

The Design Stance, Intentional Stance, and Teleological Beliefs About Biological and Nonbiological Natural Entities

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Teleology involves an appeal to function to explain why things are the way they are. Among scientists and philosophers, teleological explanations are widely accepted for human-made artifacts and biological traits, yet controversial for biological and nonbiological natural entities. Prior research shows a positive relationship between religiosity and acceptance of such controversial teleological explanations. Across three large online studies, we show that the relationship between religiosity and teleological acceptance cannot be explained by acceptance of objectively false explanations. Furthermore, we show that anthropomorphism and a belief in supernatural agents each independently predict teleological acceptance. In contrast, the tendency to inhibit intuitively appealing, yet incorrect responses to simple reasoning problems was associated with lower teleological acceptance. These results provide strong support for an intention-based account of teleology, and further contribute to the existing literature which situates teleological reasoning within a dual-process framework. Several avenues of future research are discussed, including the need to dissociate implicit and explicit measures of teleological belief, and the need for a greater focus on cross-cultural variation in teleological beliefs.

Keywords: teleology, intentional stance, cognitive science of religion, anthropomorphism, dual process theory

Globally, most people identify as being religious (Pew Research Center, 2012). Although there is considerable variation in the specific content of religious beliefs, there are also striking cross-cultural similarities (Atran, 2002; Boyer, 1994; Boyer & Ramble, 2001). Within the cognitive science of religion literature, there is converging evidence that cross-cultural similarities in religious beliefs are not due to chance. Rather, religious beliefs are said to result from ordinary cognitive processes operating in normal human environments, such that certain themes tend to reoccur across cultures (Barrett, 2000; Barrett & Lanman, 2008; Boyer, 2008; Guthrie, 1993). As such, at their most fundamental level, these reoccurring beliefs are described as being *maturationally natural*, in that they develop in the absence of explicit instruction (McCauley, 2011). One such maturationally natural belief, which is central to religious thought, is that events happen, or things

exist, to fulfil some future purpose (Kelemen, 2004). This type of reasoning, where something is explained by its purpose, function, or goal, is known as teleology (Hempel & Oppenheim, 1948).

Teleological explanations are not limited to the domain of religion. Indeed, teleological explanations are often used without making any reference (even implicitly) to the plans of a supernatural agent or divine being. For example, we could say that “chairs exist for sitting on.” In this statement, the existence of chairs is explained by the future function of providing a place to sit. Despite this inversion of causality, where the future is used to explain something which came before it, from a philosophical point of view, this explanation is legitimate. This is because the future function could be understood as resulting from the prior intentions of an agent (Kelemen, 1999c; Wright, 1976; see also Bloom, 1996)¹. Teleological explanations involving biological traits, for example, “eyes exist for seeing,” are also legitimate from a philosophical point of view (Dennett, 2017). Although in such an explanation, no human agent could plausibly be attributed with the prior intention of eyes existing to allow for sight, its legitimacy is due to the consequence etiology upon which it is based (Wright, 1976). That is, the function of light detection which early eye-like structures afforded, is the reason why the genes for eye-like structures

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¹ Although “chairs exist for sitting on” may be considered be an observed fact, we would argue that an observed fact is “the chair is being sat on.” As we can only infer the intentions of agents by observing behavior, our position is that “chairs exist for sitting on” is a factually accurate teleological explanation which is contingent upon this inference. We thank an anonymous reviewer for helping us clarify this example.

increased in prevalence in the population. Through countless generations of genetic mutations and the differences in reproductive fitness which resulted from them, eyes currently exist *for* seeing, because seeing is the function that eyes serve, and this function is the very reason for their existence.

The tendency to give teleological explanations for biological traits and human-made artifacts is, according to Keil (1992, 1995), the result of a knowledge-acquisition device known as a “teleological-design stance.” According to this psychological theory of teleological reasoning, teleological explanations are elicited only by things which clearly possess some functional utility. Accordingly, Keil (1992, 1995) argues that children and adults should be selective in their use of teleology. In support of this theory, there is evidence of a domain difference in the use of teleological reasoning, whereby young children are more teleological when explaining biological traits compared to natural nonliving objects (Keil, 1992), and when explaining human-made artifacts compared with whole biological organisms (Greif et al., 2006).

Although teleological explanations of biological traits and human-made artifacts are both legitimate and widely believed, people also hold teleological beliefs about things which no consequence etiology or prior intentions of a natural agent can explain (e.g., Casler & Kelemen, 2007; Kelemen & Rosset, 2009). One such type of teleological belief which has received considerable research attention by Kelemen and colleagues (e.g., Järnefelt et al., 2015; Kelemen & Rosset, 2009; Kelemen et al., 2013), is a belief in the teleology of nature; specifically, the belief that whole biological organisms, such as bees, and natural nonliving objects, such as the sun, exist for a purpose. Henceforth, we refer to these as teleological beliefs about biological and nonbiological natural entities, respectively.

According to Kelemen (1999a) teleological thought is not the result of a teleological-design stance, but rather due to an early-developing understanding that intentional agents have purposes. That is, teleological beliefs are the result of taking an intentional stance, whereby beliefs and desires are attributed to an agent, and an assumption is made that this rational agent will act in accordance with those beliefs and desires (Dennett, 1987). Similar to the idea that the attribution of human mental states to nonhumans (i.e., anthropomorphism) satisfies the desire for understanding, predictability, and control over one’s environment (Waytz, Morewedge, et al., 2010), Kelemen (1999a) argues that from an early age, an intentional stance is applied to things other than the actions of intentional agents. Although certain teleological beliefs may lack a consequence etiology or prior intentions of a human agent, teleological thought may nonetheless be adaptive, in the sense that the use of this predictive strategy allows us to easily infer the functions of artifacts (Casler & Kelemen, 2005; Hernik & Csibra, 2015) and reasons for novel actions (Csibra & Gergely, 2007). In contrast to Keil (1992, 1995), Kelemen’s intention-based theory predicts that children, and to some extent, adults, should be promiscuous in their use of teleology, explaining not only biological traits and human-made artifacts, but also biological and nonbiological natural entities in terms of their functions.

The tendency to agree with teleological statements about things which no consequence etiology or prior intentions of a human agent can explain, is most pronounced in young children (DiYanni & Kelemen, 2005; Kelemen, 1999c, 1999b; Kelemen & DiYanni, 2005; but see Greif et al., 2006; Keil, 1992). However, adults also

display high levels of acceptance for such explanations when semantic knowledge is impaired as the result of Alzheimer’s disease (Lombrozo et al., 2007)², in the absence of formal education (Casler & Kelemen, 2008; Sánchez Tapia et al., 2016), or when under time pressure to respond (Kelemen et al., 2013; Kelemen & Rosset, 2009; Mills & Frowley, 2014; Roberts et al., 2020). Acceptance of teleological explanations for biological and nonbiological natural entities has also been shown to negatively correlate with the tendency to inhibit intuitively appealing, yet incorrect responses to simple reasoning problems (Zemla et al., 2012). These findings suggest that although adults may inhibit teleological beliefs about biological and nonbiological natural entities when they (a) have learned alternative causal explanations, and (b) have the cognitive resources available to do so, nevertheless, such teleological beliefs continue to have an intuitive appeal; so much so, that such teleological beliefs have been described as a “developmentally persistent cognitive default” (Kelemen et al., 2013, p. 1075).

If teleology results from the use of an intentional stance (Kelemen, 1999a), then teleological beliefs about biological and nonbiological natural entities could be considered as *quasireligious* beliefs (Kelemen, 2004). For example, if an individual believes that “the sun makes light so that plants can photosynthesize,” from an intention-based view, this implies they may either believe the sun itself intends that plants photosynthesize, or that the sun was created for this purpose. Likewise, if an individual believes that “ferns grow at ground level in order to conserve humidity”, this implies they may either believe ferns themselves intend to conserve humidity, or that they were created for this purpose. Although it is possible that acceptance of teleological explanations of biological entities could reflect an understanding that certain entities can result from a function-driven causal process (i.e., natural selection; see Lombrozo & Carey, 2006), according to an intention-based account of teleology, acceptance of such explanations suggests that the natural world is understood either as a quasiagent with intentions of its own, or a quasiartifact designed by an intending creator (Kelemen et al., 2013; Kelemen & Rosset, 2009). In this view, such beliefs therefore imply belief in the existence of a supernatural agent, as they involve the attribution of intentionality where no natural agent exists.

Within the cognitive science of religion literature, there is converging evidence that supernatural agents are understood in much the same way as natural agents. Neuroimaging studies show that engaging in prayer activates the same brain regions involved in social cognition (Schjøedt et al., 2009). When social cognition is impaired, as it is in autism spectrum disorder, individuals tend to express less belief in God compared with nonautistic controls (Norenzayan et al., 2012). Furthermore, the ability to reason about the mind of God parallels the developmental trajectory of the ability to reason about the minds of other humans. When children first learn that other people can hold false-beliefs, they also attribute false beliefs to God (Lane et al., 2010, 2012). Only later in

² Findings of increased teleological acceptance in patients with Alzheimer’s disease do not suggest that impairment caused by this disease leads to the formation of teleological beliefs about biological and nonbiological natural entities. Rather, the impairment caused by Alzheimer’s disease suggests that child-like teleological tendencies persist throughout adulthood.

development do the contents of human minds and God's mind diverge, where false beliefs are still attributed to other humans but not to God (Lane et al., 2010). If teleological thought is intention-based (Kelemen, 1999a), then compared with nonbelievers, individuals who believe in gods, ghosts, or spirits—all of which can be conceptualized as minds (Tremlin, 2006)—may be more accepting of those teleological explanations for which no natural source of intentions exist.

Previous research supports this prediction by showing a positive relationship between various aspects of religious belief, and acceptance of teleological explanations of biological and nonbiological natural entities. In children, there is a positive relationship between both the acceptance and generation of teleological explanations for natural entities, and belief in intelligent design (Kelemen & DiYanni, 2005). When forced to respond at speed, adults have a tendency to default to viewing biological and nonbiological natural entities as made by a being, regardless of whether or not they are religious (Järnefelt et al., 2015, 2019), although belief in the intrinsic agency of nature positively predicts such views (Järnefelt et al., 2015). Belief in the existence of souls has also been shown to positively predict acceptance of such teleological explanations (Kelemen & Rosset, 2009), as has belief in God (Willard & Norenzayan, 2013), the perception of supernatural intentionality (Roberts et al., 2020), and the belief that “nature is a powerful being” (Kelemen et al., 2013). While this could be taken as evidence that religious beliefs accentuate teleological acceptance by reinforcing the notion that biological and nonbiological natural entities exist for a reason, there is also evidence to suggest that the difference in teleological acceptance between religious and nonreligious individuals, may be due, in part, to differences in the tendency to inhibit teleological intuitions. In earlier work (Roberts et al., 2020), we found that highly religious individuals were as accepting of teleological explanations about the natural world under both speeded and unspeeded instructions. In contrast, nonreligious individuals tended to be less accepting of such explanations when given time to think, yet were as accepting as highly religious individuals of such explanations when instructed to respond at speed. This suggests that teleological tendencies may exist across the spectrum of religiosity, and that the lower rates of teleological acceptance typically observed in nonreligious compared with religious individuals, may be due, in part, to the inhibition, rather than absence, of such tendencies.

However, several questions about the relationship between religious belief and acceptance of teleological explanations of biological and nonbiological natural entities remain unanswered. First, it is possible that religious individuals are not more teleological per se, but simply more accepting of explanations which are objectively false. In support of this possibility, previous studies have shown that on average, religious individuals tend to be less analytical than nonreligious individuals (e.g., Pennycook et al., 2014; Ross et al., 2016), and that certain aspects of religiosity are positively associated with a belief in fake news (Bronstein et al., 2019). Although Zemla et al. (2012) found no evidence of a relationship between religious belief and accuracy in responding to a series of objectively true and objectively false control statements on average, by collapsing across true and false control statements, these researchers may have diluted a potential relationship between religious belief and the tendency to accept false explanations. To our knowledge, the possibility that acceptance of

objectively false explanations could account for the previously reported relationship between religious belief and teleological acceptance (e.g., Kelemen & DiYanni, 2005; Kelemen & Rosset, 2009; Kelemen et al., 2013), has yet to be considered.

Related to this first possibility, certain spiritual and religious beliefs are positively associated with schizotypal traits and delusional ideation³. Willard and Norenzayan (2017) found that compared with a nonreligious group, those who identified as “spiritual but not religious” scored higher on certain subscales of the Schizotypal Personality Questionnaire (SPQ; Raine, 1991), including ideas of reference, magical ideation, and unusual perceptions. Measures of religious belief have also been shown to positively correlate with these subscales of the SPQ (Włodarski & Pearce, 2016), as well as with scores on the Peter et al.'s, Delusions Inventory (PDI; Peters et al., 2004; Ross et al., 2016). The positive relationship between religious belief and the PDI is, perhaps, not surprising, as several of the items refer to such beliefs (e.g., “Do you ever feel that you are especially close to God?”). However, this is not to say that feeling “especially close to God” should be considered a delusion, as total PDI scores are heavily contingent upon the degree of preoccupation and distress caused by each belief. Interestingly though, there is reason to believe that delusional ideation might be related specifically to teleological acceptance. Moore and Pope (2014) found that delusional ideation was positively associated with the so-called *intentionality bias*, whereby ambiguous actions are interpreted as being intentionally initiated by an agent (see Rosset, 2008). It is possible then, that the relationship between religious belief and teleological beliefs about biological and nonbiological natural entities (e.g., Kelemen et al., 2013), could be confounded by delusional ideation.

An intention-based account of teleology also leads to two related, but distinct possibilities regarding where intentions are being attributed. One possibility is that people are accepting of teleological beliefs about biological and nonbiological natural entities because they view the natural world as an artifact designed by an intending creator. The second possibility is that people are accepting of such explanations because they view the natural world as an agent with intentions of its own. Put another way, teleological beliefs about biological and nonbiological natural entities may arise from taking a design stance (i.e., belief in an intending creator) or an intentional stance (i.e., anthropomorphism; see Dennett, 1987). Although each is distinct from the other, a design stance arguably requires an understanding of intentions. This is because to understand what an object was designed for, is to understand, on some level, what the creator of that object *intended* it to be used for. While Kelemen (1999a) does not explicitly distinguish between these two related but distinct possibilities, evidence suggests that a design stance (Järnefelt et al., 2019; Willard & Norenzayan, 2013) and intentional stance (Kelemen et al., 2013; Willard et al., 2020; Willard & Norenzayan, 2013) are fundamental to such beliefs. Although this question has been

³ Although the terms “schizotypy” and “delusional ideation” are sometimes used interchangeably (e.g., Moore & Pope, 2014), the Schizotypal Personality Questionnaire (SPQ; Raine, 1991) includes subscales measuring positive (e.g., ideas of reference) and negative symptoms (e.g., no close friends). In contrast, measures of delusional ideation such as the Peter et al.'s, Delusions Inventory (PDI; Peters et al., 2004) focus only on positive symptoms.

considered elsewhere (Kelemen et al., 2013), to date, it has not been addressed using validated measures of both religious belief and anthropomorphism.

Finally, consistent with the notion that teleological beliefs about biological and nonbiological natural entities hold an intuitive appeal, individuals who are better at inhibiting their intuitions are less accepting of such teleological explanations (Zemla et al., 2012). Coupled with findings of increased teleological acceptance in the absence of formal education (Casler & Kelemen, 2008; Sánchez Tapia et al., 2016), or when under time pressure to respond (Kelemen et al., 2013; Roberts et al., 2020), the existing literature conceptualizes the expression of teleological beliefs within a dual-process theory framework. According to this view, intuitive attributions of intentionality could be considered a *Type I* (i.e., fast, and automatic) response to stimuli, which gives rise to teleological beliefs about biological and nonbiological natural entities. The expression of such teleological beliefs would depend not only on whether intuitive attributions of intentionality occur, but on whether such a response is overridden by *Type II* (i.e., slow, and effortful) cognitive processes in favor of an alternative response (De Neys, 2012, 2014; Pennycook et al., 2015). However, it is unclear whether intuitive attributions of intentionality, whether to an intending creator or to the natural world itself, remain positive predictors of teleological acceptance after controlling for the tendency to inhibit intuitions, and conversely, whether the tendency to inhibit intuitions negatively predicts teleological acceptance after controlling for attributions of intentionality.

Study 1

Before addressing the questions outlined above, as other authors have noted (Willard & Norenzayan, 2013), there currently exists no agreed-upon scale to measure teleological beliefs about biological and nonbiological natural entities. While most research in this field has employed subsets of items created by Kelemen and colleagues (Kelemen et al., 2013; Kelemen & Rosset, 2009), the specific items used vary across studies (e.g., Roberts et al., 2020; Willard & Norenzayan, 2013). Furthermore, beyond discriminating between individuals who hold different religious beliefs, there is little psychometric information available on the items used. Therefore, in Study 1, we sought to refine a set of teleological test statements and control statements for use in future studies. The aim in doing so was to create sets of control statements for which there was high agreement with regard to truth, and sets of teleological test statements which were internally consistent. Although no specific hypotheses were offered in regard to item selection, consistent with previous research showing a relationship between religiosity and belief in the teleology of nature (e.g., Kelemen & Rosset, 2009; Kelemen et al., 2013), it was predicted that religious individuals would be more accepting of teleological explanations of biological and nonbiological natural entities compared to nonreligious individuals, and that this difference would not be due to acceptance of control statements. The preregistration for this study can be found at <https://osf.io/judmr/>. The dataset is located at <https://osf.io/rx25y/> and the code for analysis is located at <https://osf.io/83u4j/>.

Ethics Statement

All studies in this article were approved by the Macquarie University Human Research Ethics Committee (protocol number 5201949787325), under the project titled “The Intentional Stance and Teleological Endorsement.”

Method

Participants

Two-hundred and 13 participants from Australia and the United Kingdom were recruited through the online service Prolific Academic. This sample size was determined to provide sufficient power for the reliability analyses involved in item selection (e.g., Bonett, 2002; Bonett & Wright, 2015). Participants were provided a link to a Qualtrics web-based questionnaire which took approximately 12 min to complete, and were reimbursed \$2 for their time. Five participants were excluded because they did not complete the entire questionnaire, and two were removed for taking excessively long to complete the questionnaire ($z > 4$). To check that participants were reading the statements, two attention checks were included, where participants were instructed to respond either “true” or “false.” No participants failed both checks, and so none were removed on this basis. To check for indiscriminate responding, a standardized mean endorsement rate was calculated for each participant and a cut-off of 4 *SD* was used to determine outliers. However, no participants were removed on this criterion. After exclusion, 206 participants remained.

Ages for the final sample ranged from 16 to 60 ($M = 35$, $SD = 11.2$). One-hundred and seven participants identified as female, 98 as male, and one as other. Participants also selected a religious affiliation. The modal response was Atheist (33.5%), followed by Christian (29.1%), Agnostic (26.2%), “other” (7.8%), Muslim (1.5%), and finally, Buddhist, and Hindu (both 1%). Participants whose affiliation was either Buddhist, Christian, Hindu, or Muslim, were grouped together into a “religious” category. As participants who selected “other” were not given the opportunity to explain their beliefs, these individuals were kept in their own group because it was unclear whether their beliefs about supernatural agents aligned with those of the other religions. After recording, there were 69 Atheists, 67 Religious, 54 Agnostics, and 16 Others.

Materials

A total of 146 statements were presented sequentially, and participants responded either “true” or “false” to each. One-hundred of the statements were created by Kelemen et al. (2013), and a further 20 statements were practice items from the same study. The remaining 26 statements were created for the current study. Fifty of the statements were teleological test statements. Of these, 25 referred to biological entities (e.g., “Earthworms tunnel underground in order to aerate the soil”), and 25 referred to nonbiological natural entities (e.g., “The Earth rotates around the sun so that it can receive light”). The remaining 96 items were control statements. These included 37 false causal statements (e.g., “Saturn is a planet because it has rings surrounding it”), 15 false teleological statements (e.g., “People smoke cigarettes in order to get lung cancer”), 30 true causal statements (e.g., “People earn money because

they go to work”), and 14 true teleological statements (e.g., “Doctors prescribe antibiotics in order to treat infections”).

Procedure

Upon giving informed consent, participants were told that they would be shown a series of statements which offer explanations for various things in the world, and that their task was to decide whether each statement is “true” or “false.” The 146 statements were presented over 12 blocks. Each block contained a mix of statement types proportional to the entire set. To ensure that no participants received a long run of a particular item-type, the order of statements within each block was randomized, as was the order of blocks. After responding to all items, participants provided demographic information.

Results

Item Selection

Analysis Plan. To ensure the final number of statements was balanced with regard to believability (true, test, false) and type (teleological, causal), the following numbers of each statement type were retained: 15 biological test statements, 15 nonbiological test statements, 10 true teleological control statements, 10 false teleological control statements, 25 true causal control statements, and 25 false causal control statements. This resulted in 50 teleological statements and 50 causal statements. Given that the test statements were expected to be endorsed at a moderate rate, this also resulted in a balanced design of 35 true control statements and 35 false control items, and 30 teleological test statements which were ambiguous with respect to truth.

The control statements were chosen based on their mean endorsement rates, whereby the statements with the highest mean endorsement were retained for true teleological and true causal control statements, and those with the lowest mean endorsement were retained for false teleological and false causal control statements (see Table 1). To ensure that test statements were not being treated similarly to control statements, any test statements with mean endorsement of less than .1 or greater than .9 were excluded. Two of the new test statements generated for this study were slightly reworded versions of original items created by Kelemen et al. (2013). To ensure we did not duplicate content, we tested whether the original or reworded item resulted in higher item-total correlations (ITCs) when excluding the alternate version. Only the iteration with the highest ITC was retained. For the final item selection, sequential reliability analyses were conducted, whereby the test statement with the lowest ITC was removed, until 15 items remained in each category of test statements.

After exclusion, McDonald’s Omega (ω) was calculated as a measure of internal consistency for the retained test-statements of both types separately (biological, and nonbiological)⁴. To ensure the assumption of unidimensionality was met, and due to the binary response options, a principle components analysis (PCA) was conducted on each category of test statements using tetrachoric correlations. As Alpha is a more widely reported measure of internal consistency than Omega, for ease of interpretation, both statistics are reported in Table 1.

Test Statements. Two PCAs showed that each category of test statements loaded strongly on single components. As shown

in Table S1 in the Open Science Framework (OSF) material (<https://osf.io/5s43a/>), for nonbiological test statements, the eigenvalue for the first component (8.07) was substantially larger than the second component (1.19). Likewise, for biological test statements, the eigenvalue for the first component (7.15) was substantially larger than the second component (1.36). Screeplots revealed the second component as the point of inflection for both categories of test statements, suggesting that the assumption of unidimensionality was met for each (see Figure S1 in the OSF material). A summary of the mean endorsement and internal consistencies for each category of test statements, both before and after item-exclusion, is shown in Table 1. A detailed summary of endorsement for each statement within these categories is shown in Section B of the OSF material.

Control Statements. Mean endorsement rates for each category of control statements are shown in Table 1. Compared with the sets of control statements used by Kelemen et al. (2013), there was higher agreement for the statements retained in the current study. This is evident from the category means for true and false controls for the current study items being closer to 1.00 and .00, respectively. A detailed summary of endorsement for all items within each category of control statements is shown in Section B of the OSF material.

Correlations Between Statement Types

Responses to false control statements and test statements were reverse-coded, such that higher scores represented greater accuracy. As shown in Table 2, there was a strong, positive, and significant correlation between accuracy in responding to both categories of test-statements. Accuracy for both categories of test-statements also displayed moderate-to-strong, positive, and significant correlations with accuracy for both categories of false control statements. In contrast, test-statement accuracy was not significantly correlated with accuracy for either category of true control statements. This suggests that acceptance of teleological test-statements is not related to a general inaccuracy in responding; rather, those who accept a greater number of teleological test statements are more likely to accept statements which are objectively false.

Accuracy Across Religious Groups

To test whether accuracy to the statement types differed across religious groups, a 4 (religious group: Atheist, Agnostic, Religious, Other) \times (6) (statement type: nonbiological test, biological test, true teleological, true causal, false teleological, false causal) ANOVA was conducted. A detailed summary of accuracy for the different statement types across religious groups is shown in Section C of the OSF material. As shown in Table 3, there were significant main effects of group and statement type; both of which

⁴ Omega is conceptually similar to Cronbach’s Alpha (α), in that both are measures of internal consistency. However, Alpha is defined under the *essentially tau-equivalent* model, meaning that it assumes both unidimensionality of the underlying construct, as well as constant item variances for the true scores (Dunn et al., 2014; Raykov, 1997). The second assumption of the essentially tau-equivalent model—constant item variances for the true scores—is rarely met, and in these situations, alpha has been shown to underestimate internal consistency (Graham, 2006). Omega, on the other hand, is defined under the *congeneric* model, meaning the only assumption is unidimensionality of the underlying construct (Dunn et al., 2014).

Table 1
Acceptance of Statement Types

Statement type	Before item exclusion				After item exclusion				Kelemen et al. (2013)			
	Min	Max	M	ω (α) [95% CI]	Min	Max	M	ω (α) [95% CI]	Min	Max	M	ω (α) [95% CI]
Test												
Nonbiological	.03 (.17)	.88 (.33)	.39 (.22)	.87 [.85, .90] (.87 [.84, .90])	.13 (.34)	.59 (.49)	.32 (.26)	.87 [.84, .90] (.87 [.84, .89])	.16 (.37)	.74 (.44)	.39 (.26)	.81 [.78, .85] (.81 [.77, .85])
Biological	.07 (.25)	.84 (.37)	.39 (.20)	.85 [.83, .88] (.85 [.82, .88])	.12 (.33)	.84 (.37)	.38 (.24)	.84 [.80, .87] (.83 [.80, .86])	.09 (.28)	.74 (.44)	.46 (.22)	.75 [.70, .80] (.75 [.71, .80])
Control												
True causal	.72 (.45)	.98 (.15)	.89 (.10)	—	.83 (.38)	.98 (.15)	.91 (.09)	—	.72 (.45)	.98 (.15)	.90 (.10)	—
True teleological	.86 (.34)	.99 (.10)	.95 (.08)	—	.96 (.21)	.99 (.10)	.98 (.07)	—	.91 (.28)	.99 (.10)	.97 (.07)	—
False causal	.01 (.12)	.29 (.45)	.10 (.12)	—	.01 (.12)	.10 (.30)	.06 (.10)	—	.02 (.15)	.29 (.45)	.09 (.13)	—
False teleological	<.01 (.07)	.24 (.43)	.07 (.11)	—	<.01 (.07)	.07 (.24)	.04 (.09)	—	<.01 (.07)	.24 (.43)	.08 (.12)	—

Note. Means are shown with standard deviations in parentheses. “Min” and “Max” represent the average endorsement for the statement with the lowest and highest endorsement in the category, respectively. “M” represents the average for the category. For test statements, McDonald’s Omega is shown with Cronbach’s α in parentheses and 95% CIs [L, U]. For comparison, the means and standard deviations for the statements used by Kelemen et al. (2013) are also shown.

were qualified by a significant group by statement type interaction (see Figure 1). To explore this interaction, four contrasts were conducted in which the accuracy of the religious group was compared to that of the average of the other three groups. A Bonferroni adjustment was performed, setting the alpha at .0125 for each contrast.

In an initial contrast, the two categories of test statements were collapsed and compared with the control statements on average. This contrast revealed that the religious group ($M = .53, SD = .25$) was less accurate than the other groups ($M = .71, SD = .22$) when responding to teleological test statements on average, 95% CI_{diff} [-.26, -.11], and that this difference was larger than difference in accuracy between the religious ($M = .92, SD = .08$) and other groups ($M = .95, SD = .06$) when responding to control statements on average, 95% CI_{diff} [-.05, -.01], $F(1, 202) = 21.38, p < .001, \eta_p^2 = .096$.

To determine whether the group difference in accuracy for teleological test statements could be explained by acceptance of explanations that are objectively false, in a second contrast, the two categories of test statements were collapsed and compared to the objectively false control statements. This contrast revealed that the difference in accuracy between the religious and other groups on test statements was larger than the difference in accuracy between the religious ($M = .91, SD = .13$) and other groups ($M = .97, SD = .06$) in responding to false control statements, 95% CI_{diff} [-.09, -.03], $F(1, 202) = 16.32, p < .001, \eta_p^2 = .075$.

To determine whether the group difference in accuracy for teleological test statements could be explained by a general inaccuracy of the religious group in responding to teleological explanations, in a third contrast, the two categories of test statements were collapsed and compared to the teleological control statements. This contrast revealed that the difference in accuracy between the religious and other groups on test statements was also larger than the difference in accuracy between the religious ($M = .95, SD = .08$) and other groups ($M = .98, SD = .05$) in responding to teleological control statements, 95% CI_{diff} [-.04, -.01], $F(1, 202) = 21.43, p < .001, \eta_p^2 = .096$.

Based on examination of Figure 1, a final comparison of interest was a potential difference in accuracy between the religious group and other groups when responding to nonbiological test statements compared with biological test statements. Although the religious group ($M = .54, SD = .27$) was less accurate than the other groups on average ($M = .75, SD = .23$) when responding to nonbiological test statements, 95% CI_{diff} [-.29, -.14], this was only marginally different to the difference between the religious group ($M = .52, SD = .24$) and the other groups on average ($M = .67, SD = .23$) when responding to biological test statements, 95% CI_{diff} [-.23, -.08], $F(1, 202) = 6.18, p = .014, \eta_p^2 = .030$ (compared with an alpha of .0125).

Discussion

Study 1 aimed to test the reliability and validity of a scale to measure teleological beliefs about biological and nonbiological natural entities, by partially augmenting and refining an existing set of items (Kelemen et al., 2013). By selecting teleological test statements based first on their mean endorsement rate and then on their ITC, we retained two sets of teleological test statements, which, compared with the sets of items used by Kelemen et al.

Table 2
Correlations Between Accuracy in Responding to Statement Types

Statement type	1	2	3	4	5	6
1. Nonbiological	1.000–					
2. Biological	.842*** [.797, .878]	1.000–				
3. True causal	–.015 [–.151, .122]	–.028 [–.164, .109]	1.000–			
4. True teleological	.015 [–.122, .151]	–.029 [–.165, .108]	.484*** [.372, .582]	1.000–		
5. False causal	.578*** [.479, .662]	.517*** [.409, .610]	.204** [.070, .332]	.194** [.059, .322]	1.000–	
6. False teleological	.504*** [.395, .600]	.454*** [.338, .556]	.169* [.033, .299]	.185** [.049, .314]	.569*** [.469, .655]	1.000–

Note. Pearson's r with 95% CI [L, U]. $N = 206$ for all correlations.

* $p < .01$. ** $p < .01$. *** $p < .001$.

(2013), displayed higher internal consistencies and loaded more strongly onto single components. Furthermore, compared with the set of control statements used by Kelemen et al. (2013), there was greater agreement for those in the current study, with mean endorsements for objectively true and objectively false control statements closer to 1.00 and .00, respectively.

In Study 1, we found that the rate of teleological acceptance for the religious group relative to the other groups, was not due to inaccuracy when responding to control statements on average, and nor was it due to inaccuracy when responding to teleological control statements. Notably, the difference in teleological acceptance between the religious and other groups, was larger than the difference in accuracy on false control statements. Although prior research has shown that compared to nonbelievers, religious individuals are less analytical (Ross et al., 2016) and more likely to believe in fake news (Bronstein et al., 2019), the current results suggest that the tendency of religious individuals to be more accepting of teleological explanations of biological and nonbiological natural entities, is not simply due to a tendency to agree with explanations regardless of whether they are true or false.

By successfully discriminating between religious and nonreligious individuals, these results provide preliminary evidence for the validity and utility of this scale. These results are consistent with prior research in showing a relationship between religious belief and acceptance of teleological explanations of biological and nonbiological natural entities (e.g., Kelemen & Rosset, 2009; Kelemen et al., 2013). On average, compared with nonbelievers, those who identify as religious tend to explain the natural world in terms of purpose and function. As individuals who believe in the existence of supernatural agents may be expected to attribute intentions in situations where no “natural” agent is present (but see Roberts et al., 2020), this provides support for Kelemen's (1999a) intention-based theory of teleology.

Despite the consistency with previous findings, a limitation of Study 1 was that participants were not excluded based on responses

to control items. Previous studies (e.g., Kelemen & Rosset, 2009; Kelemen et al., 2013) have excluded participants with less than 80% accuracy on control statements. Due to the fact that in Study 1, items were selected based on their endorsement, it was not possible to also exclude participants based on their responses to these items. Although religious group differences were larger for teleological test statements than for control statements, it is possible the group differences in teleological acceptance were being driven partly by certain religious individuals who were particularly inaccurate in responding to control statements.

Furthermore, although in Study 1, religious individuals endorsed significantly more teleological test statements compared to nonreligious individuals, the religious group was fairly homogeneous, being comprised mostly of Christians. Therefore, it is unclear whether this pattern of responding represents a predominantly Christian view of nature, or whether these results can be generalized to a more heterogeneous religious group.

Study 2

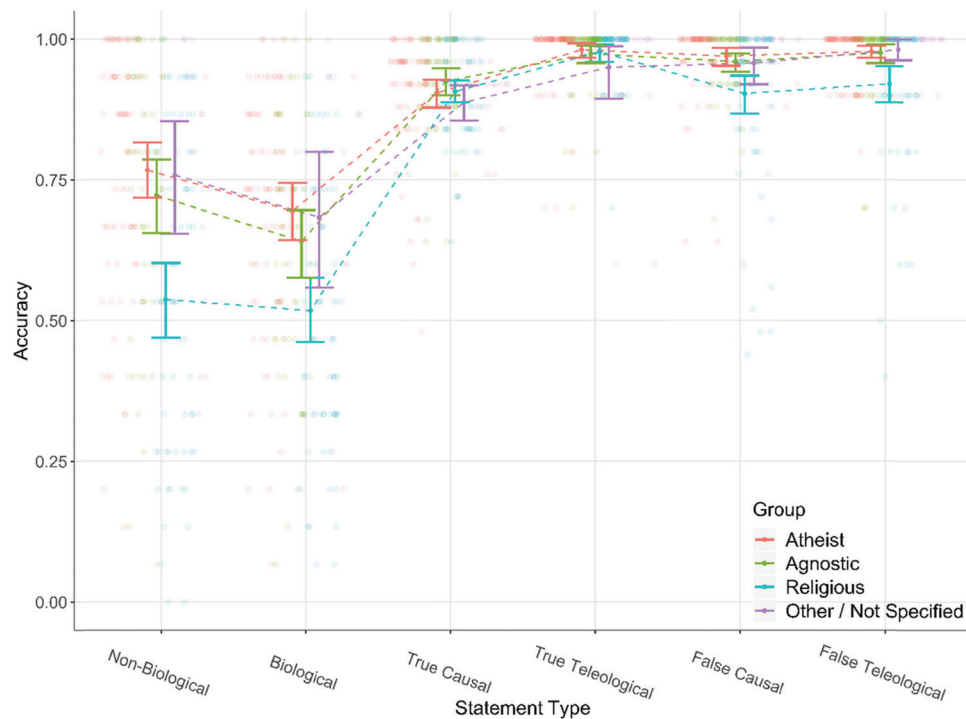
In Study 2, we address the limitations of Study 1 outlined above. To test whether the group differences on test-statement accuracy were being driven, in part, by certain religious individuals responding particularly inaccurately to control statements, we apply an exclusion criterion of less than 80% accuracy on control statements. We also address the question of whether the results from Study 1 can be generalized to a more heterogeneous religious sample in two ways: First, we address this question by recruiting individuals from a diverse range of religious affiliations. According to a relational-deictic account, teleological beliefs about the natural world may arise from an understanding of the relationships between living things and their environments (Ojalehto et al., 2013). Numerous studies have made a broad distinction between Western cognition as more analytical, and Eastern cognition as more holistic and deictic (e.g., Choi et al., 1999; Nisbett et al.,

Table 3
Significance and Effect Sizes of Group by Statement Type ANOVA for Study 1

Effect	df	F	p	η_p^2
Group ₁	3	10.55	<.001	.135
Statement type ₂	5	184.83	<.001	.478
Group × Statement Type ₃	15	6.89	<.001	.093
Error ₁	202	—	—	—
Error _{2,3}	1,010	—	—	—

Note. Due to a violation of sphericity, a Greenhouse-Geisser epsilon of .365 was applied to the effects of statement type and the interaction between group and statement type.

Figure 1
Mean Accuracy Across Statement-Types as a Function of Religious Group



Note. Error bars represent 95% confidence intervals. See the online article for the color version of this figure.

2001; Peng & Nisbett, 1999). As Abrahamic religious affiliations (e.g., Christianity, Judaism) are more common in Western than in Eastern cultures, by recruiting participants from Abrahamic and non-Abrahamic religious affiliations, it is possible to explore whether the difference in teleological acceptance between religious and nonreligious groups (e.g., Järnefelt et al., 2015; Kelemen & Rosset, 2009) generalizes to a more heterogeneous religious sample, and indeed, whether the difference is accentuated when comparing non-Abrahamic to nonreligious individuals. Second, we explore the question of whether the results from Study 1 can be generalized with the inclusion of a validated measure of religiosity—the Centrality of Religiosity Scale (CRS; Huber & Huber, 2012)—to explore the extent to which religiosity, regardless of affiliation, predicts acceptance of teleological explanations about biological and nonbiological natural entities.

Study 2 also explores the question of what, specifically, about identifying as religious might explain the acceptance of teleological explanations about biological and nonbiological natural entities. One possibility explored here is that individual differences in delusional ideation could play a role. Previous research has found a positive relationship between spiritual beliefs and certain schizotypal traits (Willard & Norenzayan, 2017), and between measures of religious belief and both positive symptoms of schizotypy (Wlodarski & Pearce, 2016) and delusional ideation (Ross et al., 2016). Delusional ideation also positively correlates both with the so-called intentionality bias, whereby ambiguous actions are judged to be intentionally initiated by an agent (Moore & Pope, 2014), and with a tendency to ascribe free-will, emotions,

intentions, and consciousness to nonhumans (Wlodarski & Pearce, 2016). Given that Kelemen (1999a) posits an understanding of intentions as the origin of teleological thought, it is possible that delusional ideation could explain, in part, the relationship between religiosity and teleological acceptance. Study 2 investigates the relative contributions of delusional ideation, as measured by the PDI (Peters et al., 2004), and religiosity, as measured by the CRS, in predicting acceptance of teleological explanations about biological and nonbiological natural entities. The preregistration for this study can be found at <https://osf.io/dv5f2/>. The dataset is located at <https://osf.io/jb523/> and the code for analysis is located at <https://osf.io/zaqh9/>.

Methods

Participants

An international pool of 304 fluent English-speakers were recruited online through Prolific Academic. The choice in sample size was determined by an a priori power analysis which showed that to detect the expected effect size for the difference in accuracy of religious and nonreligious groups on biological and nonbiological test statements with power of .80 and an alpha of .05, a sample size of $N = 274$ was required. The decision to purposely oversample was driven both by the fact that participants in Study 2 would be excluded based on control statement accuracy, and due to the more heterogeneous sample in Study 2 compared with Study 1. As one of the aims of Study 2 was to test whether the differences in teleological endorsement for religious individuals relative to

nonreligious individuals were generalizable beyond a predominantly Christian sample, we purposely sampled a diverse range of religious affiliations. With the goal of achieving a relatively balanced design when comparing religious and nonreligious individuals, the following numbers of each group were initially recruited: 163 nonreligious (95 Agnostics and 68 Atheists), and 141 religious (27 Christians, 26 Muslims, 25 Pagans, 23 Jews, 22 Hindus, and 18 Buddhists).

Two participants were excluded for taking excessively long to complete the questionnaire ($z > 4$), and 28 participants were excluded for selecting a religious affiliation in the study which was different to that of their Prolific profile. Twenty-five participants were excluded for having less than 80% accuracy in response to control statements. After exclusion, 249 participants remained. One-hundred and 24 participants identified as male, 118 as female, and seven as other. The final sample was comprised of 133 nonreligious (54 Agnostics, 79 Atheists), and 116 religious individuals (14 Buddhists, 17 Christians, 18 Hindus, 24 Pagans, 21 Muslims, and 22 Jews). Ages ranged from 18 to 71 ($M = 31.20$, $SD = 9.84$).

Materials

Teleological Beliefs Scale. Participants responded “true” or “false” to the 100 statements retained from Study 1.

Religiosity. To explore the relationship between religiosity and teleological acceptance, participants completed the CRS (Huber & Huber, 2012). The CRS contains 15 items in total across five subscales: intellect, ideology, public practice, private practice, and experience. For two questions relating to the objective frequency of prayer and meditation (e.g., How often do you pray?), responses were made on an 8-point Likert scale from 1 (*never*) to 8 (*several times a day*). For two questions relating to the objective frequencies of participation in religious services (e.g., How often do you take part in religious services?), responses were made on a 6-point Likert scale from 1 (*never*) to 6 (*more than once a week*). Responses to both of these question types were later recoded to a 5-point scale as suggested by Huber and Huber (2012). Finally, the remaining 11 questions relating to objective frequencies of experience or thought (e.g., How often do you think about religious issues?) or importance of religion (e.g., How important is it for you to be connected to a religious community?) were scored on a 5-point Likert scale from 1 (*never/not at all*) to 5 (*very often/very much so*). Scores for each subscale were obtained by calculating the mean of the three relevant questions, and the total score was obtained by calculating the mean of all 15 items. The internal consistency for the CRS in the current study was excellent ($\alpha = .955$, 95% CI [.95, .96]), and similar to previously reported norms for the scale (Huber & Huber, 2012).

Delusional Ideation. In order to assess the extent to which delusional ideation predicts teleological acceptance, participants completed the PDI (Peters et al., 2004). The PDI contains 21 yes/no questions (e.g., Do you ever feel as if there is a conspiracy against you?). On the items that are answered “yes,” three follow-up questions are presented to ask about the level of distress associated with the belief, the frequency with which the participant thinks about the belief, and how true the participant believes it to be. Each of these follow-up questions are scored on a Likert scale from 1 (*not at all distressing/hardly ever think about it/do not*

believe it's true) to 5 (*very distressing/think about it all the time/believe it is absolutely true*). Five different scores are obtained from the PDI. A yes/no score is calculated as the number of the initial binary questions endorsed, such that yes/no scores had a potential range of 0 to 21. Distress, preoccupation, and conviction scores are each calculated by summing the ratings on the relevant follow-up questions. In the cases where the binary item to which the follow-up questions relate are not endorsed, the follow-up questions are scored 0. Scores on each dimension therefore had a potential range 0 (if no binary items are endorsed) to 105 (if all binary items are endorsed and the participant selects “5” on the follow-up questions). Finally, a total PDI score is obtained by adding the yes/no score to each of the dimension scores, such that scores have a possible range of 0 to 336, with higher scores indicating greater delusional ideation. Internal consistency for the yes/no questions was acceptable ($\alpha = .779$, 95% CI [.74, .82]), and similar to reported norms ($\alpha = .820$; Peters et al., 2004). Likewise, the distress ($\alpha = .827$, 95% CI [.80, .86]), preoccupation ($\alpha = .818$, 95% CI [.79, .85]), and conviction ($\alpha = .792$, 95% CI [.76, .83]) dimensions of the PDI all displayed good internal consistency.

Procedure

Upon giving informed consent, participants were told that they would be shown a series of statements which offer explanations for various things in the world, and that their task was to decide whether each statement is “true” or “false.” The preliminary version of the Teleological Beliefs Scale was presented in five blocks of 20, with the order of presentation randomized both within and between blocks. Following this, participants answered the initial 21 PDI questions on a single page. Upon clicking next, the distress, preoccupation, and conviction questions were displayed on separate pages for each of the 21 questions which were endorsed. At the top of each page was a short reminder of the question they responded yes to (e.g., “You indicated that you sometimes feel as if there is a conspiracy against you. Please answer the following questions about this belief”). The reason for presenting the follow-up questions after the initial questions had been answered, was to avoid participants selecting “no” once they realized that a response of “yes” resulted in additional questions. Participants then completed the CRS, and finally, provided demographic information.

Results

Scale Performance

For comparison with Study 1, a summary of the minimum, maximum, and mean acceptance for each statement category, both before and after participant exclusion based on control item accuracy, is shown in Table 4. After exclusion of participants based on control statement accuracy, in both categories of test statements, one item had a mean endorsement of less than .10. In the case of biological test statements, this was “Mosquitoes bite humans in order to spread disease,” and in the case of nonbiological test statements, “Stars twinkle in order to light the night sky.” As such, both these items were removed from the final version of the Teleological Beliefs Scale, thereby leaving 14 items within each category of test statements. The biological ($\omega = .84$, 95% CI [.81, .87]) and nonbiological test categories ($\omega = .81$, 95% CI [.77, .84]) both

Table 4*Mean Endorsement and Standard Deviations, Before and After Participant Exclusion*

Statement type	Before participant exclusion			After participant exclusion		
	Min	Max	<i>M</i>	Min	Max	<i>M</i>
Nonbiological ^a	.14 (.34)	.49 (.50)	.28 (.24)	.14 (.35)	.47 (.50)	.26 (.22)
Biological ^a	.10 (.30)	.70 (.46)	.36 (.25)	.14 (.35)	.69 (.46)	.35 (.25)
True causal	.77 (.42)	.97 (.16)	.91 (.10)	.80 (.40)	.99 (.09)	.93 (.08)
True teleological	.94 (.24)	.98 (.15)	.97 (.08)	.95 (.22)	1.0 (0.0)	.98 (.05)
False causal	.04 (.20)	.13 (.33)	.08 (.15)	<.01 (.06)	.09 (.28)	.04 (.06)
False teleological	.03 (.18)	.15 (.35)	.08 (.16)	0.0 (0.0)	.10 (.31)	.04 (.07)

Note. Before exclusion ($N = 274$) refers only to exclusion based on control statement accuracy. After exclusion, $N = 249$. Standard deviations are shown in parentheses.

^aDetails for each category of test statement are after removal of the items with low endorsement.

displayed good internal consistencies. A detailed summary of each item is included in the OSF material (Section B).

Correlations

Responses to false control statements and test statements were reverse-coded, such that higher scores represented greater accuracy. As shown in Table 5, there was a strong, positive, and significant relationship between accuracy for the two categories of test statements. Accuracy in responding to both categories of test statements had moderate, positive, and significant relationships with accuracy for false causal and false teleological statements but were not significantly correlated with accuracy for true causal and true teleological statements. Also shown in Table 5, religiosity and delusional ideation were both negatively correlated with accuracy in responding to teleological test statements, religiosity was negatively correlated with accuracy in responding to false causal statements, and delusional ideation was negatively correlated with accuracy in responding to both categories of false control statements.

Differences in Teleology Across Groups

To test whether accuracy to the statement types differed across religious groups, an 8 (religious group) \times (6: statement type) mixed ANOVA was conducted. A detailed summary of accuracy to each statement type across all groups is provided Section D of the OSF material. As shown in Table 6, the main effects of group and statement type were both significant but were qualified by a significant group by statement type interaction (see Figure 2).

To explore this interaction, four preregistered contrasts were performed, whereby the six “religious” groups were collapsed and compared to the average of the two “nonreligious” groups. As these contrasts were preregistered, significance was assessed using a Holm-Bonferroni adjustment rather than the more conservative Bonferroni adjustment used in Study 1. The results of each contrast were ranked from most to least significant, and were assessed against critical alphas of .0125, .0167, .025, and .050, respectively.

In an initial contrast, the two categories of test statements were collapsed and compared with the control statements on average. This contrast revealed that the religious group ($M = .66$, $SD = .21$) was less accurate than the nonreligious group ($M = .73$, $SD = .23$) when responding to teleological test statements on average, 95% CI_{diff} [.02, .13], and that this difference was larger than the difference in accuracy between the religious ($M = .94$, $SD = .04$) and nonreligious groups ($M = .96$, $SD = .04$) when responding to

control statements on average, 95% CI_{diff} [.01, .03], $F(1, 241) = 5.29$, $p = .022$, $\eta_p^2 = .021$ (against a critical alpha of .025).

In a second contrast, the two categories of test statements were collapsed and compared with the objectively false control statements. This contrast revealed that the difference in accuracy between the religious and nonreligious group on test statements was larger than the difference in accuracy between the religious ($M = .95$, $SD = .06$) and nonreligious groups ($M = .96$, $SD = .05$) in responding to false control statements, 95% CI_{diff} [-.01, .03], $F(1, 241) = 6.54$, $p = .011$, $\eta_p^2 = .026$ (against a critical alpha of .0125).

In a third contrast, the two categories of test statements were collapsed and compared with the teleological control statements. The third contrast revealed that the difference in accuracy between the religious and nonreligious group on test statements was also larger than the difference in accuracy between the religious ($M = .97$, $SD = .04$) and nonreligious groups ($M = .97$, $SD = .04$) in responding to teleological control statements, 95% CI_{diff} [$<-.01$, .02], $F(1, 241) = 5.83$, $p = .016$, $\eta_p^2 = .024$ (against a critical alpha of .0167).

A final contrast explored the difference in accuracy between the religious and nonreligious groups when responding to biological compared to nonbiological test statements. Although in Study 1 this approached significance, there was no evidence for such an effect in the current study, $F(1, 241) = 1.54$, $p = .215$, $\eta_p^2 = .006$ (against a critical alpha of .050).

Religiosity, Delusional Ideation, and Teleology

A multiple linear regression was preregistered to assess the unique effects of religiosity and delusional ideation in predicting teleological acceptance. However, due to the negative relationships between these predictors and accuracy for false, but not true control statements, here the results of a repeated measures ANCOVA are reported, with statement type (test, false control) as the within-subject factor, and religiosity (CRS) and delusional ideation (PDI) as covariates (both mean-centered).⁵ The advantage of this analysis over a multiple linear regression, is that the interaction terms represent the difference in the strength of the predictors for teleological test items compared to the false control items. As such, this analysis helps to rule out the possibility that the

⁵Note that although accuracy on true control statements was not related to acceptance of teleological test statements or the two predictors, it is necessary to include true control statements in the scale so that the correct response is not always “false.”

Table 5
Correlations Between Accuracy in Responding to Statement Types, Religiosity, and Delusional Ideation

Variable	1	2	3	4	5	6	7	8
1. Nonbiological	1.00-							
2. Biological	.787*** [.74, .83]	1.000-						
3. True causal	.107 [-.02, .23]	.031 [-.09, .16]	1.000-					
4. True teleological	-.042 [-.17, .08]	-.056 [-.18, .07]	.162* [.04, .28]	1.000-				
5. False causal	.478*** [.38, .57]	.455*** [.35, .55]	.080 [-.05, .20]	-.038 [-.16, .09]	1.000-			
6. False teleological	.396*** [.29, .50]	.394*** [.28, .49]	.089 [-.04, .21]	-.013 [-.14, .11]	.338*** [.22, .44]	1.000-		
7. CRS	-.153* [-.27, -.03]	-.192** [-.31, -.07]	-.072 [-.19, .05]	-.092 [-.21, .03]	-.144* [-.26, -.02]	-.046 [-.17, .08]	1.000-	
8. PDI	-.198** [-.32, -.08]	-.242*** [-.36, -.12]	-.041 [-.16, .08]	-.074 [-.20, .05]	-.218*** [-.33, -.10]	-.243*** [-.36, -.12]	.430*** [.32, .53]	1.000-

Note. Pearson's *r* with 95% CI [L, U], *N* = 249 for all correlations.
* *p* < .05. ** *p* < .01. *** *p* < .001.

predictor variables were not associated with teleological acceptance specifically, but with the tendency to agree with explanations regardless of their truth. As this analysis produces parameter estimates for each level of the within-subject factor, the results for test statement accuracy are identical to the preregistered analysis.

As shown in Table 7, there was a significant main effect of statement type, reflecting the higher accuracy on average in responding to false control statements ($M = .96, SE < .01$) compared to teleological test statements ($M = .69, SE = .01$), 95% CI_{diff} [.24, .29]. There was also a significant effect of delusional ideation, which was qualified by a significant statement type by delusional ideation interaction. As shown in Table 8, although delusional ideation negatively predicted accuracy in responding to teleological test statements, this relationship was weaker than the relationship between delusional ideation and accuracy in responding to false control statements. Religiosity was not a significant predictor of accuracy overall, and this did not differ significantly by statement type.

Exploratory Analyses

Gender. Religiosity has previously been shown to vary between genders (Willard & Norenzayan, 2013). As it was not possible to make meaningful comparisons with the group of seven who selected “other” as their gender, these participants were removed from the dataset ($N = 242$). We found that females were both more religious ($M = 2.20, SD = .96$) than males ($M = 1.95, SD = .93$), 95% CI_{diff} [.01, .49], $t(240) = -2.06, p = .041, d = .265$, and less accurate when responding to test statements ($M = .63, SD = .24$) than males ($M = .75, SD = .19$), 95% CI_{diff} [.06, .17], $t(236) = 4.21, p < .001, d = .554$.

To further explore the role of gender, the previous ANCOVA with statement type (test, false control) as the within-subject factor, and religiosity (CRS) and delusional ideation (PDI) as covariates (both mean-centered) was repeated, both excluding (Model 1) and including (Model 2) gender (see Section E of the OSF material). Using this reduced dataset, the interpretation of the previous ANCOVA remained the same whether gender was included or excluded. However, there was a significant main effect of gender in model 2, as on average, males ($M = .86, SE = .01$) were more accurate than females ($M = .79, SE = .01$), 95% CI_{diff} [.03, .10]. A significant interaction between gender and statement type revealed that this was being driven by differences in accuracy between genders for teleological test statements, but not false control statements.

Belief in Supernatural Agents. Although the CRS is a validated measure of religiosity, two of the subscales—intellect and public practice—do not necessarily measure *belief* in supernatural agents. For example, in the case of the intellect subscale, the most ardent atheist may be interested in learning about religious topics (perhaps even more so than an agnostic who is indifferent to religion). In the case of the public practice subscale, it is plausible that societal pressures could result in a high score for an individual who rejects the notion of supernatural agents. Conversely, a person may be sincerely religious, yet not attend public services. In contrast, it is unlikely that a person would “pray spontaneously when inspired by daily situations” (private practice subscale) if they did not genuinely believe that a supernatural agent existed. Likewise, it is implausible that a person could endorse a question relating to

Table 6
Significance and Effect Sizes of Group by Statement Type ANOVA for Study 2

Effect	df	F	p	η_p^2
Group ₁	7	2.83	.008	.076
Statement type ₂	5	253.06	<.001	.512
Group × Statement Type ₃	35	1.82	.040	.050
Error ₁	241	—	—	—
Error _{2,3}	1,205	—	—	—

Note. Due to a violation of sphericity, a Greenhouse-Geisser epsilon of .361 was applied to the effects of statement and the interaction between group and statement.

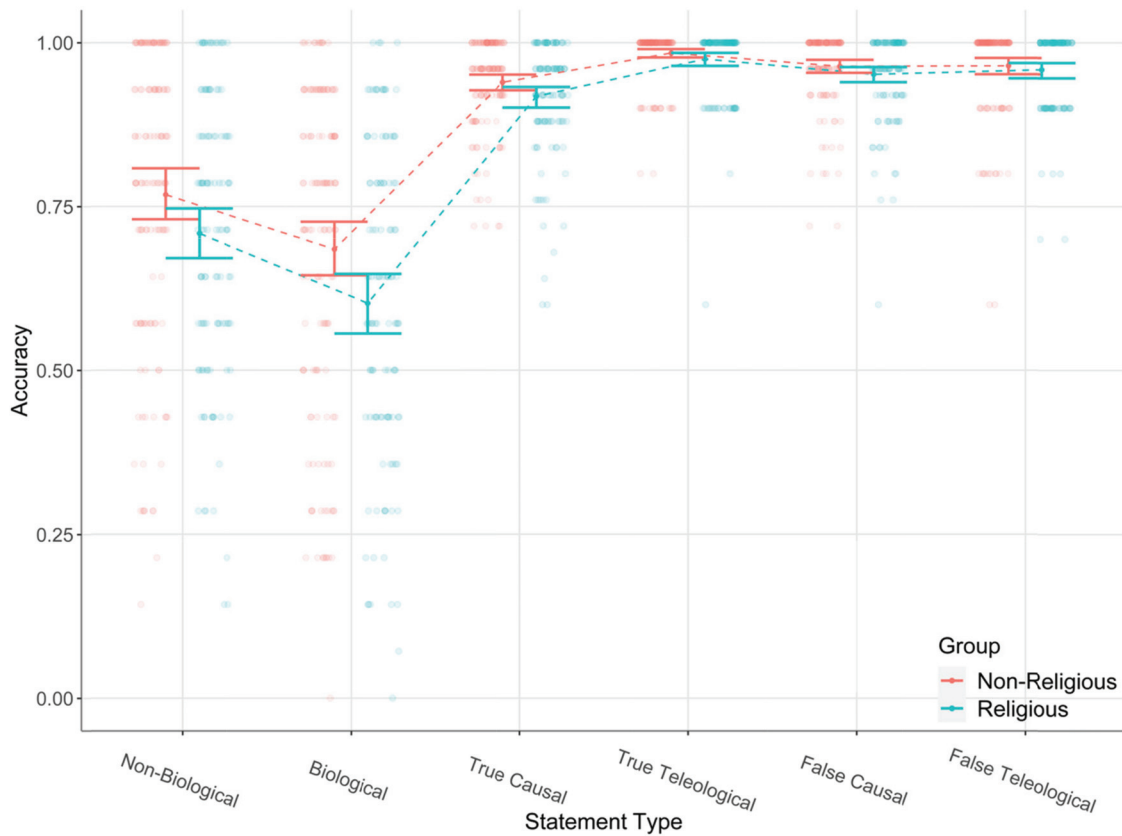
the existence of God (ideology subscale), or their experience of God wanting to communicate something to them (experience subscale), if they did not believe in God. For this reason, a reduced-CRS (r-CRS) score was calculated using the mean of only the subscales that necessarily relate to belief in supernatural agents (i.e., the ideology, private practice, and experience subscales).

An ANCOVA was performed with statement type (test, false control) as the within-subjects factor, and supernatural agent beliefs (r-CRS) and PDI as covariates. Main effects and interactions from these analyses are shown in Table 9, and parameter estimates are shown in Table 10. There was a significant main effect of statement type, due to higher accuracy in responding to false control statements ($M = .96, SE < .01$) than teleological test

statements ($M = .69, SE = .01$), 95% CI_{diff} [.24, .29]. The effect of supernatural agent beliefs (r-CRS) was also significant, but was qualified by a significant interaction with statement type (see Table 9). As shown in Table 10, supernatural agent beliefs negatively predicted accuracy in responding to teleological test statements, but not false control statements. There was also a significant effect of delusional ideation, reflecting a negative relationship between delusional ideation and accuracy across both statement types. However, there was no evidence that this differed between statement types.

Teleological Beliefs of Abrahamic and Non-Abrahamic Affiliations. The difference in teleological acceptance between the religious and nonreligious group in Study 2 was considerably

Figure 2
Mean Accuracy Across Statement-Types as a Function of Religious Group



Note. Error bars represent 95% confidence intervals. See the online article for the color version of this figure.

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Table 7
Significance and Effect Sizes for ANCOVA With Statement Type, CRS, and PDI

Effect	df	F	p	η_p^2
Statement type	1	465.31	<.001	.654
CRS	1	1.88	.172	.008
PDI	1	10.42	.001	.041
Statement Type \times CRS	1	2.42	.121	.010
Statement Type \times PDI	1	4.34	.038	.017
Error	246	—	—	—

Note. CRS = Centrality of Religiosity Scale; PDI = Peter et al.'s, Delusions Inventory. CRS and PDI are both total scores of each scale. Statement type compares test statement acceptance with false control statement accuracy.

smaller than in Study 1 (see Figures 1 and 2). A possible reason for this is the heterogeneous sample with respect to religious affiliation in Study 2, which included Abrahamic and non-Abrahamic affiliations, compared with the homogenous sample in Study 1 comprised mostly of Christians.

To explore the differences in accuracy across affiliations, religious affiliation was collapsed to form three groups: nonreligious (Agnostic, Atheist; $n = 133$), Abrahamic (Christian, Jewish, Muslim; $n = 60$), and non-Abrahamic (Buddhist, Hindu, Pagan; $n = 56$), and a 3 (affiliation) \times (6: statement type) mixed ANOVA was conducted. The main-effects of affiliation, $F(2, 246) = 4.12$, $p = .017$, $\eta_p^2 = .032$, and statement type, $F(5, 1230) = 282.18$, $p < .001$, $\eta_p^2 = .534$, were both significant, but were qualified by a significant affiliation by statement type interaction, $F(10, 1230) = 2.85$, $p = .029$, $\eta_p^2 = .023$.

As shown in Figure 3, there was considerable variation in how the Abrahamic and non-Abrahamic religious affiliations responded to teleological test statements. On nonbiological test-statements, the nonreligious group ($M = .77$, $SD = .23$) was significantly more accurate than the Abrahamic group ($M = .69$, $SD = .23$), 95% CI_{diff} [.01, .15], $t(191) = 2.30$, $p = .022$, $d = .348$, yet there was no significant difference in accuracy between the nonreligious group and the non-Abrahamic group ($M = .73$, $SD = .20$), 95% CI_{diff} [-.03, .10], $t(187) = 1.03$, $p = .305$, $d = .186$. Conversely, on biological test-statements, the nonreligious group ($M = .68$, $SD = .25$) was significantly more accurate than the non-Abrahamic group ($M = .58$, $SD = .24$), 95% CI_{diff} [.03, .18], $t(187) = 2.73$, $p = .007$, $d = .408$, yet there was no significant difference in accuracy between the nonreligious group and the Abrahamic group ($M = .63$, $SD = .25$), 95% CI_{diff} [-.02, .14] $t(191) = 1.54$, $p = .126$, $d = .200$.

Discussion

The aims of Study 2 were twofold. First, to test whether the finding from Study 1, that religious individuals were more accepting than nonreligious individuals of teleological explanations of

biological and nonbiological natural entities, could be generalized to a heterogeneous religious sample. In support of this, on average, those who identified as either Buddhist, Christian, Hindu, Jewish, Muslim, or Pagan, accepted a greater number of these teleological explanations compared to those who identified as atheist or agnostic. As in Study 1, differences in teleological acceptance between religious and nonreligious groups were not due to a general inaccuracy in responding to control items, nor to inaccuracy in responding to teleological control statements, or a tendency to accept explanations which were objectively false. The comparison of teleological test statements with false control statements is important, as it suggests that rates of teleological acceptance were not due to a tendency to agree with explanations regardless of their truth. Furthermore, as false control statements were objectively false, yet contained terms which were related (e.g., "gray hair" and "older"), this comparison helps to rule out the possibility that rates of teleological acceptance were due to a tendency to recognize the correlation between two terms in the explanation, but to ignore the semantics of the conjunction (e.g., "so that"). Instead, consistent with Study 1 and previous research (Kelemen et al., 2013; Kelemen & Rosset, 2009), religious individuals were more likely to explain the natural world in terms of purpose and function.

The smaller effect-sizes in Study 2 were likely due to a combination of two factors. First, as all "religious" affiliations were collapsed to form a single group, there was greater variation in teleological acceptance within this group compared to Study 1. Indeed, an exploratory analysis in which religious affiliations were collapsed to form three groups (nonreligious, Abrahamic, non-Abrahamic), revealed that when responding to nonbiological test statements, the nonreligious group was significantly more accurate than the Abrahamic group, but did not differ significantly to the non-Abrahamic group. In contrast, when responding to biological test statements, the nonreligious group was significantly more accurate than the non-Abrahamic group, but did not differ significantly to the Abrahamic group. In showing that the non-Abrahamic group was particularly accepting of teleological explanations about biological entities, yet not of teleological explanations for

Table 8
Parameter Estimates From ANCOVA With Statement Type, CRS, and PDI

Predictor	Teleological test statements					False control statements				
	β	SE	t	p	95% CI (β)	β	SE	t	P	95% CI (β)
CRS	-.101	.068	-1.48	.139	-.236, .033	-.025	.068	-0.36	.717	-.159, .109
PDI	-.190	.068	-2.79	.006	-.325, -.056	-.256	.068	-3.78	<.001	-.390, -.112

Note. CRS = Centrality of Religiosity Scale; PDI = Peter et al.'s, Delusions Inventory. CRS and PDI are both total scores of each scale.

Table 9
Significance and Effect Sizes for ANCOVA With Statement Type, r-CRS, and PDI

Effect	df	F	p	η_p^2
Statement type	1	471.62	<.001	.666
r-CRS	1	4.56	.034	.018
PDI	1	8.31	.004	.033
Statement Type × r-CRS	1	5.79	.017	.023
Statement Type × PDI	1	2.89	.090	.012
Error	246	—	—	—

Note. CRS = Centrality of Religiosity Scale; PDI = Peter et al.’s, Delusions Inventory. r-CRS contains only the ideology, private practice, and experience subscales of the CRS. PDI is the total score on the PDI. Statement type compares test statement acceptance with false control statement accuracy.

nonbiological natural entities, these findings highlight the complexity of the relationship between religious and teleological beliefs.

According to a relational-deictic account (Ojalehto et al., 2013), teleological beliefs about the natural world result from an appreciation of the relationship between parts of the natural system, whereas according to an intention-based account (Kelemen, 1999a), such beliefs result from an understanding that intentional agents have purposes. As Western cultures tend to be associated with more analytic styles of cognition compared with Eastern cultures, which tend to be associated with more deictic and holistic styles of cognition (Nisbett et al., 2001; Peng & Nisbett, 1999), it would have been reasonable to expect higher rates of teleological acceptance in non-Abrahamic compared with Abrahamic affiliations. However, the relational-deictic and intention-based accounts are clearly not mutually exclusive. It is possible, for example, that people are more inclined to take a relational perspective when explaining biological compared with nonbiological natural entities, due to the relative proximity of biological entities with the proper domain of an intentional stance (i.e., the actions of an intentional agent).

While variation in teleological acceptance across affiliations may have contributed to the reduced effect size relative to Study 1, it is unlikely to fully account for this difference. Examination of Tables S8 and S9 in the OSF material reveals that in comparison to the religious group in Study 1, which was comprised mostly of Christians, the Christian group in Study 2 tended to be more accurate in responding to teleological test statements. Therefore, a second factor which may have contributed to the reduced effect size, is that in Study 2, participants were excluded for inaccurate responding to control statements, whereas in Study 1 they were not. Although the difference in teleological acceptance between groups was substantially smaller than in Study 1, the exclusion of participants based on control item accuracy helps to rule out the possibility that rates of teleological acceptance were being driven by inattention to the task. By demonstrating that the relationship between religious belief and acceptance of teleological explanations about biological and nonbiological natural

entities can be generalized beyond a predominantly Christian sample, these results provide further support for Kelemen’s (1999a) intention-based theory of teleology, yet also highlight the complexity of this relationship when comparing prototypically Western (i.e., Abrahamic), to non-Western religious affiliations.

A second aim of Study 2 was to examine the relative contributions of religiosity and delusional ideation in predicting teleological acceptance. Consistent with previous research (e.g., Ross et al., 2016), bivariate analyses revealed both predictors were positively associated with one another. Although neither predictor was associated with accuracy in responding to control statements which were objectively true, religiosity was associated with acceptance of false causal statements, and delusional ideation with both categories of false control statements. Crucially, both predictors were also associated with acceptance of teleological test statements. While a positive relationship between religiosity and the PDI is to be expected, partly due to the subset of items in the PDI which ask about religious belief (e.g., “Do you ever feel that you are especially close to God?”), surprisingly, when religiosity and delusional ideation were included together in a model, religiosity was not a significant predictor of inaccuracy to test-statements or false control statements. Delusional ideation was a significant predictor of inaccuracy for both statement types, yet contrary to expectations, this was stronger for false control statements than test statements. Adding gender to this model did not change the previous interpretation, although males were more accurate than females in responding to teleological test statements but not false control statements. However, a potential limitation of Study 2 is that gender was not balanced across self-reported religious affiliation. These results suggest that delusional ideation is not related to belief in the teleology of nature per se, but rather to a tendency to accept objectively false explanations.

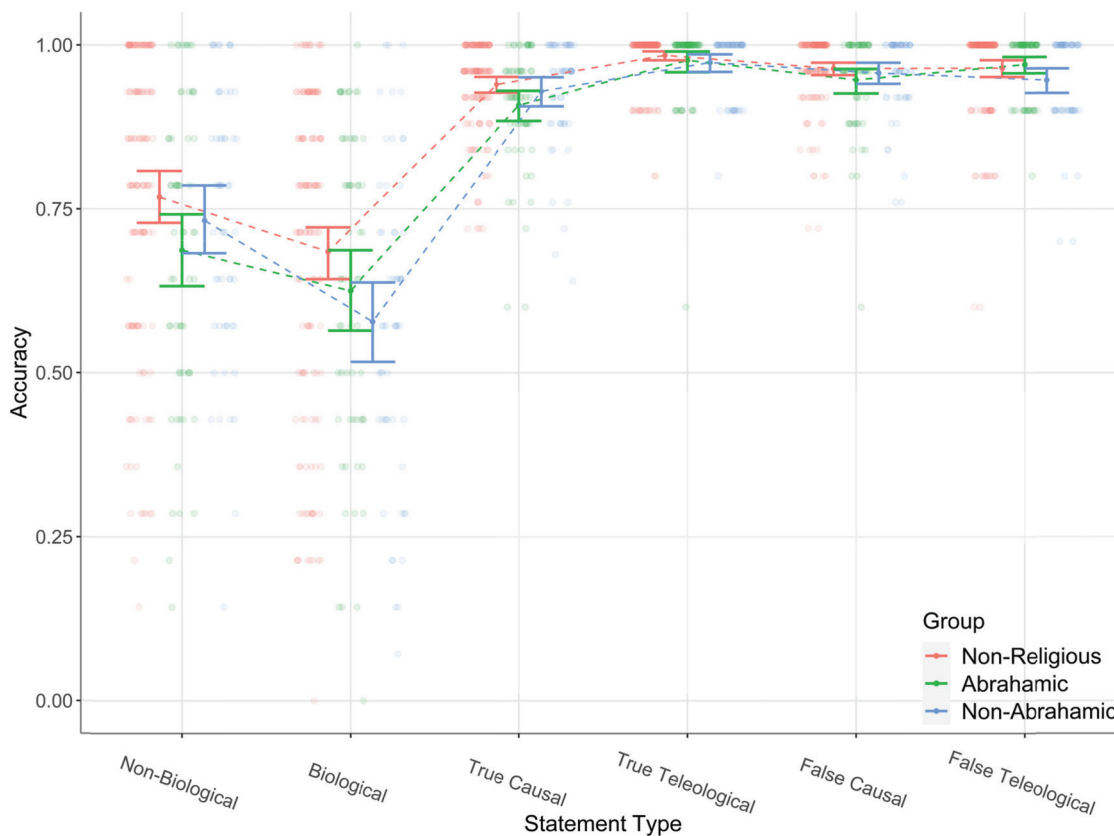
An exploratory analysis using only the subscales of the CRS which were necessarily related to a belief in the existence of supernatural agents, revealed that belief in supernatural agents (as opposed to religious behaviors) was a significant predictor of

Table 10
Parameter Estimates From ANCOVA With Statement Type, r-CRS, and PDI

Predictor	Teleological test statements					False control statements				
	β	SE	t	p	95% CI (β)	β	SE	t	P	95% CI (β)
r-CRS	-.157	.069	-2.30	.022	-.292, -.023	-.042	.069	-0.61	.544	-.176, .093
PDI	-.165	.069	-2.42	.016	-.299, -.031	-.248	.069	-3.63	<.001	-.383, -.113

Note. CRS = Centrality of Religiosity Scale; PDI = Peter et al.’s, Delusions Inventory. r-CRS contains only the ideology, private practice, and experience subscales of the CRS. PDI is the total score on the PDI.

Figure 3
Mean Accuracy Across Statement-Types as a Function of Affiliation



Note. Error bars represent 95% confidence intervals. See the online article for the color version of this figure.

inaccuracy to teleological test statements but not false control statements, and that delusional ideation was a significant predictor of inaccuracy to both. Although exploratory, these results suggest that an important aspect of religiosity in predicting acceptance of teleological explanations about biological and nonbiological natural entities, is a belief in the *existence* of supernatural agents. From a theoretical perspective (Kelemen, 1999a), the importance of a belief in the existence of supernatural agents makes sense, as this may provide a source of intentions which is otherwise lacking in such teleological explanations.

Study 3

The results of Study 2 highlighted several possibilities. First, although delusional ideation was related to inaccuracy for false control statements and teleological test statements, it is possible that delusional ideation predicts teleological acceptance due, in part, to a positive relationship with the tendency to attribute human mental states to nonhumans. This possibility is explored in Study 3 by testing whether anthropomorphism, as measured by the Individual Differences in Anthropomorphism Questionnaire (IDAQ; Waytz, Cacioppo, et al., 2010), mediates the relationship between delusional ideation and teleological belief.

Related to this point, a belief that “rain falls so that plants can grow,” could arise from taking either a design stance (i.e., belief in an intending creator), or an intentional stance (i.e., anthropomorphism). Although previous research has found a positive relationship between the IDAQ and teleological acceptance (Willard et al., 2020; Willard & Norenzayan, 2013), and that Gaia beliefs positively predict teleological acceptance after controlling for belief in God (Kelemen et al., 2013), to date, the relative contributions of anthropomorphism and supernatural agent beliefs have not been addressed using validated measures of each in the same statistical model. Furthermore, no studies have addressed the question of whether the relationships between teleology and both supernatural agent beliefs and anthropomorphism, could be explained by acceptance of explanations which are objectively false. Study 3 explores the relative contributions of a design stance, as measured by the r-CRS, and intentional stance, as measured by the IDAQ, on acceptance of teleological explanations about biological and nonbiological natural entities.

Belief in the intrinsic agency of nature is more common in certain religious traditions than others (e.g., Pagan or Vedic religions may view nature as agentive). To minimize the potential confound of such explicit agentive nature beliefs, we restricted this investigation to religions that do not explicitly involve the attribution of human-mental states to natural (nonhuman) entities. As such, Study 3 includes only

nonreligious individuals and those identifying with an Abrahamic religious affiliation. Furthermore, in order to address a limitation of Study 2, the number of males and females were balanced between the religious and nonreligious groups. As highly educated individuals have been shown to be less religious and less accepting of teleological explanations about biological and nonbiological natural entities compared to less educated individuals (Kelemen et al., 2013), we also restricted our sample to those with high school or undergraduate qualifications only. It was predicted that supernatural agent beliefs and the tendency to anthropomorphize, would both independently predict acceptance of teleological explanations about biological and nonbiological natural entities.

Finally, consistent with the notion that teleological beliefs arise from intuitive processes, individuals who are better at inhibiting their intuitions tend to be less accepting of teleological explanations about biological and nonbiological natural entities (Zemla et al., 2012). However, there is also a negative relationship between the inhibition of intuitions and religiosity (Bronstein et al., 2019; Ross et al., 2016). Therefore, it is unclear whether intuitive attributions of intentionality, to an intending creator or to nature itself, remain positive predictors of teleological acceptance after controlling for the tendency to inhibit intuitions, and conversely, whether the tendency to inhibit intuitions negatively predicts teleological acceptance after controlling for attributions of intentionality. Furthermore, it is possible that the tendency to inhibit intuitions moderates the effect of attributions of intentionality on teleological acceptance, such that attributions of intentionality more strongly predict acceptance of teleological explanations about biological and nonbiological natural entities for those who are less likely to inhibit their intuitions, compared to those who are more likely to inhibit their intuitions. Study 3 explores these questions with an extended version of the CRT (Frederick, 2005; Thomson & Oppenheimer, 2016). The preregistration for this study can be found at <https://osf.io/dgr4y/>. The dataset is located at <https://osf.io/m6dgz/> and code for analysis is located at <https://osf.io/t4yhr/>.

Method

Participants

An international pool of 361 native English-speakers were recruited online through Prolific Academic. The choice in sample size was determined by an a priori power analysis which showed that to detect the unique effects of supernatural agent beliefs and delusional ideation on teleological acceptance with power of .80 and an alpha of .05, a sample size of $N = 368$ was required. Only individuals who identified as nonreligious or from an Abrahamic religion (i.e., Christian, Jewish, or Muslim) were recruited. The decision not to purposely oversample to allow for exclusion based on control statement accuracy was due to the more homogeneous sample in Study 3 compared with Study 2. The number of males and females were balanced across those identifying as religious or nonreligious. Finally, only those with a high-school or undergraduate qualification were eligible to participate. One participant was excluded for taking excessively long to complete the study ($z > 4$), 24 for failing to respond to at least 80% of control-statements correctly, 14 for indicating they had educational qualifications other than those listed in the inclusion criteria, and 12 for indicating they identified with a non-Abrahamic religion. After exclusion,

310 participants remained. Ages ranged from 18 to 71 ($M = 36.06$, $SD = 13.11$), with 157 females and 153 males.

Materials

Teleological Beliefs Scale. Participants responded “true” or “false” to the 98 statements retained from Study 2.

Supernatural Agent Beliefs. As in Study 2, participants completed the CRS (Huber & Huber, 2012). Although the entire CRS was administered, for all analyses we used a reduced version, the r-CRS (as per the preregistration), comprised of the mean score of the ideology, private practice, and experience subscales only. The internal consistency for the r-CRS was excellent ($\alpha = .965$, 95% CI [.96, .97]).

Delusional Ideation. As in Study 2, in order to assess the extent to which delusional ideation predicts belief in the teleology of nature, participants completed the PDI (Peters et al., 2004). The total PDI score was used in all relevant analyses.

Anthropomorphism. To assess the extent to which the attribution of human mental states to nonhumans predicts belief in the teleology of nature, we administered the IDAQ (Waytz, Cacioppo, et al., 2010). The IDAQ contains 15 items (e.g., “To what extent does the ocean have consciousness?”) scored from 0 (*not at all*) to 10 (*very much*). The total score is obtained by summing all items, such that scores have a possible range of 0 to 150, with higher scores representing a greater tendency to anthropomorphize. Similar to previously reported results ($\alpha = .820$; Waytz, Cacioppo, et al., 2010), the IDAQ displayed good internal consistency ($\alpha = .838$, 95% CI [.81, .86]).

Inhibition of Intuitions. To assess the extent to which the tendency to inhibit intuitions predicts belief in the teleology of nature, a modified version of the CRT was administered. We used the seven-item CRT previously used by Pennycook and Rand (2019). This includes a slightly reworded version of the original three-item CRT (Frederick, 2005) and the less math-focused four-item CRT (Thomson & Oppenheimer, 2016). Each question has an intuitively appealing, yet incorrect answer (e.g., “If you are running a race and you pass the person in second place, what place are you in?”). The total score on the CRT was calculated as the number of correct responses, such that scores had a possible range of 0 to 7, with higher scores being indicative of a greater tendency to inhibit intuitions. The CRT displayed good internal consistency ($\alpha = .756$, 95% CI [.71, .80]).

Procedure

The procedure of Study 3 was identical to that of Study 2, except for the addition of the IDAQ and CRT. Participants first completed the Teleological Beliefs Scale, followed by the IDAQ, PDI, and CRT in fixed order. Participants then selected their religious affiliation, and the questionnaire then branched to display the relevant version of the r-CRS. Finally, participants provided demographic information of age, gender, and educational attainment.

Results

Scale Performance

A summary of the minimum, maximum, and mean endorsement for each statement category, both before and after participant exclusion, is shown in Table 11. The internal consistencies of both

the nonbiological test statements ($\omega = .846$, 95% CI [.83, .87]) and biological test-statements ($\omega = .831$, 95% CI [.80, .86]) were excellent. For a detailed summary of each statement, see Section B of the OSF material.

Correlations

Responses to both categories of false control statements and both categories of test statements were reverse-coded, such that higher scores represented greater accuracy. As shown in Table 12, the relationships between accuracy for the six categories were similar to Studies 1 and 2. There was a strong, positive, and significant relationship between accuracy for the two categories of test statements. Accuracy in responding to both categories of test statements had moderate, positive, and significant relationships with accuracy in responding to false causal and false teleological statements, but were not related to accuracy in responding to true causal and true teleological statements. Accuracy in responding to both categories of teleological test statements and false causal statements was negatively related to supernatural agent beliefs, delusional ideation, and anthropomorphism, and positively related to the tendency to inhibit intuitions. Except for anthropomorphism and inhibition of intuitions which both displayed weak but significant relationships with accuracy for true causal statements, the predictors were not related to accuracy for true control statements.

Differences in Teleology Between Groups

To replicate the basic finding from the previous two studies of higher teleological acceptance in religious compared with nonreligious individuals, a 2 (religious group) \times (6: statement type) mixed ANOVA was conducted with accuracy as the dependent variable. As shown in Table 13, the main effects of group and statement type were both significant, but were qualified by a significant group by statement type interaction (see Figure 4).

To explore this interaction, the same four contrasts were performed as in Studies 1 and 2. In the first contrast, the two categories of test statements were collapsed and compared with the control statements on average. This contrast revealed that the religious group ($M = .59$, $SD = .25$) was less accurate than the nonreligious group ($M = .69$, $SD = .23$) when responding to teleological test statements on average, 95% CI_{diff} [-0.15, -0.05], and that this difference was larger than the difference in accuracy between the religious ($M = .95$, $SD = .05$) and nonreligious group ($M = .96$, $SD = .04$) in responding to control statements on average, 95% CI_{diff} [-0.02, -0.001], $F(1, 308) = 12.45$, $p < .001$, $\eta_p^2 = .039$.

Table 11

Mean Endorsement and Standard Deviations, Before and After Participant Exclusion

Statement type	Before participant exclusion			After participant exclusion		
	Min	Max	<i>M</i>	Min	Max	<i>M</i>
Nonbiological	.17 (.38)	.58 (.49)	.34 (.27)	.15 (.36)	.57 (.50)	.31 (.26)
Biological	.20 (.40)	.82 (.39)	.41 (.26)	.17 (.37)	.83 (.37)	.40 (.25)
True causal	.83 (.37)	.98 (.13)	.93 (.10)	.85 (.36)	.99 (.08)	.94 (.06)
True teleological	.96 (.19)	.99 (.09)	.97 (.08)	.98 (.15)	>.99 (.06)	.99 (.04)
False causal	.02 (.15)	.15 (.36)	.07 (.13)	.01 (.10)	.12 (.33)	.04 (.07)
False teleological	.02 (.13)	.16 (.36)	.06 (.12)	<.01 (.06)	.12 (.33)	.04 (.07)

Note. Before ($N = 361$), and after exclusion ($N = 310$). Standard deviations shown in parentheses.

In the second contrast, the two categories of test statements were collapsed and compared with the objectively false control statements. This contrast revealed that the difference in accuracy between the religious and nonreligious group on test statements was larger than the difference in accuracy between the religious ($M = .95$, $SD = .08$) and nonreligious group ($M = .97$, $SD = .05$) in responding to false control statements, 95% CI_{diff} [-0.04, -0.01], $F(1, 308) = 10.11$, $p < .001$, $\eta_p^2 = .032$.

In a third contrast, the two categories of test statements were collapsed and compared with the teleological control statements. This contrast revealed that the difference in accuracy between the religious and nonreligious group on test statements was also larger than the difference in accuracy between the religious ($M = .97$, $SD = .05$) and nonreligious groups ($M = .98$, $SD = .04$) in responding to teleological control statements, 95% CI_{diff} [-0.02, .001], $F(1, 308) = 12.26$, $p = .001$, $\eta_p^2 = .038$.

A final contrast explored the difference in accuracy between the religious and nonreligious group in responding to biological compared to nonbiological test statements. Consistent with the results from Study 2, there was no evidence of such an effect, $F(1, 308) = .16$, $p = .691$, $\eta_p^2 = .001$.

Predictors of Teleological Beliefs

Although several analyses were preregistered to compare test statement acceptance with control statement accuracy, as supernatural agent beliefs, delusional ideation, and anthropomorphism were related to accuracy for false, but not true controls, we instead report comparisons between test statements and false control statements only. This is arguably a more stringent test of the hypotheses, as collapsing across true and false controls would result in a weaker relationship with the predictors. However, it is important to note that the true control statements are required in this scale so that the correct response is not always "false." Results from the preregistered analyses are included in Section F of the OSF material, and the interpretation does not change.

Attributions of Intentionality

To assess the relative contributions of supernatural agent beliefs and delusional ideation on response accuracy, a one-way repeated-measures ANCOVA was conducted, with statement type (test, false control) as the within-subject factor, and supernatural agent beliefs (r-CRS) and delusional ideation (PDI) as covariates (both mean-centered). Main effects and interactions from this analysis are shown in Table 14 (Model 1), and parameter estimates are shown in Table 15 (Model 1).

Table 12
Correlations Between Accuracies in Responding to Statement Types and Predictors of Teleological Beliefs

Variable	1	2	3	4	5	6	7	8	9	10
1. N-BIO	1.00-									
2. BIO	.826*** [.787, .859]	1.000-								
3. TC	.045 [-.067, .155]	.060 [-.051, .171]	1.000-							
4. TT	-.028 [-.139, .083]	-.013 [-.124, .099]	.295*** [.189, .393]	1.000-						
5. FC	.527*** [.441, .603]	.483*** [.393, .564]	.071 [-.040, .181]	.060 [-.052, .170]	1.000-					
6. FT	.385*** [.286, .476]	.330*** [.227, .425]	.005 [-.107, .116]	-.020 [-.131, .092]	.415*** [.318, .503]	1.000-				
7. r-CRS	-.211*** [-.315, -.102]	-.200*** [-.305, -.091]	-.007 [-.118, .104]	-.017 [-.128, .095]	-.177** [-.283, -.067]	-.083 [-.193, .028]	1.000-			
8. PDI	-.218*** [-.321, -.109]	-.160** [-.267, -.050]	-.048 [-.158, .064]	-.038 [-.148, .074]	-.171** [-.278, -.061]	-.098 [-.208, .013]	.293*** [.188, .391]	1.000-		
9. IDAQ	-.365*** [-.457, -.264]	-.404*** [-.493, -.306]	-.114* [-.223, -.003]	-.039 [-.150, .072]	-.333*** [-.429, -.230]	-.064 [-.175, .047]	.019 [-.093, .130]	.152** [.041, .259]	1.000-	
10. CRT	.396*** [.298, .486]	.316*** [.212, .413]	.115* [.004, .224]	.073 [-.038, .183]	.311*** [.207, .408]	.187*** [.077, .292]	-.146** [-.253, -.035]	-.182** [-.287, -.072]	-.266*** [-.366, -.159]	1.000-

Note. Pearson's *r* with 95% CI [L, U]. *N* = 310 for all correlations. N-BIO = nonbiological; BIO = biological; TC = true causal; TT = true teleological; FC = false causal; FT = false teleological; r-CRS = reduced Centrality of Religiosity Scale; PDI = Peter et al.'s Delusion Inventory; IDAQ = individual differences in anthropomorphism questionnaire; CRT = cognitive reflection test. * *p* < .05. ** *p* < .01. *** *p* < .001.

There was a significant main effect of statement type, with higher accuracy for false control statements ($M = .96, SE < .01$) than test statements ($M = .65, SE = .01$), 95% CI_{diff} [.29, .34]. The effects of supernatural agent beliefs and delusional ideation were also significant, but both were qualified by significant interactions with statement type. As shown in Table 15 (Model 1), although supernatural agent beliefs and delusional ideation both negatively predicted accuracy in responding to false control statements, they were stronger predictors of poor accuracy in responding to teleological test statements. Adding gender to this model did not change the interpretation of results, and in contrast to Study 2, the main effect of gender was nonsignificant, and accuracy between genders did not differ by statement type (see Tables S18 and S19 in Section G of the OSF material).

To assess the relative contributions of supernatural agent beliefs and anthropomorphism on response accuracy, the IDAQ was added to the previous repeated-measures ANCOVA. Main effects and interactions from this analysis are shown in Table 14 (Model 2), and parameter estimates are shown in Table 15 (Model 2).

The effect of statement type remained significant, with accuracy to false control statements ($M = .96, SE < .01$) significantly higher than accuracy for teleological test statements ($M = .65, SE = .01$), 95% CI_{diff} [.29, .34]. The effects of supernatural agent beliefs and anthropomorphism were significant and both were qualified by significant interactions with statement type. Both were stronger predictors of teleological acceptance than inaccuracy for false control statements, whereas delusional ideation was not a significant predictor overall, and did not differ by statement type.

To test whether delusional ideation positively predicts acceptance of teleological explanations about biological and nonbiological natural entities due, in part, to increased attribution of human mental states to nonhumans, we conducted a mediation analysis. As shown in Figure 5, this mediation revealed a significant indirect effect of delusional ideation on teleological acceptance through anthropomorphism.

Inhibition of Intuitions

The previous results suggest that teleological beliefs about biological and nonbiological natural entities are facilitated by supernatural agent beliefs and anthropomorphism. An additional question Study 3 aimed to answer was whether the tendency to inhibit intuitions might be associated with a reduction in the expression of such teleological beliefs, and whether the tendency to inhibit intuitions moderates the effects of supernatural agent beliefs and anthropomorphism on teleological acceptance. A repeated-measures ANCOVA was conducted with statement type (teleological test, false control) as the within-subject factor, and supernatural agent beliefs (r-CRS), anthropomorphism (IDAQ), and willingness to inhibit intuitions (CRT) as numeric predictors (all mean-centered). Main effects and interactions from this analysis are shown in Table 16, and parameter estimates are shown in Table 17.

The effect of statement type was highly significant, with higher accuracy for false control statements ($M = .96, SE < .01$) than teleological test statements ($M = .64, SE = .01$), 95% CI_{diff} [.30, .34]. The effects of supernatural agent beliefs, anthropomorphism, and the tendency to inhibit intuitions were all significant, but were qualified by significant interactions with statement type. As shown in Table 17, all three were stronger predictors of accuracy for teleological test

Table 13
Significance and Effect Sizes of Group by Statement Type ANOVA for Study 3

Effect	df	F	p	η_p^2
Group 1	1	13.90	<.001	.043
Statement type 2	5	494.93	<.001	.616
Group \times Statement Type 3	5	10.07	<.001	.032
Error 1	308	—	—	—
Error 2, 3	1,540	—	—	—

Note. Due to a violation of sphericity, a Greenhouse-Geisser epsilon of .331 was applied to the effects of statement and the interaction between group and statement.

statements than for false control statements. The tendency to inhibit intuitions did not moderate the effects of religious belief or anthropomorphism, and this did not differ between statement types.

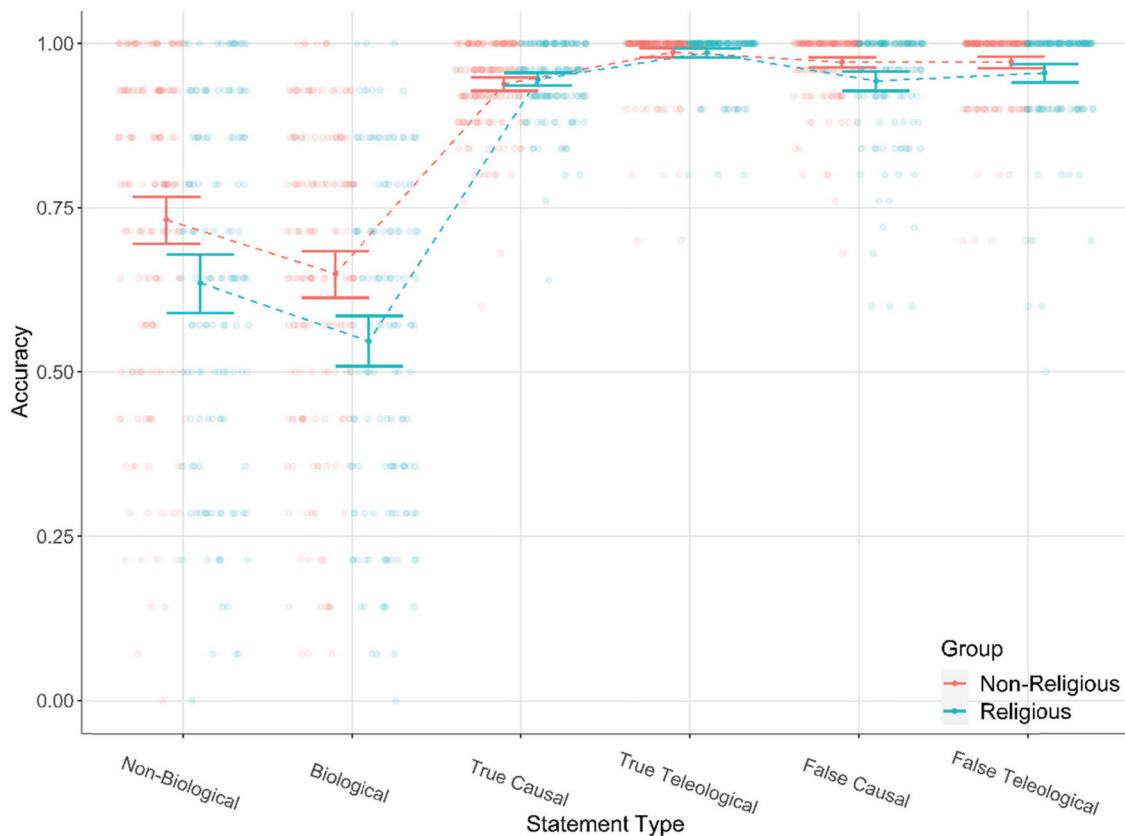
Predictors of Teleology Within Groups

The preceding results show that compared with nonreligious individuals, religious individuals are more accepting of teleological explanations of biological and nonbiological natural entities, and that rates of acceptance for such teleological explanations are positively predicted by supernatural agent beliefs and anthropomorphism, and negatively predicted by the tendency to inhibit intuitions. Although within the nonreligious group there was variation in supernatural agent beliefs ($M = 1.50, SD = .05$), anthropomorphism ($M = 40.45, SD = 20.26$), and

inhibition of intuitions ($M = 4.11, SD = 2.01$), one surprising aspect of these results may be that across all three studies, the nonreligious group accepted teleological test statements to the extent they did (see Table S20 for a summary of teleological accuracy and scores on predictor variables split by religious group across all three studies).

To explore whether supernatural agent beliefs, anthropomorphism, and inhibition of intuitions predicted teleological accuracy over and above false control statement accuracy for both groups, a 2 (religious group) \times (2: statement type) mixed ANCOVA was conducted, with supernatural agent beliefs (r-CRS), anthropomorphism (IDAQ), and inhibition of intuitions (CRT) as numeric predictors (all mean-centered). Main effects and interactions from this analysis are shown in Table 18.

Figure 4
Mean Accuracy Across Statement-Types as a Function of Religious Group



Note. Error bars represent 95% confidence intervals. See the online article for the color version of this figure.

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Table 14
Significance and Effect Sizes for ANCOVA With Statement Type, r-CRS, PDI, and IDAQ

Effect	Model 1				Model 2			
	df	F	p	η^2	df	F	p	η^2_p
Statement type	1	704.67	<.001	.697	1	807.29	<.001	.725
r-CRS	1	9.47	.002	.030	1	12.72	<.001	.040
PDI	1	7.44	.007	.024	1	3.11	.079	.010
IDAQ	—	—	—	—	1	59.17	<.001	.162
Statement Type × r-CRS	1	7.15	.008	.023	1	9.28	.003	.029
Statement Type × PDI	1	4.87	.028	.016	1	1.69	.194	.005
Statement Type × IDAQ	—	—	—	—	1	45.71	<.001	.130
Error	307	—	—	—	306	—	—	—

Note. CRS = Centrality of Religiosity Scale; PDI = Peter et al.'s, Delusions Inventory; r-CRS = reduced Centrality of Religiosity Scale; IDAQ = Individual Differences in Anthropomorphism Questionnaire. r-CRS contains only the ideology, private practice, and experience subscales of the CRS. PDI is the total score on the PDI. Statement type compares test statement with false control statement accuracy.

The main effect of statement type was highly significant, with higher accuracy for false control statements ($M = .96, SE = .01$) than teleological test statements ($M = .64, SE = .02$), 95% CI_{diff} [.29, .35]. The effects of supernatural agent beliefs, anthropomorphism, and inhibition of intuitions were all significant, but all were qualified by significant interactions with statement type. In contrast to the analysis without covariates (see Table 13), the main effect of religious group was nonsignificant, and there was no evidence of an interaction between statement type and religious group.

Importantly, there was no evidence that the effects of supernatural agent beliefs, anthropomorphism, or inhibition of intuitions differed by religious group, nor was there evidence that the difference in the effects of supernatural agent beliefs, anthropomorphism, or inhibition of intuitions between teleological test statements and false control statements, varied by religious group. Averaged across religious groups, supernatural agent beliefs, $\beta = -.171, 95\% CI_{beta} [-.27, -.07], t = -3.45, p < .001$, and anthropomorphism, $\beta = -.329, 95\% CI_{beta} [-.43, -.23], t = -6.48, p < .001$, were significant predictors of inaccuracy for teleological test-statements (i.e., increased acceptance), and inhibition of intuitions was a significant predictor of increased accuracy, $\beta = .261, 95\% CI_{beta} [.16, .36], t = 5.07, p < .001$, (i.e., decreased acceptance). Furthermore, averaged across groups, the effects in predicting teleological accuracy were significantly stronger than the effects of supernatural agent beliefs, $\beta = -.133, 95\% CI_{beta} [-.24, -.03], t = -2.52, p = .012$, anthropomorphism, $\beta = -.227, 95\% CI_{beta} [-.33, -.12], t = -4.19, p <$

.001, and inhibition of intuitions, $\beta = .236, 95\% CI_{beta} [.13, .34], t = 4.30, p < .001$, in predicting false control statement accuracy. Importantly, the combination of supernatural agent beliefs, anthropomorphism, and inhibition of intuitions, explained a similar amount of variance in teleological test statement accuracy for both groups (religious group, $F(3, 134) = 14.84, p < .001, R^2 = .25$; non-religious group, $F(3, 168) = 16.68, p < .001, R^2 = .23$).

Discussion

Study 3 replicated the results of Studies 1 and 2, with the difference in acceptance of teleological test-statements between religious and nonreligious groups being significantly greater than the difference in control statement accuracy overall, greater than the difference in accuracy between groups for teleological control statements, and greater than the difference in accuracy between groups for false control statements. The comparison with false control statements is important, as again, it suggests that teleological acceptance cannot be explained by a general tendency to accept explanations regardless of their truth. Although religious individuals were more likely than nonreligious individuals to view the natural world as purposeful, consistent with Studies 1 and 2, nonreligious individuals still accepted a considerable proportion of test items. While this may seem surprising, because there was variation in the predictors of teleology within this group, some teleological acceptance was to be expected. An exploratory analysis

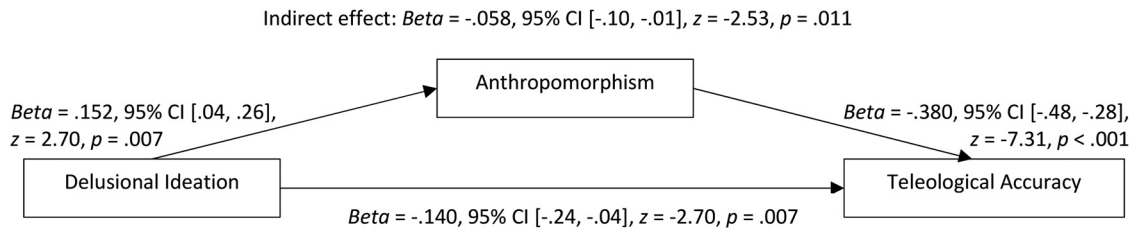
Table 15
Parameter Estimates From ANCOVA With Statement Type, r-CRS, PDI, and IDAQ

Predictor	Model 1					Model 2				
	β	SE	t	p	95% CI	β	SE	t	p	95% CI
Teleological										
r-CRS	-.172	.058	-2.98	.001	-.285, -.058	-.183	.053	-3.44	.001	-.287, -.078
PDI	-.148	.058	-2.57	.011	-.261, -.035	-.086	.054	-1.61	.109	-.192, .019
IDAQ	—	—	—	—	—	-.385	.051	-7.50	<.001	-.486, -.284
False control										
r-CRS	-.133	.058	-2.27	.024	-.247, -.018	-.140	.056	-2.50	.013	-.251, -.030
PDI	-.134	.058	-2.29	.023	-.248, -.019	-.089	.057	-1.58	.116	-.201, .022
IDAQ	—	—	—	—	—	-.276	.054	-5.09	<.001	-.383, -.169

Note. CRS = Centrality of Religiosity Scale; PDI = Peter et al.'s, Delusions Inventory; r-CRS = reduced Centrality of Religiosity Scale; IDAQ = Individual Differences in Anthropomorphism Questionnaire. r-CRS contains only the ideology, private practice, and experience subscales of the CRS. PDI is the total score on the PDI.

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Figure 5
Indirect Effect of Delusional Ideation Through Anthropomorphism



found no evidence to suggest that the effects of supernatural agent beliefs, anthropomorphism, and inhibition of intuitions in predicting teleological beliefs about biological and nonbiological natural entities, varied between religious and nonreligious groups. Indeed, this is consistent with work which conceptualizes teleological reasoning within a dual-process framework (e.g., Kelemen & Rosset, 2009; Zemla et al., 2012), and supports the idea that such beliefs represent somewhat of a default mode of explanation (Järnefelt et al., 2015; Kelemen et al., 2013).

Using a reduced measure of religiosity from the exploratory analysis in Study 2, the current study found that supernatural agent beliefs and delusional ideation were both significant predictors of teleological acceptance and inaccuracy to false controls. Consistent with Study 2, supernatural agent belief was a stronger predictor of teleological acceptance than of inaccuracy to false controls. However, in contrast to Study 2, so was delusional ideation. By balancing religious and nonreligious individuals between genders, the current study also tested whether the findings from Study 2—that females were more accepting of teleological explanations than males—could be due to the fact that on average, females tend to be more religious compared to males. The current results support this interpretation, as when gender was added to the model with supernatural agent belief and delusional ideation, supernatural agent belief, but not gender, was a significant predictor of teleological acceptance.

The current study also tested the contributions of a design stance and intentional stance on acceptance of teleological explanations about biological and nonbiological natural entities. Using only individuals identifying as nonreligious or affiliated with an

Abrahamic religious tradition, a design stance (i.e., belief in an intending creator) and an intentional stance (i.e., anthropomorphism) each independently predicted acceptance of test statements. These results are consistent with previous research showing that under time-pressure, people tend to view natural entities as “made by a being” (Järnefelt et al., 2015, 2019), as well as belief in “nature as a powerful being” positively predicting teleological acceptance (Kelemen et al., 2013). Although the relationship between anthropomorphism and teleology has been reported elsewhere (Willard et al., 2020; Willard & Norenzayan, 2013), the current study extends these findings by showing not only that this relationship remains after controlling for supernatural agent beliefs when measured by an established scale, but also, that this relationship is significantly stronger than the relationship between anthropomorphism and acceptance of statements that are objectively false. As the religious beliefs of the current sample did not directly involve anthropomorphism—evident from the weak and nonsignificant correlation between supernatural agent beliefs and anthropomorphism—this suggests that both a design stance and intentional stance may independently facilitate acceptance of teleological explanations about biological and nonbiological natural entities.

When looking at the relative contributions of a design stance and intentional stance on teleological acceptance, the effect of delusional ideation became nonsignificant. Furthermore, a mediation analysis revealed a significant indirect effect of delusional ideation on teleological acceptance through anthropomorphism, suggesting that one of the reasons why delusional ideation was a significant predictor of teleological acceptance in the model excluding anthropomorphism,

Table 16
Significance and Effect Sizes for ANCOVA With Statement Type, r-CRS, IDAQ, and CRT

Effect	<i>df</i>	<i>F</i>	<i>p</i>	η_p^2
Statement type	1	812.76	<.001	.728
r-CRS	1	12.88	<.001	.041
IDAQ	1	40.42	<.001	.117
CRT	1	29.62	<.001	.058
Statement Type × r-CRS	1	9.19	.003	.029
Statement Type × IDAQ	1	36.61	<.001	.108
Statement Type × CRT	1	18.57	<.001	.058
CRT × r-CRS	1	0.03	.862	<.001
CRT × IDAQ	1	0.11	.735	<.001
CRT × Statement × r-CRS	1	0.22	.636	.001
CRT × Statement × IDAQ	1	2.53	.113	.008
Error	304	—	—	—

Note. CRS = Centrality of Religiosity Scale; CRT = cognitive reflection test; r-CRS = reduced Centrality of Religiosity Scale; IDAQ = Individual Differences in Anthropomorphism Questionnaire. r-CRS contains only the ideology, private practice, and experience subscales of the CRS. Statement type compares test statement with false control statement accuracy.

Table 17
Parameter Estimates From ANCOVA With Statement Type, r-CRS, IDAQ, and CRT

Predictor	Teleological test statements					False control statements				
	β	SE	T	p	95% CI (β)	β	SE	t	p	95% CI (β)
r-CRS	-.171	.11	-3.44	<.001	-.269, -.073	-.132	.11	-2.50	.013	-.235, -.028
IDAQ	-.346	.09	-6.41	<.001	-.452, -.240	-.189	.10	-3.31	.001	-.302, -.077
CRT	.262	.14	5.09	<.001	.161, .364	.233	.15	4.27	<.001	.126, .341
CRT \times r-CRS	-.003	.12	-0.12	.909	-.102, .091	.060	.13	1.14	.254	-.043, .162
CRT \times IDAQ	-.022	.13	-0.92	.359	-.151, .055	.107	.14	1.91	.057	-.003, .216

Note. CRT = cognitive reflection test; r-CRS = reduced Centrality of Religiosity Scale; IDAQ = Individual Differences in Anthropomorphism Questionnaire. All continuous predictors were mean-centered for this analysis.

was that those higher in delusional ideation also tended to attribute human mental states to nonhumans. This is consistent with research showing that delusional ideation is positively related to both an intentionality bias (Moore & Pope, 2014), and the tendency to ascribe free-will, emotions, intentions, and consciousness to nonhumans (Wlodarski & Pearce, 2016).

Whereas supernatural agent beliefs and anthropomorphism may facilitate teleological acceptance, the current results suggest that the tendency to inhibit intuitions may constrain rates of acceptance for teleological explanations about biological and nonbiological natural entities. After controlling for supernatural agent beliefs and anthropomorphism, those who were better at inhibiting intuitively appealing, yet incorrect responses to simple reasoning problems, were less accepting of such teleological explanations. Although this is not the first study to investigate the relationship between teleological acceptance and the inhibition of intuitions (Zemla et al., 2012), it is the first to explore this relationship while controlling for the facilitators of teleology. This is also the first study to show that the relationship between inhibition of intuitions and teleological acceptance is significantly stronger than the relationship between inhibition of intuitions and inaccuracy in responding to false control statements. These findings support both an intention-based theory of teleology (Kelemen, 1999a), and

the idea that teleological reasoning can be conceptualized within a dual-process framework (Kelemen et al., 2013; Kelemen & Rosset, 2009; Zemla et al., 2012). According to this view, the attribution of intentionality is an intuitive response to certain stimuli (e.g., Gergely et al., 1995), and this gives rise to teleological thought (Kelemen, 1999a). Whether teleological explanations are accepted or rejected, depends not only on whether an attribution of intentionality occurs, but whether this is inhibited.

Finally, there was no evidence that the tendency to inhibit intuitions moderates the effects of supernatural agent beliefs or anthropomorphism on teleological acceptance. Although this may seem to contradict the previous claim, as supernatural agent beliefs, anthropomorphism, and teleological acceptance were all measured explicitly, it is possible that those who inhibit attributions of intentionality, whether to an intending creator or to nature itself, also inhibit teleological beliefs which are hypothesized to arise from such intuitions. However, it is also possible that those who inhibit their intuitions, genuinely find teleological explanations about biological and nonbiological natural entities unconvincing. In much the same way as a dissociation between implicit and explicit teleological acceptance has already been made (Kelemen et al., 2013; Kelemen & Rosset, 2009; Roberts et al., 2020), future research should aim to dissociate implicit and explicit measurements of the

Table 18
Significance and Effect Sizes for ANCOVA With Statement Type, Group, r-CRS, IDAQ, and CRT

Effect	df	F	p	η_p^2
Statement	1	424.47	<.001	.584
Group	1	0.02	.907	<.001
r-CRS	1	7.55	.006	.024
IDAQ	1	40.76	<.001	.119
CRT	1	28.50	<.001	.086
Statement \times Group	1	0.15	.699	<.001
Statement \times r-CRS	1	5.36	.021	.017
Statement \times IDAQ	1	32.49	<.001	.097
Statement \times CRT	1	16.40	<.001	.052
Group \times r-CRS	1	0.91	.342	.003
Group \times IDAQ	1	1.65	.199	.005
Group \times CRT	1	0.16	.686	.001
Statement \times Group \times r-CRS	1	0.26	.607	.001
Statement \times Group \times IDAQ	1	0.80	.370	.003
Statement \times Group \times CRT	1	0.46	.500	.002
Error	302	—	—	—

Note. CRT = cognitive reflection test; r-CRS = reduced Centrality of Religiosity Scale; IDAQ = Individual Differences in Anthropomorphism Questionnaire. r-CRS contains only the ideology, private practice, and experience subscales of the CRS. Statement type compares test statement with false control statement accuracy. All continuous predictors were mean-centered for this analysis.

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facilitators of teleology. If the tendency to inhibit intuitions has a moderating effect on the facilitators of teleology when they are measured implicitly, such that the relationship between implicit attributions of intentionality and explicit teleological acceptance was stronger for those who are worse at inhibiting their intuitions compared with those who are better, this would provide strong support for the first possibility outlined above.

General Discussion

Measuring Teleological Beliefs About Biological and Nonbiological Natural Entities

Across three large online studies, we have provided evidence for the reliability, validity, and potential utility of a modified version of Kelemen et al. (2013) scale to measure teleological beliefs about biological and nonbiological natural entities. Starting in Study 1 with an initial item pool containing statements created by Kelemen et al. (2013) as well as statements created for the current study, through a process of sequential reliability analyses and backward elimination, we retained two sets of teleological test statements (biological, and nonbiological) which loaded strongly onto single factors, and which were shown to be internally consistent across all studies. Furthermore, by examining the endorsement rates of control statements, we also retained four sets of control statements (true teleological, true causal, false teleological, and false causal) for which there was high agreement with regard to truth.

Support for an Intention-Based Theory of Teleology

Across all three studies, we found evidence that religious individuals were, on average, more accepting than nonreligious individuals of teleological explanations about biological and nonbiological natural entities. Of particular interest was the possibility that the relationship between religiosity and teleological acceptance might be due to a relationship between religiosity and acceptance of explanations which were objectively false. There are two reasons to believe this is not the case. First, in all three studies we found that the difference in teleological acceptance between the religious and nonreligious group, was significantly greater than the difference in false control statement accuracy between groups. Second, using a reduced version of the CRS focusing only on belief in supernatural agents, in Studies 2 and 3 we found that the relationship between supernatural agent beliefs and teleological acceptance, was stronger than the relationship between supernatural agent beliefs and inaccuracy in responding to false control statements. Both these findings show that greater teleological acceptance among religious compared with nonreligious individuals, is not due to a tendency to agree with explanations regardless of their truth. As false control statements were objectively false, yet contained terms which were related (e.g., “gray hair” and “older”), this suggests that rates of teleological acceptance cannot be explained by a tendency to recognize the relationship between the two terms, but to ignore the semantics of the conjunction (e.g., “so that”). However, consistent with findings of a relationship between aspects of religiosity and belief in fake news (Bronstein et al., 2019), in Study 3, belief in supernatural agents was also a significant predictor of inaccuracy in responding to false control statements. While the relationship between religious belief and teleological acceptance is well documented (e.g., Kelemen & Rosset, 2009; Kelemen et al., 2013), this is the first set of studies to test an alternative account; that

this relationship may be due to religious individuals being more accepting of explanations which are objectively false.

Just as belief in supernatural agents predicted acceptance of teleological explanations about biological and nonbiological natural entities, so too did anthropomorphism. The possibility that the natural world is viewed as either an artifact designed by an intending creator, or an agent with intentions of its own, has been explored elsewhere (Kelemen et al., 2013). However, this is the first study to approach this question using validated measures of both religious belief (e.g., Willard et al., 2020; Willard & Norenzayan, 2013) and anthropomorphism (e.g., Kelemen et al., 2013). In doing so, we have provided evidence that anthropomorphism positively predicts teleological acceptance after controlling for belief in supernatural agents, and that this relationship is significantly stronger than the relationship between anthropomorphism and acceptance of explanations that are objectively false.

While the results of Study 3 align with those of Kelemen et al. (2013), in suggesting that acceptance of teleological explanations about biological and nonbiological natural entities may be more strongly related to an intentional stance than to a design stance, this is not to say that anthropomorphic and supernatural agent beliefs are perfect correlates of an intentional stance and a design stance, respectively. Focusing only on the subscales of the CRS in Studies 2 and 3—which necessarily measured religious *beliefs*—goes some way to addressing the relationship between supernatural agent beliefs and a design stance, yet it is possible that for some religious individuals, supernatural agent beliefs may be orthogonal to whether they believe that supernatural agent to be a designer. Moreover, there are aspects of a design stance that almost certainly do not involve supernatural agent beliefs (e.g., seeing design in human-made artifacts). Similarly, although taking an intentional stance includes the attribution of beliefs and desires to a real or imagined agent, it also includes an assumption of rational action in accordance with those beliefs and desires (Dennett, 1987). While measures of anthropomorphism may relate to the former, there is no guarantee they relate to the latter.

Support for Intention-Based Teleology Within a Dual-Process Framework

Whereas religious belief and anthropomorphism appear to facilitate teleological beliefs about nature, the tendency to inhibit intuitions seems to constrain the expression of such beliefs. These results are consistent with the majority of literature which conceptualizes the expression of teleological beliefs about biological and nonbiological natural entities within a dual-process theory framework (e.g., Jämfelt et al., 2015; Kelemen et al., 2013; Kelemen & Rosset, 2009; Roberts et al., 2020; Zemla et al., 2012). All dual-process models argue there are two qualitatively different types of cognitive processes (Trippas et al., 2016). The defining features of so-called *Type I* processes are that they are automatic, and typically fast responses to stimuli, whereas *Type II* processes require effort, and are typically slower (Evans & Stanovich, 2013). Both the logical intuition (De Neys, 2012) and three-stage dual-process models (Pennycook et al., 2015), hold that multiple type I responses can co-occur⁶. According to the three-stage dual

⁶ Although a thorough discussion of the various dual-process theories is beyond the scope of the current article, interested readers should see De Neys (2014).

process model, the tendency to inhibit intuitively appealing, yet incorrect responses to simple reasoning problems, as measured by the CRT, could relate to individual differences in the ability to detect conflict between competing Type I responses, as well as to the ability to “decouple” and override one intuitive response in favor of another once conflict has been detected (Pennycook et al., 2015). Hence, according to this model, the current results suggest that individuals who are less accepting of teleological explanations about biological and nonbiological natural entities, could either be better at detecting conflict with competing automatic responses, or better at decoupling from an intentional stance once the conflict has been detected.

The notion that an intention-based theory of teleology can be situated within a dual-process framework is consistent with previous findings that adults display high levels of teleological acceptance when semantic knowledge is impaired as a result of Alzheimer’s disease (Lombrozo et al., 2007), in the absence of formal education (Casler & Kelemen, 2008; Sánchez Tapia et al., 2016), or when under time pressure to respond (Kelemen et al., 2013; Kelemen & Rosset, 2009; Mills & Frowley, 2014; Roberts et al., 2020). Although the negative relationship between the inhibition of intuitions and teleological beliefs about biological and nonbiological natural entities has been reported elsewhere (Zemla et al., 2012), the current study extends these findings in two ways: First, by showing that this relationship is not just due to rates of acceptance for explanations which are objectively false, and second, by showing that the relationship remains after controlling for the facilitators of teleology.

It is an open question whether the tendency to inhibit intuitions truly constrains the formation of teleological beliefs about biological and nonbiological natural entities, or whether individuals who are better at inhibiting their intuitions are merely less likely to express their teleological tendencies. However, if teleological beliefs are facilitated by intuitive attributions of intentionality (Kelemen, 1999a), then in line with the three-stage dual process model (Pennycook et al., 2015), we might expect that those who are better at inhibiting their intuitions are simply better at detecting conflict with, or decoupling from an intentional stance. Hence, the dual-process perspective leads to the prediction that despite the explicit rejection of teleological beliefs about biological and nonbiological natural entities by some, due to the intuitive cognitive processes through which such beliefs are formed, there may be a dissociation between what is explicitly expressed and what is implicitly believed (Kelemen et al., 2013; Kelemen & Rosset, 2009; Roberts et al., 2020).

Future Directions

To further explore this issue, a focus of future research should be in dissociating implicitly held, from explicitly expressed beliefs. Several studies have already approached this topic with the use of speeded decision-making tasks (e.g., Kelemen et al., 2013; Roberts et al., 2020). However, an issue with this approach is that it ultimately leads to different rates of attrition between groups, as participants in the speeded condition have an exclusion criterion of failing to respond to enough statements within the time limit. An alternative to speeded decision-making may be to present participants with the Teleological Beliefs Scale and ask them to respond randomly (Polito et al., 2018; Sparrow & Wegner, 2006; Wegner et al., 2003; Zuckerman et al., 2014). If deviation from randomness on the teleological test items was found to be

contingent on supernatural agent beliefs, anthropomorphism, and the tendency to inhibit intuitions, this could arguably be a better approach than speeded decision-making, as it would mitigate the issue of different rates of attrition between groups.

In addition to focusing on the divergence of implicitly held and explicitly expressed teleological beliefs, future research should seek to replicate the current findings using different measures of anthropomorphism. A potential limitation of Study 3 was with the measure of anthropomorphism used. All items in the IDAQ are high in face validity (e.g., “To what extent do cows have intentions?”), meaning although believing that “cows have intentions” is undoubtedly anthropomorphic, it may be too obvious in its aims. Furthermore, the IDAQ has been criticized for requiring reflection on abstract, and often philosophical concepts (e.g., “consciousness”; Neave et al., 2015). For an individual to score high on the IDAQ, they would have to be both willing and able to reflect on such abstract concepts, as well comfortable with expressing such explicitly anthropomorphic views. An alternative would be to use the Anthropomorphism Questionnaire (AQ; Neave et al., 2015). Rather than requiring deliberate reflection on abstract philosophical concepts, the AQ focuses on childhood (e.g., “As a child, I felt at times that some of my toys were in a bad mood”) and adult experiences (e.g., “I sometimes wonder whether my computer deliberately runs more slowly after I have shouted at it”). Although the scores on the IDAQ and AQ are strongly and positively correlated (Neave et al., 2015), replicating the basic findings from Study 3 using this alternative measure of anthropomorphism would increase confidence in these results.

Finally, as the results of Study 2 highlight, in comparing nonreligious, Abrahamic, and non-Abrahamic affiliations, the relationship between religious belief and acceptance of teleological explanations about biological and nonbiological natural entities is complex. With most research having focused on this relationship in Western cultures (e.g., Kelemen et al., 2013; Kelemen & Rosset, 2009; Mills & Frowley, 2014; Roberts et al., 2020), future research should seek to better understand the ways in which various non-Western religious traditions perceive purpose in the natural world. In approaching this topic, the relational-deictic perspective (Ojalehto et al., 2013) provides a useful framework which may be compatible with Kelemen’s (1999a) intention-based account. In exploring rates of teleological acceptance across Western and non-Western religious traditions and across cultures, future research should also seek to measure individual differences in deictic and holistic cognition (e.g., Choi et al., 2007), as this would help to clarify the potential compatibility between the relational-deictic and intention-based accounts. Because variation in scores on the Teleological Beliefs Scale is clearly dependent on English-language ability (e.g., the ability to correctly interpret the meaning of “in order to”), cross-cultural studies would require translation of this scale. However, by providing evidence for the reliability, validity, and utility of this scale across three large online studies, future studies can address the question of cross-cultural variation in teleological beliefs about biological and nonbiological natural entities from a common starting point.

Conclusion

Our findings are consistent both with the underlying theory of intention-based teleology (Kelemen, 1999a), and previous findings

of teleological beliefs about biological and nonbiological natural entities being predicted by an agentive view of nature (Kelemen et al., 2013). The current findings contribute to the existing literature in three ways. First, we have provided evidence that increased teleological acceptance in highly religious or anthropomorphic individuals cannot be explained by increased acceptance of statements which are objectively false. Second, by showing that the tendency to inhibit intuitions relates more strongly to rates of teleological acceptance than to agreement with statements which are objectively false, and that this remains the case after controlling for the facilitators of teleology, our findings have contributed to the existing literature which conceptualizes an intention-based theory of teleology within a broader dual-process theory framework. This dual-process account leads to testable predictions which highlight the need for future research to focus on ways to dissociate explicitly expressed beliefs from implicitly held beliefs. Third, by providing evidence for the reliability, validity, and potential utility of a modified version of Kelemen et al. (2013) Teleological Beliefs Scale, the current studies provide a strong foundation from which future research can address these important questions.

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Appendix
Final Version of the Teleological Beliefs Scale

Category	Statement
Biological test	<p>Moss forms around rocks in order to stop soil erosion. Mites live on skin in order to eliminate dead skin cells. Trees grow on riverbanks to prevent soil erosion. Grass grows so that herbivores can graze on it. Cacti grow in the desert in order to provide water for animals. Plants consume CO₂ in order to reduce greenhouse gases. Earthworms tunnel underground in order to aerate the soil. Birds transfer seeds in order to help plants germinate. Ferns grow at ground level in order to conserve humidity. Trees produce oxygen so that animals can breathe. Microbes convert nitrogen in order to enrich the soil. Bees frequent flowers in order to aid pollination. Parasites multiply in order to infect a host.</p>
Nonbiological test	<p>Bacteria live in your gut in order to help with digestion. Mountains fold inwards in order to maintain mass. Sand dunes form in order to stop waves eroding vegetation. Glaciers compact snow in order to conserve volume. Rocks roll downhill in order to come to rest at the bottom. Oceans dissolve rocks in order to retain ocean minerals. Days grow longer in summer so that plants receive more sunlight. The sun radiates heat because warmth nurtures life. The Earth has a moon in order to control the tides. Rain falls in order to allow plants to grow. The Earth rotates around the sun so that it can receive light. Pressure builds in volcanoes so that they can erupt. The sun makes light so that plants can photosynthesize. Rivers flow downstream in order to get to the ocean. Particles collide in order to produce chemical reactions. Post-it notes are sticky because they are yellow.</p>
False causal control	<p>Cars use petrol because they have four wheels. Pebbles have rounded edges because they are little. Chocolate is brown because it contains a significant amount of sugar. Toads make croaking noises because they catch flies with their tongues. Polar bears are white because they swim in icy ocean water. Raspberries are bright red because they grow on bushes. Coyotes howl because they live in the hot desert. Rivers have rapids because a lot of fish swim in them. Billboards are brightly colored because they are large. Skunks are nocturnal because they produce bad odors. Cows make mooing noises because they graze on grass. Cleaning fluids are corrosive because they have pungent odors. Pruning shears have sharp blades because they have handles. Snowflakes are white because they are symmetrical. American prairies are flat because they are covered with grass. The sun is hot because it is in space. Paper towels are absorbent because they are thin. Oceans have waves because they contain a lot of saltwater. Soup is hot because it is primarily a liquid. Chipmunks hibernate in the winter because they eat nuts. Male lions have large manes because they are carnivores. Snakes make hissing noises because they move by slithering on the ground. Saturn is a planet because it has rings surrounding it. Keys open locked doors because they are made of metal.</p>

(Appendix continues)

Appendix (Continued)

Category	Statement
True causal control	<p>Objects fall downwards because they are affected by gravity. Water turns to steam because the temperature rises above boiling point. Suction cups stick because they create a pressure vacuum. Soda fizzes because carbon dioxide gas is released. Water turns to ice because the temperature drops below freezing. Icicles melt because the temperature increases. Lollipops are sweet because sugar is a main ingredient. Fireworks explode because gunpowder ignites when a fuse is lit. Candles melt because the wax becomes very hot. A lightbulb shines because electricity passes through its filaments. Conception occurs because sperm and egg cells fuse together. Butcher knives slice through meat because they have sharp edges. Cigarettes produce smoke because tobacco burns. Butter is greasy because it contains a great deal of fat. People put on weight because they eat too much food. Redwood trees stay firmly planted because they have strong roots. Teeth decay because the enamels are dissolved. Magnets stick together because their poles attract. Mushrooms grow in the forest because the soil has the right nutrients. Otters are water resistant because their fur has natural oils. Canyons are formed because erosion occurs. Boiling water kills germs because it is hot. Balloons pop because their skin gets perforated. People earn money because they go to work. Tadpoles become frogs because they undergo metamorphosis.</p>
False teleological control	<p>Mice run away from cats in order to get exercise. People smoke cigarettes in order to get lung cancer. Houses have doorbells in order to make dogs bark. Mobile phones have screens in order to waste electricity. Noses exist in order to support glasses. Musicians have two hands in order to play instruments. People put coins into meters in order to get rid of spare change. People buy food in order to spend money. Hair becomes gray so that people can look older. Lamps shine brightly so that they can produce heat.</p>
True teleological control	<p>Doctors prescribe antibiotics in order to treat infections. People buy microwaves in order to heat their food. Traffic lights change color in order to control traffic. People drink water in order to stay hydrated. Children wear mittens in the winter in order to keep their hands warm. Women put on perfume in order to smell pleasant. Schools exist in order to help people learn new things. Bicycles have handlebars so that people can steer them. Alarm clocks beep in order to wake people up. People wear contact lenses in order to see more clearly.</p>

Note. The presentation of items should be randomized, with one item presented on the screen at a time. All items are rated as either true (1) or false (0). Responses to biological test, nonbiological test, false causal, and false teleological statements are reverse-coded, such that higher scores represent more accurate responding (i.e., responses of “false”). To compute an accuracy score for each category, take the mean of all items in the category.

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