
632 can fully account for all of the observed data. And importantly, neither of them (as they are
633 currently posited) seem fully equipped to deal with how intuition and/or analytical thinking may or
634 may not be implicated in ‘religious and supernatural belief’ (broadly construed) in a variety of
635 different cultural contexts. Although it is the counter-normative rationality model that went
636 entirely unsupported – it is the dual process model of belief, given its broad predictive potential,
637 that requires the *most* re-calibration. The dual process model of belief as it is currently formulated
638 provides no explanation for the observed within-sample heterogeneity in how the strength of the
639 association between analytical thinking and beliefs depends on political orientation. And thus, it
640 has the *most* difficulty accounting for some observations, like those reported here, that the
641 relationship between cognitive style and belief is sometimes (though not always) moderated by
642 political orientation. The evidence suggests, in part, the operation of motivated reasoning
643 processes in justifying both believing and not believing. Importantly, the current analyses show
644 that the dual process and expressive rationality models as applied to religious belief likely have
645 independent explanatory value (despite their shortcomings) and are not necessarily incompatible
646 theoretical accounts. The pattern of results is thus consistent with the idea that at least two
647 independent, interacting psychological processes are at play, one guided by the intuitiveness of
648 supernatural beliefs consistent with a dual process account, the other guided by motivated
649 reasoning consistent with the expressive rationality account. And from what we have learned from

650 other recent work in this area (Gervais et al. 2019), it is all together possible that the extent to
651 which either or both of these processes contribute to belief may covary in meaningful ways with a
652 third psychological mechanism – cultural learning driven by social exposure to religion.

653 Given the expressive rationality’s model explanatory power in other domains (e.g., climate
654 change beliefs; Kahan et al., 2012), at least where it has been tested (i.e., in nationally
655 representative samples of Americans) - it remains an open question, as to whether our results
656 would look different with access to a broader, fully representative sample. Our results demonstrate
657 some cross-culturally recurrent patterns in predicting diverse religious and supernatural beliefs.
658 But of course, a clear way forward in unpacking the contributions of cognitive style to belief is to
659 continue broadening the scope of these types of investigations, in more diverse cultures – but also
660 more broadly within cultures. On this front, future work should broaden the scope of the content of
661 examined supernatural beliefs to include those that might also be more representative of both
662 liberals and conservatives in their investigations of the cognitive mechanisms supporting
663 supernatural beliefs. For example, belief in astrology, horoscopes, and the Tarot is high amongst
664 North American youth, consistent with other secularized corners of the world (Beck, 2018; Pew
665 Research Center, 2009) – and are similarly endorsed by liberals and conservatives (e.g., Lindgren,
666 2014).

667 Although the focal measures employed here are nearly ubiquitous in studies of the
668 relationship between cognitive style and religious belief, they are certainly not without fault. It is
669 important to note that some of the mismatch between the predictions and results reported here may
670 result from measurement issues. For instance, single item indicators of belief like those used here
671 for belief in God, although face valid, and having adequate but limited reliability, also tend to be
672 bimodally distributed. As a consequence, we concede that the models presented here may very

673 well underestimate the magnitude of the relationship between analytical thinking and belief.
674 However, even more reliable multi-item measures such as the often used Supernatural Belief Scale
675 (Jong et al., 2013; used here in Study 2) still exhibit some degree of bimodality (see Figures S1 and
676 S2). And thus, there is a clear need for new measurement tools, and perhaps even more to be
677 gained in the application of novel modelling techniques to potentially capture with greater
678 precision the correlates of religious and supernatural beliefs. Moreover, single item measures of
679 belief do not adequately capture the diversity in the kinds of gods (and other supernatural
680 agents/forces) that people believe in across cultures, and the traits/qualities/capacities afforded to
681 them (Johnson et al., 2019; Lang et al., 2019). In our data, we cannot identify, for example, which
682 God Indian respondents (mostly Hindus) were considering at the time (though we note that belief
683 in God is strongly endorsed by Hindu participants here and in previous research, e.g., White et al.,
684 2019; Baimel, 2019). In so doing, research of this kind may otherwise be missing important pieces
685 of the puzzle of understanding how belief covaries with psychological intuitions. In line with this
686 view, recent evidence from samples of American Hindus suggests that intuitions are more
687 supportive of belief in, for example, personal as opposed to abstract god concepts, even when they
688 are more culturally normative (Baimel, 2019).

689 The three-item CRT employed across most of the studies here has more recently been
690 expanded to seven items to increase reliability and relies less on participant's numerical intuitions
691 (Thomson & Oppenheimer, 2016). And while the data from Stagnaro et al. (2019) as presented in
692 Study 2 provide some evidence of consistency in results between the two versions, future work
693 might benefit from the use of more diverse measures of cognitive style. Moreover, the single item
694 measure of political orientation employed in both of our studies could be elaborated into a more
695 reliable and valid measure that also distinguishes between different types or aspects of political

696 orientation (e.g., social vs. economic conservatism). More fine-grained measurements of
697 political orientation may be particularly valuable for future cross-cultural research on this topic
698 that considers more deeply the relationship between religious belief and political orientation (and
699 types of conservatism) in diverse cultural settings.

700 Our results contribute to the growing literature examining the relative contributions of
701 cognition and culture to the form and prevalence of religious beliefs around the world. Willard &
702 Cingl (2017), for example, provide evidence that the contributions of cultural learning are
703 substantially larger than that of cognitive processes in explaining between-country differences in
704 the prevalence and strength of religious belief. Our results suggest that the contributions of
705 cognition to belief might be greater when the cultural norms to hold certain beliefs are weak (i.e.,
706 commitment to religious beliefs in liberals as compared to conservatives). This interpretation fits
707 well with previous work that demonstrates that intuitively-supported cognitive biases are more
708 strongly related to the endorsement of paranormal beliefs than the more culturally-constrained
709 belief in God (Willard & Norenzayan, 2013). Weighing the relative contributions of cognitive
710 processes, motivational factors, and cultural learning is essential in broadening our understanding
711 of what supports the world's "theodiversity" (Norenzayan, 2016); and our results also demonstrate
712 that there may be even more to be gained from considering how cognitive processes *interact* with
713 social and cultural factors in the maintenance of religious beliefs (e.g., see Purzycki & McNamara,
714 2016). This is an important future direction for the cultural and cognitive sciences of religion.

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