



Full Length Article

Teleology and the intentions of supernatural agents^{☆,☆☆}Andrew J. Roberts^{a,*}, Colin A. Wastell^a, Vince Polito^b^a Department of Psychology, Macquarie University, Australia^b Department of Cognitive Science, Macquarie University, Australia

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ABSTRACT

Teleological beliefs about the natural world often exist implicitly, and there is a positive relationship between teleological endorsement and belief in supernatural agents. In the current study, participants judged a series of scientifically unwarranted teleological explanations of biological organisms and natural non-living objects, under speeded or un-speeded instructions. After controlling for belief in the *existence* of supernatural agents, rates of implicit (speeded) and explicit (un-speeded) teleological endorsement were moderated by the belief that supernatural agents *intentionally interact* with the world. Amongst non-religious individuals, rates of implicit endorsement were significantly higher than explicit endorsement, whereas for highly religious individuals the difference was non-significant. This interaction was driven predominantly by explanations of natural non-living objects. These results are consistent with an intention-based theory of teleology, and help to reconcile the finding of a positive relationship between teleological endorsement and belief in supernatural agents, with the those of an enduring teleological bias.

1. Introduction

To say that “the chair is for sitting on” seems to be stating the obvious, yet it could be argued that there is nothing objectively true about this statement; it is true only insofar as an agent, whether the designer or user of the chair, intends the chair to serve this function (Kelemen, 1999b; see also Bloom, 1996). This form of explanation, where something is explained with reference to its function, purpose, or goal, is known as teleology (Hempel & Oppenheim, 1948; Kelemen, 1999a; Lombrozo & Carey, 2006). What is interesting about teleology is not its use in explaining the existence of human-made artefacts such as chairs, but rather its use in explaining the natural world.

Broadly speaking, two psychological theories have been proposed as to the origins of teleological thought. These theories differ not only with respect to the origin of teleological thought, but in the domains to which teleological explanations apply. The first theory, known as *Promiscuous Teleology* (PT), holds that teleology develops as a consequence of taking an intentional stance (Kelemen, 1999a); that is, the attribution of beliefs and desires to an agent, and the assumption that the agent will act rationally and in accordance with those beliefs and desires (Dennett, 1987). This strategy of thinking in intentional terms to explain the behaviour of agents is thought to be over-extended, due to an inherent need to make sense of the world, to explain things other than the behaviour of agents (Kelemen, 1999c, 1999a). The theory of intention-based teleology is “promiscuous” in the sense that it predicts that children, and to some extent, adults, will endorse functional explanations not just for human-made artefacts and properties of

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biological organisms, but also for whole biological organisms and natural non-living objects.

Under this account, just as functional explanations of artefacts are true only if the stated function accurately reflects an agent's intentions, the statement "clouds rain so that plants can grow" could be considered true, only if allowing plants to grow is the intended function of a cloud raining. When applied to other domains, such a strong form of teleology is of course restrictive, as it does not allow for evolutionary teleological explanations involving biological traits. For example, it would not be possible to say that chameleons have camouflage in order to hide from predators. Evolutionary teleological explanations of this kind are not only common, but considered legitimate (Dennett, 2017). The legitimacy of such explanations is due to the consequence aetiology upon which they are based (Wright, 1976). That is, due to the increased reproductive fitness which resulted from it, the function of "hiding from predators" is the very reason why camouflage increased in prevalence in the population of chameleon ancestors. Evidence shows that agreement with teleological explanations is indeed partly dependent upon the function having played a causal role in the existence of the thing being explained (Lombrozo & Carey, 2006). While evolutionary teleological explanations can be legitimate, the legitimacy of a given argument should be considered contingent upon acknowledgement of this consequence aetiology. Natural selection is often misunderstood as an intentional and goal-directed process, driven towards optimisation of the organism to suit its environment (Brumby, 1984). If natural selection was capable of intentionally optimising an organism to suit its environment, then in much the same way as teleological explanations of human-made artefacts are legitimate, evolutionary teleological explanations grounded in such beliefs would be legitimate. However, as natural selection is neither an intentional nor goal-directed process, when evolutionary teleological explanations are grounded in such misbeliefs, they should be considered illegitimate.

The second theory of teleological reasoning, known as *Selective Teleology* (ST), arose from efforts to explain children's seemingly intuitive understanding of biology, including notions such as inheritability and growth. According to Keil (1992, 1995), from a young age, children are equipped with a knowledge-acquisition device in the form of a "teleological-design stance" (for a related view, see Atran, 1995). Keil posits that teleological explanations are elicited only by human-made artefacts and properties of biological organisms; both of which appear to have some functional utility. In support of this theory, young children have been reported to prefer teleological explanations for why plants are green, but mechanistic explanations for why emeralds are green (Keil, 1992), as well as asking significantly more questions about the functions of artefacts than of whole biological organisms (Greif, Kemler Nelson, Keil, & Gutierrez, 2006). Furthermore, in the case of natural non-living objects, although children are able to learn teleological explanations and generalise them to novel items, they are able to do this equally as well with mechanistic explanations (Lombrozo, Bonawitz, & Scalise, 2018). Hence, in this view, teleology is said to be selective in the sense that for both adults and children, teleological explanations should only be elicited by human-made artefacts and the properties of biological organisms.

More recently, Liquin and Lombrozo (2018) have argued that an important factor in determining the appropriateness of a teleological explanation is its structure-function fit. For example, Liquin and Lombrozo (2018) argue that a reason why "animals grow fur because they need to smell things" is less compelling than "trees produce oxygen so that animals can breathe", is that in the former, growing fur does not fit well with the function of smelling things, whereas in the latter, producing oxygen does fit well with the function of animals breathing. In support of this theory, the authors provide compelling evidence of a positive relationship between agreement with scientifically unwarranted teleological explanations of the natural world, and the degree to which a given argument was judged to have good structure-function fit.

Liquin and Lombrozo's (2018) theory differs from those of Keil (1995) and Kelemen (1999a), in the sense that teleology is not tied to a particular explanatory domain. However, the idea of structure-function fit is compatible with Kelemen's (1999a) intention-based theory. Taking an intentional stance involves not only the attribution of beliefs and desires, but the assumption of rational action in accordance with those beliefs and desires (Dennett, 1987). In the case of misunderstanding natural selection, the assumption of rationality in accordance with the "goal" of optimisation of the organism for its environment, could indeed result high structure-function fit. For example, if natural selection was misunderstood as having the goal of allowing birds to fly, then a rational course of action would be to favour structures, such as wings, which fulfil the function of flying. If this were the case, then judgments of high structure-function fit may indicate the application of an intentional stance which gives rise to teleological thought. In this way, Liquin and Lombrozo's (2018) theory could be seen as complementary to Kelemen's (1999a), in that teleology may be intention-based, but the most compelling teleological explanations are ones in which the rationality assumption of the intentional stance is met.

1.1. Co-existence

In support of PT, research has shown an early developing sensitivity to intentions, which appears to persist as an intentionality heuristic in adulthood. After witnessing an adult perform three failed attempts at achieving a goal (e.g., trying to push a button with a stick, but missing the button), 18-month-old infants re-enact the intended act but not the failed attempts, despite never having witnessed the intended act (Meltzoff, 1995). In a similar paradigm, 15-month-old infants imitated the intended outcome of the actions of an animated stuffed toy, even when that stuffed toy's actions ultimately failed to achieve its intended goal (Johnson, Booth, & O'Hearn, 2001). Similarly, when the perceived "goals" of animated shapes on a computer screen appear inconsistent with the shapes' movements, infants fixate on the shapes longer than when the goals appear consistent with the shapes' movements (Csibra, Gergely, Bíró, Koós, & Brockbank, 1999; Gergely, Nádasdy, Csibra, & Bíró, 1995). Adults, too, appear overly sensitive to perceived intentions. Heider and Simmel (1944) were the first to show that adults describe the movements of simple shapes on a screen in terms of the shapes' intentions. More recently, Rosset (2007, 2008) found that it takes effort to overcome initial judgments of intentionality, and to judge even typically accidental situations as being unintended.

Patterns of scientifically unwarranted teleological endorsement are also consistent with the predictions of PT, in suggesting that implicit and explicit teleological beliefs may co-exist, even when one seems to be a rejection of the other. Rates of endorsement for

teleological explanations involving whole biological organisms and natural non-living objects are higher in primary school-aged children compared to university undergraduates (Kelemen, 1999d, 1999c, 2003; Kelemen & DiYanni, 2005). However, although the degree of scientifically unwarranted teleological endorsement decreases with age, this tendency nonetheless endures at least implicitly throughout adulthood (Kelemen & Rosset, 2009). When responding at speed, university undergraduates and research-active academics show increased rates of scientifically unwarranted teleological endorsement relative to un-speeded responding (Kelemen, Rottman, & Seston, 2013). Furthermore, in the absence of formal education, neurologically healthy adults endorse unwarranted teleological explanations at rates similar to primary school-aged children (Casler & Kelemen, 2008), although age and culture have been shown to have independent effects on teleological beliefs (Sánchez Tapia et al., 2016). Finally, when semantic knowledge is impaired as a result of neurological degeneration, rates of unwarranted teleological endorsement are significantly higher than in age-matched neurologically healthy controls (Lombrozo, Kelemen, & Zaitchik, 2007). These results provide strong converging evidence that although teleological tendencies can be inhibited through education, they are unlikely to be fully extinguished. Thus, consistent with the predictions of PT, while a person may explicitly reject scientifically unwarranted teleological beliefs, implicitly, that same person may still find them compelling.

1.2. Teleology and religious belief

Given that according to PT, teleological reasoning develops from an early understanding of intentionality which is then over-extended (Kelemen, 1999a), the notion of agency is central to teleology. This is because the only things capable of having intentions are things with minds, and the only things with minds are agents. In this view, just as “chairs are for sitting on” is true only if an agent intends the chair to serve this function, the statement “clouds rain so that plants can grow” is based in the misbelief that plants growing is the intended function of the cloud raining. The difference between these two teleological explanations is that whereas the former implies the intentions of a natural agent (a human), the latter seems to imply the intentions of a *supernatural* agent.

Prior research suggests a positive relationship between religiosity and teleological endorsement. In children, both the generation of open-ended, and endorsement of closed-ended teleological explanations of natural phenomena, share a significant positive relationship with belief in intelligent design (Kelemen & DiYanni, 2005). In adults, a positive relationship exists between belief in supernatural agents and endorsement of teleological explanations of life events, with even ardent atheists endorsing such notions significantly above floor-level (Banerjee & Bloom, 2014; Heywood & Bering, 2014). Furthermore, compared to un-speeded responding, when responding at speed, adults have a tendency to default to viewing biological and non-biological natural phenomena as purposely made by a being, regardless of religiosity (Järnefelt, Canfield, & Kelemen, 2015; Järnefelt, Zhu, Canfield, Chen, & Kelemen, 2018). However, belief in the intrinsic agency of nature positively predicts endorsement of such notions after controlling for belief in God (Järnefelt et al., 2015). Likewise, Kelemen et al. (2013) found that after controlling for the speed of response and belief in God, the belief that “Nature is a powerful being”, was a significant and positive predictor of scientifically unwarranted teleological endorsement of the natural world.

A reasonable question to ask in response to these results, is what exactly does “belief” in supernatural agents entail? One of the strongest predictors of whether a person explicitly expresses belief in the existence of a specific supernatural agent, is the extent to which they were exposed as children to credibility enhancing displays (CREDS) of religious commitment by their caregivers (Lanman, 2012; Lanman & Buhrmester, 2016; Maij et al., 2017). However, if teleology stems from an understanding of intentionality which is then over-extended to explain non-agents (Kelemen, 1999a), the aspect of belief which logically should predict teleological endorsement, is the belief that supernatural agents intentionally act in accordance with their desires. This perception of supernatural intentionality should not only predict rates of scientifically unwarranted teleological endorsement over and above a belief in the general *existence* of supernatural agents, but should remain significant after controlling for exposure to CREDS.

Results from Kelemen et al. (2013) actually support the argument that perceived supernatural intentionality is an important predictor of teleological endorsement, as a belief that “Nature is a powerful being” was found to be a stronger predictor of scientifically unwarranted teleological endorsement than belief in God. Although a belief in the former implies that agency is intrinsic to the natural world, it also implies that Nature is a being capable of causing change (i.e., a powerful being). A belief in God, on the other hand, likely implies that agency is extrinsic to the natural world, but makes no implications regarding the capabilities of God to cause change (i.e., God may exist, but doesn’t necessarily *do* anything). Therefore, it is possible that rather than belief in the *existence* of Nature as a powerful being, it is the perception of supernatural intentionality which predicts endorsement of scientifically unwarranted teleological explanations of nature.

It is also unclear how the difference in implicitly and explicitly held teleological beliefs (e.g., Kelemen & Rosset, 2009) can be reconciled with findings of a positive relationship between belief in supernatural agents and unwarranted teleological endorsement (Heywood & Bering, 2014; Kelemen et al., 2013). On the one hand, research supporting the co-existence perspective suggests an implicit teleological bias, even in individuals with very low rates of explicit endorsement (Kelemen et al., 2013). On the other hand, a positive relationship has been established between religiosity and scientifically unwarranted teleological beliefs when measured explicitly. However, if teleology is intention-based, then it is possible that the difference between rates of implicit and explicit teleological endorsement, would depend on the individuals’ expressed beliefs about supernatural intentionality.

1.3. The current study

To explore these possibilities, the current study employs a decision-making task adapted from Kelemen et al. (2013), in which participants judge a series of scientifically unwarranted teleological explanations about biological organisms and natural non-living

objects, under either speeded or un-speeded instructions. As speeded responding limits access to the cognitive resources needed to inhibit an intuitive response (Kelemen & Rosset, 2009; Kelemen et al., 2013), we consider this to be an implicit measure of such beliefs.

If teleology develops from an over-extension of taking an intentional stance (Kelemen, 1999a), then in line with previous findings (Kelemen & Rosset, 2009; Kelemen et al., 2013), higher rates of teleological endorsement are predicted during speeded compared to un-speeded responding, reflecting the co-existence of implicitly held teleological beliefs with potentially conflicting explicitly expressed views. Furthermore, given that teleological explanations of the natural world are often quasi-religious (Kelemen, 2004), inhibition of scientifically unwarranted teleological beliefs should vary according to the perception of supernatural intentionality. According to an intention-based account of teleology, scientifically unwarranted teleological explanations should be incongruent with the explicitly stated beliefs of individuals who reject notions of supernatural intentionality. Even though these individuals might still show evidence of a teleological bias when responding at speed, when given time to consider their responses, they would be expected to disagree with scientifically unwarranted teleological explanations. Conversely, scientifically unwarranted teleological explanations should be congruent with the explicitly stated beliefs of individuals who accept notions of supernatural intentionality. For this reason, when given time to consider their responses, they would be expected to have less reason to inhibit their teleological bias, and to therefore agree with these scientifically unwarranted explanations. Therefore, it is predicted that after controlling for belief in the existence of supernatural agents and exposure to CREs, perceived supernatural intentionality should interact with the speed of responding. Specifically, the difference between implicit and explicit teleological endorsement should be larger for individuals who reject notions of supernatural intentionality, compared to those who accept notions of supernatural intentionality.

Just as “belief” is a broad concept, so too is “nature”. Whether teleology is based on an understanding that certain entities can result from a function-driven causal process (Lombrozo & Carey, 2006), or on an over-extension of thinking in terms of intentions (Kelemen, 1999a), rates of endorsement should differ depending on whether the explanations refer to biological organisms or natural non-living objects. In both views, endorsement should be higher for explanations referring to biological organisms than for those referring to natural non-living objects. According to Lombrozo and Carey (2006), this would be because biological organisms could be understood as resulting from a function-driven causal process (i.e., natural selection), whereas natural non-living objects could not. According to an intention-based view, this would be because it would be more reasonable to attribute intentions to biological organisms than to natural non-living objects. For example, in the statement “earthworms tunnel underground in order to aerate the soil”, it would be reasonable (but wrong) to attribute the intention of ‘aerating the soil’ to earthworms, as it is conceivable that earthworms might act intelligently and purposefully. However, in the statement “clouds rain so that plants can grow”, it is less reasonable to attribute the intention of ‘allowing plants to grow’ to clouds, as it is less conceivable that clouds could act intelligently or purposefully.

If it is less reasonable to attribute intentions to natural non-living objects compared to biological organisms, it follows that perceived supernatural intentionality should relate more strongly to teleological endorsement for the former than the latter, as supernatural agents may provide a source of intentions which is otherwise lacking in natural non-living objects. Therefore, it is predicted that the relationship between implicit and explicit teleological endorsement and perceived supernatural intentionality, should depend on whether the teleological explanation refers to a biological organism or natural non-living object. Specifically, the moderating effect of perceived supernatural intentionality on the difference between implicit and explicit teleological endorsement, should be stronger for natural non-living test items than for biological test items. Although evidence in support of this hypothesis would not differentiate an intention-based view from a function-driven causal process view for explanations referring to biological organisms, it would provide support for an intention-based view of teleology for natural non-living objects.

The current study also addresses three exploratory hypotheses. Firstly, although speeded responding may work to uncover a teleological bias by limiting access to the cognitive resources needed to inhibit an intuitive response, another explanation is possible. According to compensatory control theory, a perceived lack of personal control can result in a temporarily heightened need for structure and intolerance to ambiguity in one’s environment (Ma & Kay, 2017), which then motivates a search for alternative external sources of control (Landau, Kay, & Whitson, 2015). One manifestation of this threat to personal control is a temporary increase in self-reported belief in God (Kay, Moscovitch, & Laurin, 2010). As participants cannot control the rate at which statements are presented in a speeded decision-making task (e.g., Kelemen & Rosset, 2009; Kelemen et al., 2013), it is possible that speeded responding threatens the perception of personal control. As teleological explanations of nature may imply the intentions of an agent (Kelemen et al., 2013), increased endorsement of these explanations during speeded responding, could be due to teleological explanations functioning as an alternative external source of control. Although this is not an alternative to co-existence *per se*, it is an alternative account of the mechanism by which speeded responding leads to increased teleological endorsement relative to un-speeded responding. The current study investigates this possibility with the inclusion of an Ambiguity Intolerance measure (Kruglanski, Atash, De Grada, Mannetti, & Pierro, 2013), the Personal Need for Structure questionnaire (PNS; Neuberg & Newsom, 1993), and a subjective anxiety slider scale. If speeded responding threatens the perception of personal control which then leads to increased teleological endorsement, we would expect these three measures to mediate the effect of speeded responding on teleological endorsement.

Belief in supernatural agents has also been linked to two latent constructs which could influence endorsement of teleological explanations of the natural world. Cross-culturally, gods are conceptualised as having minds and of being capable of acting in accordance with their mental states to bring about desired outcomes (Tremblin, 2006). As such, the extent to which one considers the mental states of others has been implicated as a factor which positively correlates with both a belief in the existence of supernatural agents (Norenzayan, Gervais, & Trzesniewski, 2012, although see Reddish, Tok, & Kundt, 2016), and the tendency to see meaning in life events (Banerjee & Bloom, 2014, study 2). To explore whether this same relationship applies to scientifically unwarranted teleological explanations of nature, the Empathy Quotient - Short (EQ; Wakabayashi et al., 2006) was administered.

Conversely, the extent to which individuals are willing to engage in effortful analytical thought has been shown to negatively predict both belief in gods (e.g., Pennycook, Cheyne, Barr, Koehler, & Fugelsang, 2014) and belief in the teleology of nature (Zemla, Steiner, & Sloman, 2012). While the study by Zemla et al. (2012) used a performance-based measure of analytic cognitive style - the Cognitive Reflection Test, the current study explores the relationship between belief in the teleology of nature and analytic cognitive style using a self-report measure - the Need for Cognition scale (NFC; Cacioppo & Petty, 1982). Evidence of a negative relationship between analytic cognitive style and teleological beliefs would be consistent with the notion that implicitly, teleological beliefs persist throughout adulthood, but explicitly, may be inhibited.

2. Method

2.1. Participants

A total of 138 participants (71% female) enrolled in a first-year psychology course at a large Australian university, self-selected into the study in exchange for course credit. Ages ranged from 17 to 45, although this distribution was positively skewed ($M = 19.40$, $SD = 3.80$). The most common religious affiliation was Christianity (40.60%), followed by Agnosticism (18.80%) and Atheism (15.90%), indicating that this sample was roughly representative of the broader Australian population (Australian Bureau of Statistics, 2017).

2.2. Materials

2.2.1. Decision-making task

Participants were presented with 100 statements, one at a time, and were told these represented “explanations for various things in the world”. The 100 statements, adapted from Kelemen et al. (2013), were comprised of 30 scientifically unwarranted teleological statements and 70 control statements, to which participants responded either “true” or “false”. The 30 scientifically unwarranted teleological statements included 15 biological test items (e.g., “Trees produce oxygen so that animals can breathe”), and 15 natural non-living test items (e.g., “The Earth has an ozone layer in order to protect it from UV light”). The 70 control statements included 10 true teleological items (e.g., “Schools exist in order to help people learn new things”), 10 false teleological items (e.g., “Houses have doorbells in order to make dogs bark”), 20 true causal items (e.g., “Magnets stick together because their poles attract”), and 30 false causal items (e.g., “Saturn is a planet because it has rings surrounding it”).

Statements were presented to participants at one of two speeds: un-speeded or speeded. In the speeded condition there was a 3200 ms time-limit in which to respond, which was determined by Kelemen et al. (2013) to be two standard deviations above the average reading time for these explanations. Although all test items were presented, three of the natural non-living test items were not included in the analysis, as their teleological status was questionable (e.g., “Earthquakes happen because tectonic plates must realign”). The removal of these three items was planned, and consistent with Kelemen et al. (2013). The reason for their presentation during the experiment was simply to ensure consistency across blocks.

2.2.2. Religiosity

To isolate the unique effect of perceived supernatural intentionality over and above other aspects of religiosity, two measures were included.

2.2.2.1. Centrality of religiosity scale (CRS; Huber & Huber, 2012). The CRS was administered to examine the unique effect of perceiving the intentions of supernatural agents, over and above a belief in the existence of supernatural agents. The full 15-item measure (CRS15) includes five subscales (Experience, Ideology, Intellect, Public Practice, and Private Practice), each with three items. This study focused only on Experience (i.e., perceived supernatural intentionality) and Ideology (i.e., belief in the existence of supernatural agents). Although the full CRS15 measure was administered, subscales were scored according to the procedure for the 10-item version of the scale (CRS10), which contains two items in each subscale. The reason for using the CRS10 instead of the CRS15, was that the two items in the Experience subscale of the CRS10 specifically refer to experiencing the intentions of a supernatural agent (“How often do you experience situations in which you have the feeling that God or something divine intervenes in your life?”, and “How often do you experience situations in which you have the feeling that God or something divine wants to communicate or reveal something to you?”), whereas the additional item included in the CRS15 scoring procedure referred only to experiencing the presence of a supernatural agent (“How often do you experience situations in which you have the feeling that God or something divine is present?”). Both subscales were scored from 1 (*never/not at all*) to 5 (*very often/very much so*). The total score for each subscale was obtained by calculating the mean of the relevant items, such that scores had a potential range of 1 to 5. The CRS10 showed excellent internal consistency ($\alpha = 0.95$), which is similar to the reported norms for this measure (Huber & Huber, 2012).

2.2.2.2. Credibility enhancing displays (CREDS; Lanman & Buhrmester, 2016). To explore the extent to which teleological endorsement can be predicted by exposure to a religious upbringing, the CREDS measure was administered. This measure includes seven items (e.g., “To what extent did your caregiver(s) live a religiously pure life?”), scored on a Likert scale from 1 (*to no extent at all*) to 7 (*to an extreme extent*). The overall score on the measure was obtained by taking the mean of all seven items, such that scores had a potential range of 1 to 7. Internal consistency for this measure was excellent ($\alpha = 0.95$).

2.2.3. Compensatory control

To assess whether speeded responding threatens the perception of personal control, and whether this leads to increased rates of scientifically unwarranted teleological endorsement relative to un-speeded responding, three measures were included.

2.2.3.1. Ambiguity intolerance (Kruglanski et al., 2013). An individual's intolerance of ambiguity has previously been linked to their tendency to require compensatory control (Ma & Kay, 2017). The Ambiguity Intolerance subscale of the Need for Closure questionnaire includes nine items (e.g., "I'd rather know bad news than stay in a state of uncertainty"), which were scored on a 6-point Likert scale from 1 (*strongly disagree*) to 6 (*strongly agree*). The total score was obtained by summing all nine items, such that scores had a possible range of 9 to 54. Internal consistency for this measure was adequate ($\alpha = 0.80$).

2.2.3.2. Personal need for structure (PNS; Neuberg & Newsom, 1993). An individual's need for structure in their environment has also been linked to their need for compensatory control. The PNS includes 11 items (e.g., "It upsets me to go into a situation without knowing what I can expect from it"), two of which were reverse coded. Responses were made on a scale from 1 (*strongly disagree*) to 6 (*strongly agree*). After reverse scoring the relevant items, a total score was obtained by summing all 11 items, such that scores had a potential range of 11 to 66. Internal consistency for this measure was adequate ($\alpha = 0.78$).

2.2.3.3. Subjective anxiety. As a threat to personal control results in increased anxiety (Landau et al., 2015), participants rated their anxiety on a sliding scale from 0 to 100 at the beginning and the end of the study. A difference score was calculated as the post- minus pre-rating, such that a higher score represented an increase in anxiety during the experiment. Scores therefore had a potential range of -100 , representing the maximum decrease in anxiety, to 100 , representing the maximum increase in anxiety throughout the task.

2.2.4. Dispositional measures

To investigate whether previously reported correlates of religiosity also apply to rates of scientifically unwarranted teleological endorsement, two measures were administered.

2.2.4.1. Empathy quotient - short (EQ; Wakabayashi et al., 2006). The EQ was administered to explore a possible positive relationship between empathy and teleological endorsement. The EQ includes 22 items (e.g., "I can pick up quickly if someone says one thing but means another"), six of which were reverse-scored, on a 4-point Likert scale from 1 (*strongly disagree*) to 4 (*strongly agree*). In accordance with Baron-Cohen and Wheelwright (2004), normal-scored items were recoded such that a response of strongly disagree or slightly disagree was scored 0, a response of slightly agree was scored 1, and a response of strongly agree was scored 2. Conversely, reverse-scored items were recoded such that a response of strongly agree or slightly agree was scored 0, a response of slightly disagree was scored 1, and a response of strongly disagree was scored 2. The EQ therefore had a potential range of 0 to 44, with higher scores representing a greater tendency to empathise with others. The internal consistency of this measure was acceptable ($\alpha = 0.87$).

2.2.4.2. Need for cognition (NFC; Cacioppo & Petty, 1982). To assess whether the previously reported negative relationship between analytic cognitive style and religiosity (Gervais & Norenzayan, 2012; Pennycook, Cheyne, Seli, Koehler, & Fugelsang, 2012) might also extend to teleological endorsement, the NFC was administered. The NFC includes 18 items (e.g., "I would prefer complex to simple problems"), nine of which are reverse-scored. Responses were made on a 9-point Likert-scale from -4 (*very strongly disagree*) to 4 (*very strongly agree*). After reverse-coding the relevant items, the total score was obtained by summing all 18 items, such that scores had a potential range of -74 to 74 , with higher scores representing a more analytic cognitive style. The internal consistency for this measure was acceptable ($\alpha = 0.85$).

2.2.5. Demographics

Demographic information of age, religious affiliation, and gender was collected. Religious affiliation was selected from one of eight options: Agnostic, Atheist, Buddhist, Christian, Hindu, Jewish, Muslim, or Other. In cases where "Other" was selected, a text-box appeared, allowing participants to type their response.

2.3. Procedure

2.3.1. Assignment and exclusion

Participants were tested in groups of up to four at a time, in a session which took approximately 25 min to complete. Assignment to speed of response (un-speeded or speeded) was determined quasi-randomly for each group as a whole. Consistent with Kelemen et al. (2013), participants were excluded from analysis if they failed to answer over 80% of control items correctly, or if they failed to respond to at least 75% of the teleological test items within the time limit. Due to this additional exclusion criterion for the speeded condition, this condition was purposely oversampled at a ratio of 1.5:1.

2.3.2. Presentation

After assignment, participants were told that they would be shown a series of "explanations for various things in the world", and their task was to "decide whether each statement was true or false by clicking the relevant button on the screen". All stimuli were presented on computer screens using the Qualtrics web-based platform. Upon clicking "begin", the first question that participants responded to was the initial measure of anxiety. Following this, a page of written instructions appeared. The speeded instructions

stated that participants would have just over three seconds to make their response, and that it was important to respond within this time limit as the next statement would automatically appear. The un-speeded instructions stated that after participants made their response, the next statement would automatically appear. The reason for presenting written instructions after the initial measure of anxiety, was to avoid the initial rating being affected by expectations of the task.

All participants completed one practice block of 10 statements; the format of which was presented according to the participant's allocated speed. This block was representative of the full task, containing three teleological test items and seven control items, presented in random order. Participants judged each statement as true or false by using the mouse to select the relevant choice on the screen. In both speeds, after the response was selected, the program automatically moved to the following trial. If a participant failed to respond within 3200 ms during speeded responding, the program automatically proceeded to the next statement. Between each trial a fixation cross was displayed in the centre of the screen for 250 ms to encourage participants to return their gaze to the position where the next explanation would appear.

After completion of the practice items, the program automatically moved onto the main task. Items were presented in blocks of ten, with each block containing three test items and seven control items. The seven control items included one true teleological, one false teleological, two true causal, and three false causal items. The three test items in each block included either one biological and two natural non-living, or two biological and one natural non-living test item. The order of items presented within each block was randomised for every participant, as was the order of blocks. Following this, participants completed the remaining measures in a fixed order. The subjective anxiety scale was presented immediately after the judgement task, followed by the Personal Need for Structure, Ambiguity Intolerance, Empathy Quotient, Credibility Enhancing Displays, Need for Cognition, Centrality of Religiosity, and finally, demographics.

3. Results

3.1. Descriptive statistics

In the speeded condition, a total of 29 participants were excluded for failing to respond to at least 75% of test items within the time limit, 13 were excluded for failing to respond to over 80% of control items correctly, and seven were excluded for failing to meet both criteria. One additional participant was excluded from the un-speeded condition for failing to provide their age. After exclusion, 88 participants remained, with 54 in the un-speeded condition and 34 in the speeded condition. There were no significant differences in age or gender between conditions (both p s > 0.35). The retained and excluded participants did not differ significantly on any measure (all p s > 0.11) other than subjective anxiety, with the excluded participants ($M = 15.24$, $SD = 20.00$) reporting greater increases in anxiety than the retained participants ($M = 5.45$, $SD = 15.10$), $t(86) = 3.01$, $p = .004$, $d = 0.552$. Means and standard deviations for the retained participants are shown in Table 1, and a comparison of retained and excluded participants is included in Table S1 of the [Supplementary Materials](#).

3.2. Manipulation check

To check that speeded responding had a greater effect on endorsement of teleological test items compared to control item inaccuracy, a 2 (speed; un-speeded, speeded) \times 3 (item-type; biological test, natural non-living test, control) mixed ANOVA was conducted. Responses to test items were coded as 1 for "true" and 0 for "false", whereas for control items, incorrect responses were coded 1, and correct responses were coded 0.

A strong main effect of speed was found, indicating less accurate responding in the speeded compared to un-speeded condition, $F(1,86) = 670.56$, $p < .001$, $\eta^2 = 0.203$. There was also a strong and highly significant main effect of item-type, $F(2,172) = 295.92$, $p < .001$, $\eta^2 = 0.775$. As expected, both main effects were subsumed under a significant speed by item-type interaction which was moderate in strength, $F(2,172) = 8.47$, $p < .001$, $\eta^2 = 0.090$. As shown in Fig. 1 and Table 2, whereas speed had a greater effect on endorsement of test items on average than on incorrect responses to control items, $F(1,86) = 14.21$, $p < .001$, $\eta^2 = 0.142$, speed did not moderate the difference in endorsement between biological and natural non-living test items, $F(1,86) = 0.18$, $p = .673$, $\eta^2 = 0.002$. Thus, speed had a similar effect on endorsement of biological and natural non-living test items, and this effect was significantly greater than the effect of speed on incorrect responses to control items.

Table 1

Univariate Descriptives.

	Teleology	Experience	Ideology	CREDS	PNS	Ambiguity	Anxiety	EQ	NFC
M	51.49	2.31	3.27	3.27	46.14	39.40	5.45	25.89	9.33
SD	21.26	1.19	1.33	1.78	6.82	5.96	15.10	7.16	15.70

Note: Teleology = percentage of test items endorsed collapsed across speed. Experience = CRS10 Experience subscale. Ideology = CRS10 Ideology subscale. CREDS = Credibility Enhancing Displays. PNS = Personal Need for Structure. Ambiguity = Ambiguity Intolerance. EQ = Empathy Quotient. NFC = Need for Cognition.

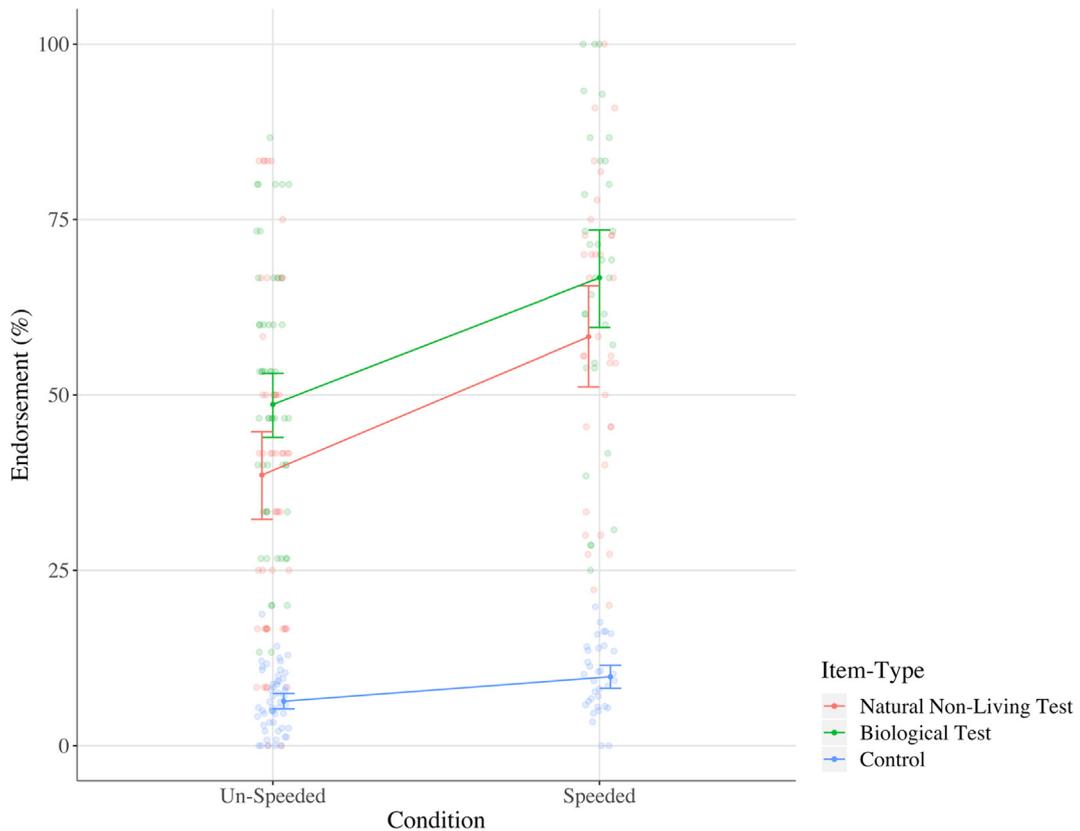


Fig. 1. Endorsement of biological test items, natural non-living test items, and incorrect responses to control items as a function of speed. For the speeded condition, percentage endorsement is calculated as the number of items endorsed out of the number of items with valid responses. Error bars represent 95% confidence intervals.

Table 2
Mean Endorsement of Item-Type as a Function of Condition.

		Item-Type			
		Biological Test	Natural Non-Living Test	Total Test	Incorrect Control
Un-Speeded	<i>M</i>	48.64	38.58	44.17	6.34
	<i>SD</i>	18.97	23.75	19.26	4.28
	<i>95CI</i>	[43.29, 54.00]	[32.41, 44.75]	[38.97, 49.37]	[5.11, 7.57]
Speeded	<i>M</i>	66.69	58.29	63.11	9.84
	<i>SD</i>	21.03	21.24	19.19	4.94
	<i>95CI</i>	[59.94, 73.44]	[50.51, 66.07]	[56.55, 69.67]	[8.29, 11.39]
Difference	<i>M</i>	18.05	19.71	18.94	3.50
	<i>SE</i>	4.33	5.00	4.21	1.00
	<i>95CI</i>	[9.43, 26.66]	[9.78, 29.64]	[10.57, 27.32]	[1.52, 5.47]

Note: For the speeded condition, means are calculated from the number of items with valid responses. Difference scores are calculated as speeded minus un-speeded means.

3.3. Supernatural intentionality

Having established that the effect of speed on endorsement of test items was greater than the effect of speed on incorrect responses to control items, the following analyses focused only on test items; specifically, whether rates of implicit and explicit teleological endorsement diverged according to the unique effect of perceived supernatural intentionality. A mixed ANCOVA was performed with speed as a between-subject factor (speeded, un-speeded), item-type as a within-subject factor (biological test, natural non-living test), and the CRS10 Experience subscale as a continuous independent variable to measure perceived supernatural intentionality. The CRS10 Ideology subscale and CREds exposure were included as covariates to control for belief in the existence of supernatural agents and religious exposure during childhood, respectively. All continuous variables were mean-centered for analysis. The dependent

Table 3
Significance and Effect Sizes for Overall ANCOVA.

	<i>df</i>	<i>F</i>	<i>p</i>	η^2
Item-type	1	25.00	< .001	0.234
Speed	1	22.25	< .001	0.213
Experience	1	0.30	.585	0.004
Ideology	1	0.05	.831	0.001
CRED	1	1.09	.300	0.013
Item-type * Speed	1	0.38	.538	0.005
Item-type * Experience	1	1.67	.200	0.020
Item-type * Ideology	1	2.72	.103	0.032
Item-type * CREDs	1	1.56	.215	0.019
Speed * Experience	1	5.65	.020	0.064
Item-type * Speed * Experience	1	6.86	.011	0.077
Error	82	–	–	–

Note: All continuous variables are mean-centred.

variable was the mean percentage of teleological test-items endorsed. In the case of the speeded condition, this was calculated from the number of explanations with valid responses. Responses to the test items were coded as 0 for “false” and 1 for “true”, such that higher scores represented greater teleological endorsement. All assumptions for this analysis were met. Results of this analysis performed without covariates is shown in Table S2 of the [Supplementary Materials](#). The pattern of findings did not change.

The significance and effect sizes of the main-effects, interaction, and covariates from this analysis are shown in [Table 3](#). As expected, there was a strong main-effect of speed, with significantly higher endorsement of test items during speeded ($M = 62.70$, $SE = 3.26$) compared to un-speeded responding ($M = 42.96$, $SE = 2.58$), $F(1,82) = 22.25$, $p < .001$, $\eta^2 = 0.213$, 95% CI [11.42, 28.07], thereby providing evidence of an implicit bias for unwarranted teleological explanations of the natural world. Also, as expected, there was a strong main-effect of item-type, with biological test items ($M = 57.57$, $SE = 2.19$) endorsed significantly more than natural non-living test items ($M = 48.10$, $SE = 2.36$), $F(1,82) = 25.00$, $p < .001$, $\eta^2 = 0.234$, 95% CI [5.70, 13.24].

There was a weak-to-moderate speed by Experience interaction, $F(1,82) = 5.65$, $p = .020$, $\eta^2 = 0.064$. For low-Experience individuals there was a strong effect of speed, with the difference in endorsement between speeded ($M = 65.90$, $SE = 5.45$) and un-speeded responding ($M = 35.50$, $SE = 5.23$) being highly significant, $F(1,82) = 25.16$, $p < .001$, $\eta^2 = 0.235$, 95% CI [18.34, 42.44], whereas for high-Experience individuals, the difference between speeded ($M = 56.14$, $SE = 9.89$) and un-speeded responding ($M = 58.27$, $SE = 9.50$) was non-significant, $F(1,82) = 0.04$, $p = .835$, $\eta^2 = 0.001$, 95% CI [-22.41, 18.15]. However, as expected, the two-way interaction between speed and Experience was subsumed by a three-way interaction with item-type, $F(1,80) = 6.86$, $p = .011$, $\eta^2 = 0.077$. To examine this in more detail, rates of endorsement for biological and natural non-living test items were analysed separately. For both categories of test item, a between-subjects ANCOVA was conducted with speed (speeded, un-speeded) and the CRS10 Experience subscale, while also controlling for the CRS10 Ideology subscale and CREDs exposure. Again, these analyses were repeated without covariates and are included in the [Supplementary Materials](#) (Tables S3 and S4). The pattern of results did not change.

3.3.1. Biological test items

The significance and effect sizes of the main-effects, interaction, and covariates from this analysis are shown in [Table 4](#). There was a moderate-to-strong main-effect of speed, with significantly higher endorsement of biological test items during speeded ($M = 66.84$, $SE = 3.45$) compared to un-speeded responding ($M = 48.28$, $SE = 2.73$), $F(1,82) = 17.63$, $p < .001$, $\eta^2 = 0.177$, 95% CI [9.77, 27.35], thereby providing evidence of an implicit bias for these explanations. However, as shown in [Fig. 2](#), the interaction between speed and Experience was non-significant, $F(1,82) = 1.25$, $p = .268$, $\eta^2 = 0.015$, providing no evidence that rates of implicit and explicit endorsement for biological test items diverge in relation to perceived supernatural intentionality.

3.3.2. Natural non-living test items

The significance and effect sizes of the main-effects, interaction, and covariates from this analysis are shown in [Table 5](#). There was

Table 4
Significance and Effect Sizes for ANCOVA of Biological Organisms.

	<i>df</i>	<i>F</i>	<i>p</i>	η^2
Speed	1	17.63	< .001	0.177
Experience	1	< 0.01	.968	< 0.001
Ideology	1	0.26	.610	0.003
CREDs	1	0.20	.656	0.002
Speed * Experience	1	1.25	.268	0.015
Error	82	–	–	–

Note: All continuous variables are mean-centred.

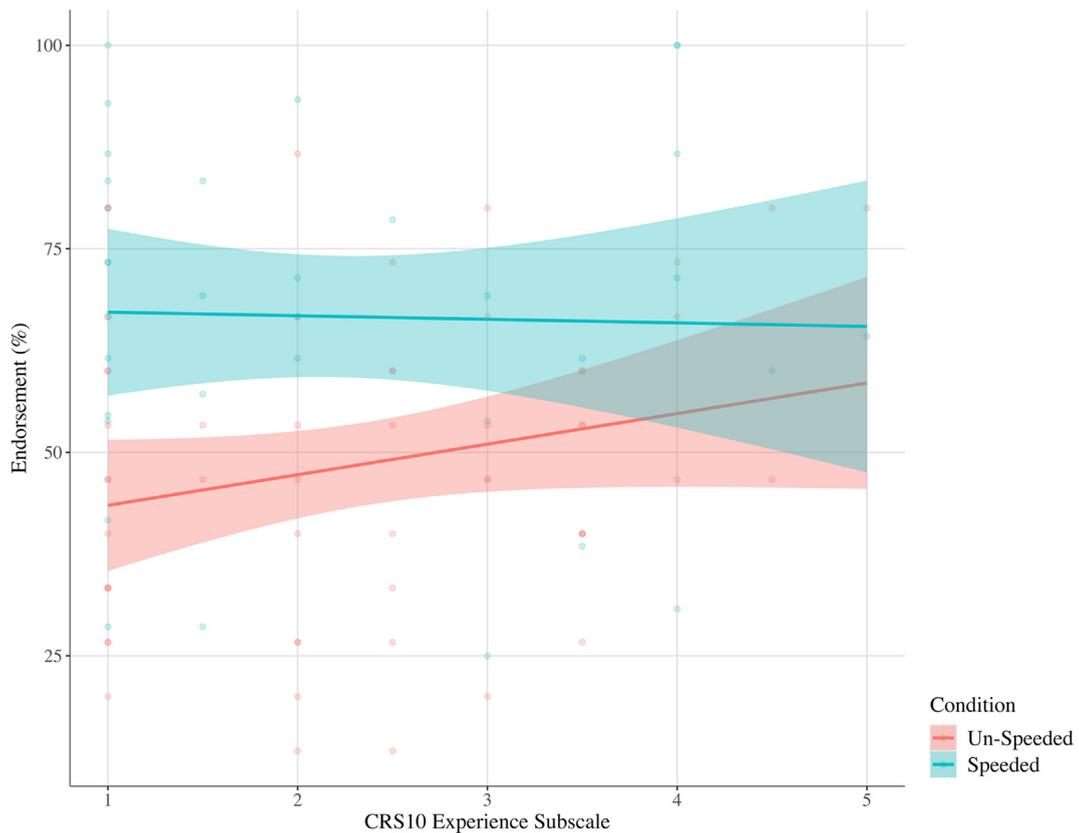


Fig. 2. Scatterplot of raw data-points for the CRS10 Experience subscale with percentage endorsement for biological test items by condition. Lines represent predicted values for each condition with CRS10 Ideology subscale and CREDs set at zero. Shaded areas represent 95% confidence intervals.

Table 5
Significance and Effect Sizes for ANCOVA of Natural Non-Living Test Items.

	<i>df</i>	<i>F</i>	<i>p</i>	$\eta\rho^2$
Speed	1	19.18	< .001	0.190
Experience	1	1.00	.321	0.012
Ideology	1	0.72	.399	0.009
CREDs	1	2.00	.161	0.024
Speed * Experience	1	9.81	.002	0.107
Error	82	–	–	–

Note: All continuous variables are mean-centred.

a moderate-to-strong main effect of speed, with significantly higher endorsement of natural non-living test items during speeded ($M = 58.56$, $SE = 3.73$) compared to un-speeded responding ($M = 37.63$, $SE = 2.95$), $F(1,82) = 19.18$, $p < .001$, $\eta\rho^2 = 0.190$, 95% CI [11.42, 30.42], again providing evidence of an implicit bias for these explanations. As shown in Fig. 3, the interaction between speed and Experience was significant, $F(1,82) = 9.81$, $p = .002$, $\eta\rho^2 = 0.107$. After controlling for covariates, there was a strong effect of speed for low-Experience individuals, with a significant difference in endorsement between speeded ($M = 62.14$, $SE = 6.22$) and un-speeded responding ($M = 25.20$, $SE = 5.97$), $F(1,82) = 28.52$, $p < .001$, $\eta\rho^2 = 0.258$, 95% CI [23.18, 50.71]. However, for high-Experience individuals the difference in endorsement between speeded ($M = 51.20$, $SE = 11.29$) and un-speeded responding ($M = 63.18$, $SE = 10.84$) was non-significant, $F(1,82) = 1.06$, $p = .307$, $\eta\rho^2 = 0.013$, 95% CI [–35.13, 11.18]. Furthermore, as shown by the parameter estimates produced by this analysis in Table 6, this interaction was being driven primarily by a positive relationship between scores on the Experience subscale and teleological endorsement during un-speeded, as opposed to the speeded responding.

3.3.3. Alternative explanations

An alternative interpretation of the preceding results could be that perhaps accuracy in general differed according to the perception of supernatural intentionality. A 2 (control item-type; true, false) \times 2 (speed; un-speeded, speeded) mixed ANCOVA was

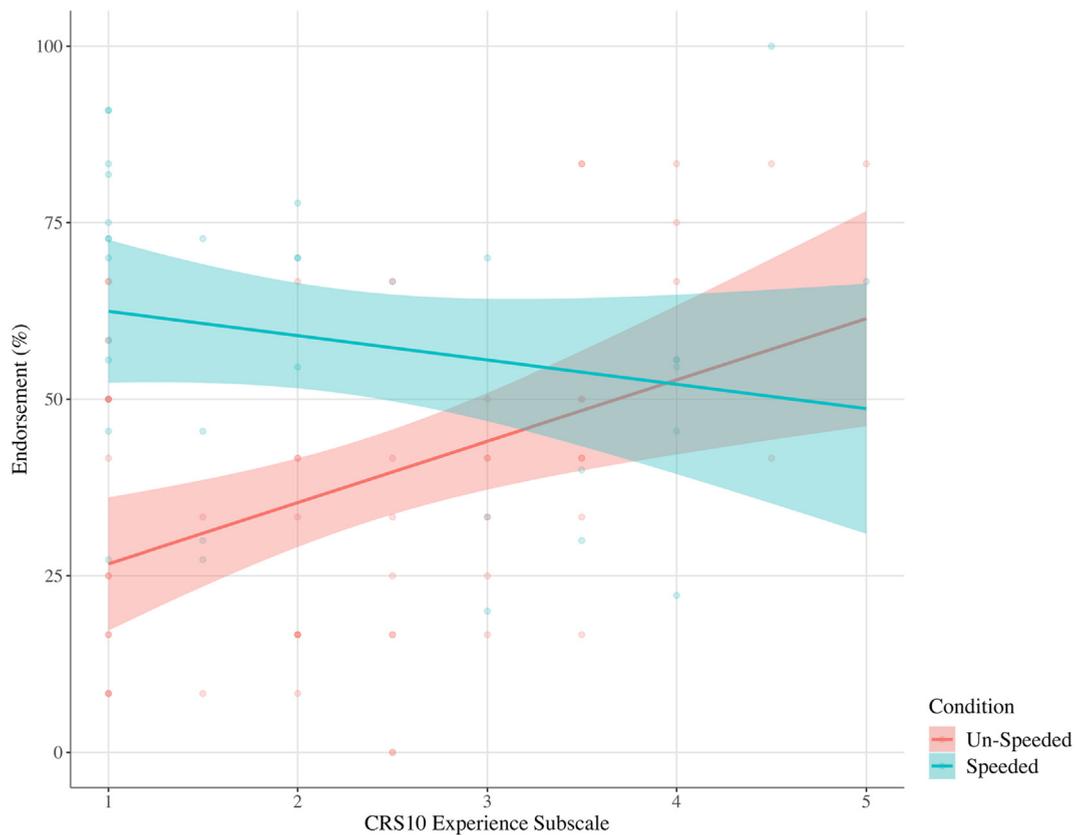


Fig. 3. Scatterplot of raw data-points for the CRS10 Experience subscale with percentage endorsement for natural non-living test items by condition. Lines represent predicted values for each condition with CRS10 Ideology subscale and CREDs set at zero. Shaded areas represent 95% confidence intervals.

Table 6
Parameter Estimates from ANCOVA Predicting Teleological Endorsement.

	Biological Test Items				Natural Non-Living Test Items			
	<i>B</i>	<i>SE</i>	95% <i>CI</i>	<i>p</i>	<i>B</i>	<i>SE</i>	95% <i>CI</i>	<i>p</i>
Intercept	48.29	2.73	[42.87, 53.71]	–	37.63	2.95	[31.77, 43.50]	–
Speed	18.56	4.42	[9.77, 27.35]	< 0.001	20.92	4.78	[11.42, 30.43]	< 0.001
CREDs	0.64	1.43	[–2.21, 3.49]	0.656	2.19	1.55	[–0.89, 5.27]	0.161
Ideology	1.45	2.83	[–4.18, 7.09]	0.610	–2.60	3.06	[–8.69, 3.49]	0.399
Experience	1.89	3.61	[–5.30, 9.08]	0.603	9.50	3.91	[1.73, 17.27]	0.017
Speed * Experience	–4.03	3.61	[–11.22, 3.16]	0.268	–12.23	3.91	[–20.00, –4.46]	0.002

Note: All continuous variables are mean-centred. The un-speeded condition is used as the reference group.

conducted which included the CRS10 Experience subscale as a continuous predictor, and the CRS10 Ideology subscale and CREDs exposure as covariates. Responses to control items were coded as 0 for correct and 1 for incorrect, such that higher scores represented greater inaccuracy.

There was a moderate and significant main-effect of speed, $F(1,82) = 9.82, p = .002, \eta^2 = 0.107$, with greater inaccuracy during speeded ($M = 10.12, SE = 0.77$) compared to un-speeded responding ($M = 6.16, SE = 0.61$), 95% CI [1.90, 5.82]. However, the Experience subscale was not a significant predictor of control item inaccuracy, $F(1,82) = 0.86, p = .358, \eta^2 = 0.010$, and speed did not moderate the effect of Experience, $F(1,82) = 2.05, p = .156, \eta^2 = 0.024$. If a general inaccuracy in responding for high-Experience individuals was the reason for the pattern of endorsement for teleological test-items, then a significant result would be expected for one or both these effects.

Another possibility was that high-Experience individuals may be biased towards judging explanations as true. If this were the case, then these individuals should be less accurate on false-control items (i.e., those which warrant a response of “false”) compared to low-Experience individuals. Conversely, low-Experience individuals may be biased towards judging explanations as false. If this were the case, then these individuals should be less accurate on true-control items (i.e., those which warrant a response of “true”)

Table 7
Bivariate Correlations Collapsed Across Speed.

Teleology	EXP	IDE	CREG	PNS	AMB	ANX	EQ	NFC
Teleology	0.109 [-0.103, 0.311]	0.100 [-0.112, 0.303]	0.079 [-0.132, 0.248]	-0.138 [-0.338, 0.073]	0.040 [-0.171, 0.248]	0.093 [-0.119, 0.296]	0.067 [-0.145, 0.272]	-0.167 [-0.363, 0.044]
EXP	-	0.815** [0.731, 0.875]	0.499** [0.323, 0.641]	0.123 [-0.089, 0.324]	0.145 [-0.066, 0.344]	-0.039 [-0.246, 0.172]	-0.054 [-0.261, 0.157]	-0.029 [-0.237, 0.181]
IDE	-	-	0.514** [0.341, 0.653]	0.056 [-0.155, 0.262]	0.166 [-0.045, 0.363]	-0.057 [-0.263, 0.154]	-0.024 [-0.232, 0.187]	-0.098 [-0.301, 0.114]
CREG	-	-	-	-0.079 [0.284, 0.132]	0.133 [-0.078, 0.333]	-0.064 [-0.270, 0.148]	0.085 [-0.127, 0.289]	0.016 [-0.194, 0.225]
PNS	-	-	-	-	0.485** [0.307, 0.361]	-0.239* [-0.427, -0.031]	-0.051 [-0.258, 0.160]	-0.023 [-0.231, 0.188]
AMB	-	-	-	-	-	0.117 [-0.319, 0.095]	-0.040 [-0.247, 0.171]	-0.011 [-0.220, 0.199]
ANX	-	-	-	-	-	-	-0.012 [-0.221, 0.198]	-0.032 [-0.240, 0.179]
EQ	-	-	-	-	-	-	-	0.276** [0.070, 0.459]
NFC	-	-	-	-	-	-	-	-

Note: Pearson's correlation coefficients collapsed across speed with 95% CI in parentheses [lower, upper]. *N* = 88 for all correlations. Teleology represents percentage of test items endorsed collapsed across speed. EXP = CRS10 Experience subscale. IDE = CRS10 Ideology subscale. CREG = Credibility Enhancing Displays. PNS = Personal Need for Structure. AMB = Ambiguity Intolerance. ANX = Subjective Anxiety. EQ = Empathy Quotient. NFC = Need for Cognition. * *p* < .05, ** *p* < .01 (unadjusted).

compared to high-Experience individuals. However, no support was found for either of these possibilities.

There was no evidence of an interaction between control item-type (true, false) and the Experience subscale on inaccuracy of responses, $F(1,82) = 1.94, p = .211, \eta^2 = 0.019$. There was also no evidence for a three-way interaction between control item-type, speed, and the Experience subscale, $F(1,82) = 1.95, p = .166, \eta^2 = 0.023$. Thus, there was no evidence of a “true-bias” or “false-bias” for individuals at the high- and low-ends of the Experience subscale, respectively, and this did not differ by speed.

3.4. Exploratory hypotheses

3.4.1. Compensatory control

An additional question this study aimed to answer was whether increased teleological endorsement during speeded responding could be due to a perceived lack of personal control. However, scores on the PNS, Ambiguity Intolerance, and Subjective Anxiety measures did not differ according to speed (all $ps > 0.08$). Furthermore, as shown in Table 7, no significant correlations were found between these three measures and the CRS10 Experience or Ideology subscales, or with teleological endorsement. As the speed of response was not a significant predictor of scores on the PNS, Ambiguity Intolerance, or subjective anxiety measures, and since these three measures did not significantly predict teleological endorsement, they could not mediate the relationship between speeded responding and teleological endorsement (see Baron & Kenny, 1986).

3.4.2. Disposition

A final question this study aimed to address was the relationship between teleological endorsement and both empathy and analytic disposition. However, contrary to expectations, these two measures did not significantly correlate with the CRS10 Experience or Ideology subscales, or with scientifically unwarranted teleological endorsement (see Table 7).

4. Discussion

4.1. Summary of results

As predicted, when participants were instructed to respond under time-pressure, a significantly higher percentage of teleological test items with valid responses were endorsed compared to during un-speeded responding. Furthermore, as expected, this difference between speeded (i.e., implicit) and un-speeded (i.e., explicit) endorsement, was moderated by the extent to which individuals reported experiencing the intentions of supernatural agents. The prediction that biological test items would be endorsed at a higher rate than natural non-living test items was also supported by the results, as was the prediction that the interaction between speed and perceived supernatural intentionality would be stronger for natural non-living test items than for biological test items.

4.2. Co-existence

The finding of greater teleological endorsement when responding under speeded compared to un-speeded instructions, is consistent with the idea that implicitly a person may believe in the teleology of nature, yet explicitly reject such beliefs (e.g., Kelemen & Rosset, 2009). The results of this study also help to rule out a possible alternative to the co-existence perspective, as the effect of speeded responding was significantly greater for endorsement of teleological test items than for incorrectly answered control items. This shows that the higher endorsement of test items during speeded compared to un-speeded responding, could not be due to a general inaccuracy caused by speeded responding. In comparison to Kelemen et al. (2013) who found an un-speeded mean endorsement of 45% and a speeded mean endorsement of 56% ($SD = 21$) for teleological test items in their college sample, the difference between conditions in the current study is larger. Mean endorsement in the un-speeded condition of Kelemen et al.’s study was similar to that in the current study ($M = 44.17$). The difference in effect sizes between the two studies was driven by the mean endorsement in the speeded condition of Kelemen et al.’s study being lower than that of the current study ($M = 63.11$). There are two small methodological differences which may have contributed to these results. Firstly, Kelemen et al. gave participants a three-second break between blocks, whereas participants were not given a break between blocks in the current study. The absence of a break may have increased the cognitive load in the speeded condition of the current study. Secondly, Kelemen et al. used a key-press procedure, whereas the current study required participants to respond using a mouse. As a mouse response requires additional time to move to the correct location on the screen, this may have increased the difficulty of the speeded condition in the current study relative to that of Kelemen et al. However, it is worth noting that the 95% confidence intervals of the difference between conditions for Kelemen et al.’s study [7.36, 14.64] do overlap with those of the current study [10.57, 27.32]. Therefore, although the larger effect of speeded responding in the current study should be interpreted with caution, it is within the expected margin of error.

An alternative account of the mechanism by which speeded responding works to uncover a teleological bias, was that because participants cannot control the rate at which explanations are presented during speeded responding, this may have motivated a search for alternative external sources of control (Kay, Gaucher, McGregor, & Nash, 2010; Landau et al., 2015). Given that teleological explanations of the natural world are quasi-religious (Kelemen, 2004), it was conceivable that increased endorsement during speeded compared to un-speeded responding, may be due not to speeded responding limiting access to the cognitive resources needed to inhibit an intuitive response, but instead to teleological explanations serving as a source of compensatory control. However, no support was found for this alternative explanation. There were no significant differences on the Personal Need for Structure, Ambiguity Intolerance, or subjective anxiety measures between speeds, which would have been expected if speeded responding caused a

threat to personal control.

Given the evidence in favour of the co-existence perspective, somewhat surprisingly, the extent to which individuals reported to enjoy engaging in effortful analytic thought, as measured by the Need for Cognition scale (NFC), was not significantly correlated with teleological endorsement. However, in contrast to previous research linking religious disbelief to analytic cognitive style (e.g., Pennycook et al., 2014, 2012), the present study found no significant relationship between scores on the NFC and either of the CRS10 subscales. A possible reason for this discrepancy could be the use of a self-report measure of cognitive disposition in the current study, rather than performance-based measures such as the Cognitive Reflections Test (CRT) used in previous research (Zemla et al., 2012). Although the NFC purports to measure the tendency to engage in and enjoy thinking (Cacioppo & Petty, 1982), previously reported correlations between scores on the NFC and performance-based measures of analytic disposition such as the CRT, are positive, but weak (Frederick, 2005). Future research should seek to replicate the previously reported negative relationship between scientifically unwarranted teleological endorsement and performance-based measures of analytic disposition such as the CRT (Zemla et al., 2012). Replication of this effect would provide further support for the co-existence perspective.

4.3. Reconciliation of opposing views

The current results also help to reconcile the positive relationship between belief in supernatural agents and teleological endorsement (Banerjee & Bloom, 2014; Kelemen et al., 2013), with findings of an enduring teleological bias (Casler & Kelemen, 2008; Kelemen & Rosset, 2009). Consistent with the theory of intention-based teleology, an aspect of belief in supernatural agents which uniquely predicts the divergence of implicit and explicit teleological endorsement, is the belief that these agents intentionally interact with the world. Although this effect was only weak-to-moderate in strength, that this effect was found after controlling for CREDS exposure speaks to the naturalness with which teleology arises. This also highlights the possibility that previous findings of belief in “Nature as a powerful being” as a stronger predictor of scientifically unwarranted teleological endorsement than a belief in “God” (Kelemen et al., 2013), may be due, in part, to the wording of the questions. As previously discussed, although a belief in the former implies agency which is intrinsic to the natural world, it also implies that Nature is a being capable of causing change (i.e., powerful). A belief in the latter, on the other hand, likely implies agency which is extrinsic to the natural world, but makes no implications regarding the capabilities of God to cause change. Therefore, the strength of a belief in “Nature as a powerful being” in predicting scientifically unwarranted teleological endorsement, may have less to do with viewing the natural world as *intrinsically* agentic, and more to do with the fact that this item emphasises the intentional aspect of an agent, whereas a belief in “God” does not.

Given the relationship between perceived supernatural intentionality and endorsement of teleological explanations of natural non-living objects, it is surprising that in contrast to Banerjee and Bloom (2014, study 2), the extent to which individuals reported thinking about the mental states of others, as measured by the Empathy Quotient (EQ), did not significantly correlate with rates of teleological endorsement. However, in the current study the relationship between scores on the EQ and both the CRS10 subscales were also non-significant. Given that prior research has found a positive relationship between EQ scores and belief in a personal god (Norenzayan et al., 2012), this was unexpected. However, the current study is not the first to obtain null-results when investigating the link between understanding the mental states of others and belief in gods (e.g., Maji et al., 2017; Reddish et al., 2016; Vonk & Pitzten, 2017). Closer inspection of the items used in previous research to measure a belief in gods, offers insight into a possible reason for this discrepancy. Whereas Norenzayan et al. (2012) measured belief in God using items which emphasised a personal relationship (e.g., “When I am in trouble, I find myself wanting to ask God for help”), Maji et al. (2017) measured religiosity using items which emphasised behavioural aspects of belief (e.g., “How often do you pray?”). It is possible then, that the extent to which individuals think about the mental states of others is predictive of their perceived personal relationship with supernatural agents, yet is not predictive of other aspects of belief, such as the perception that supernatural agents intentionally interact with the world.

4.4. Nature is heterogeneous

As predicted, there was a strong effect of item-type, with scientifically unwarranted teleological explanations viewed as more acceptable when they referred to biological organisms, compared to natural non-living objects. While this is consistent with Kelemen's (1999a) intention-based account of teleology, in that the conceivability of an entity having intentions is an important factor in determining the appropriateness of teleological explanations, it is also consistent with an alternative account; specifically, this could be due to biological organisms being understood as resulting from a function-driven causal process (i.e., natural selection). However, the moderate-to-strong unique effect of perceived supernatural intentionality in predicting the divergence of implicit and explicit endorsement of natural non-living test items, does provide support for an intention-based theory of teleology, as these entities could not result from natural selection. Furthermore, although there was no evidence that perceived supernatural intentionality moderates the difference between implicit and explicit endorsement of biological test items, this does not mean that the biological world is not subject to explanation through the lens of an intentionality heuristic. Rather, the very reason why a stronger interaction between the speed of responding and perceived supernatural intentionality was predicted for natural non-living test items than for biological test items, was because some biological organisms can have intentions of their own, whereas natural non-living objects cannot. Therefore, it is possible that individuals have an implicit tendency to view the natural world as purposeful, and that supernatural agents provide a potential source of intentions for certain natural entities which are incapable of having intentions of their own.

However, despite the prediction of a dissociation in endorsement between explanations of natural non-living objects and biological organisms being supported, this does not necessarily mean that the perception of *supernatural* intentionality is unrelated to

endorsement of teleological explanations of biological organisms. As both questions in the CRS10 Experience subscale mention “God or something divine”, this emphasises a supernatural agent which, due to this study being conducted in a predominantly Christian culture (Australian Bureau of Statistics, 2017), would likely be viewed as extrinsic to the physical world by most participants. If biological organisms are understood as having intentions of their own, then the current lack of moderation may be due to an incongruence between a supernatural agent conceptualised as being removed from nature, serving as the source of perceived intentions for biological organisms.

The possibility of a sensitivity to the source of perceived intentions as an explanation for the current results is, admittedly, speculative. Data from this study offer no way of testing this hypothesis, and unfortunately, the results from Kelemen et al. (2013) showing ‘belief in nature as a powerful being’ as a predictor of teleological endorsement, were not reported separately for biological and natural non-living test items. However, if congruence between the source of perceived intentions and the location of the proposed supernatural agent is important, then a dissociation might be expected in future research. Specifically, the “intentional agent” aspect of a belief in Nature (as a being) should positively predict explicit endorsement of biological test items, and this should be stronger than the effect of this belief in predicting explicit endorsement of natural non-living test items. Conversely, and in-line with the current results, the “intentional agent” aspect of a belief in God should positively predict explicit endorsement of natural non-living test items, and this should be stronger than the effect of this belief in predicting explicit endorsement of biological test items. Although speculative, the idea of a sensitivity to the source of perceived intentions is worthy of investigation, and would further clarify the relationship between teleology and religious beliefs.

4.5. Conclusion

Although the results of this study are consistent with the underlying theory and prior empirical work, the use of first-year psychology undergraduates limits the generalisability of these results due to the homogeneity of the sample. However, while this sample was homogenous, as the majority of teleology research has been conducted within North America (e.g., Banerjee & Bloom, 2014; Kelemen & Rosset, 2009; Kelemen et al., 2013), the use of Australian undergraduates provides further evidence that a teleological bias arises independently of one’s immediate culture. An additional limitation of the current study was the level of exclusion from the speeded condition. A possible solution to the high exclusion rate would be to slightly increase the time-limit in the speeded condition, which would allow the retention of more participants.

Despite these limitations, this study has contributed to the current understanding of teleology in several ways. This is the first study to isolate the effect of perceived intentions from general “belief” in supernatural agents. From a theoretical perspective, this aspect of religiosity should be central to teleology, as PT rests on the claim that teleology is based in an understanding of intentions. This study has also helped to reconcile two major themes in teleology research: the co-existence of teleological beliefs at an implicit level with the rejection of these beliefs at an explicit level, and the positive relationship between teleology and belief in supernatural agents. In reconciling these two themes, this study helps to qualify previous findings from both lines of research. Specifically, implicitly held teleological beliefs can differ from explicitly expressed beliefs, but the perception of supernatural intentionality moderates the difference between the two.

Taken together, these results suggest that although non-religious individuals may reject notions of supernatural intentionality, this does little to alter their underlying intuitions which give rise to teleological beliefs about nature. Given the naturalness with which teleological explanations occur, it is possible that the tendency to view nature as the result of an agent’s prior intention is very much a normal feature of adult cognition. Whereas non-religious individuals may purposely inhibit the response of “intentional” when explaining the natural world, religious individuals give the source of the perceived intentions a name.

Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.concog.2020.102905>.

References

- Atran, S. (1995). Causal constraints on categories and categorical constraints on biological reasoning across cultures. In D. Sperber, D. Premack, & A. J. Premack (Eds.). *Causal cognition: A multidisciplinary debate* (pp. 205–233). Oxford: Clarendon Press.
- Australian Bureau of Statistics (2017). *2016 census data summary: Religion in Australia* (Government census data). Retrieved from [https://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/E3E51096DAC0AD7CCA25814D00240616/\\$File/religion,%202016%20census%20data%20summary%20\(updated\).pdf](https://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/E3E51096DAC0AD7CCA25814D00240616/$File/religion,%202016%20census%20data%20summary%20(updated).pdf).
- Banerjee, K., & Bloom, P. (2014). Why did this happen to me? Religious believers’ and non-believers’ teleological reasoning about life events. *Cognition*, 133(1), 277–303. <https://doi.org/10.1016/j.cognition.2014.06.017>.
- Baron-Cohen, S., & Wheelwright, S. J. (2004). The empathy quotient: An investigation of adults with Asperger syndrome or high functioning autism and normal sex differences. *Journal of Autism and Developmental Disorders*, 34(2), 163.
- Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51(6), 1173–1182. <https://doi.org/10.1037/0022-3514.51.6.1173>.
- Bloom, P. (1996). Intention, history, and artifact concepts. *Cognition*, 60(1), 1–29. [https://doi.org/10.1016/0010-0277\(95\)00699-0](https://doi.org/10.1016/0010-0277(95)00699-0).
- Brumby, M. N. (1984). Misconceptions about the concept of natural selection by medical biology students. *Science Education*, 68(4), 493–503. <https://doi.org/10.1002/sce.3730680412>.
- Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology*, 42(1), 116–131. <https://doi.org/10.1037/0022-3514.42.1.116>.
- Casler, K., & Kelemen, D. (2008). Developmental continuity in teleo-functional explanation: Reasoning about nature among Romanian Romani adults. *Journal of Cognition and Development*, 9(3), 340–362. <https://doi.org/10.1080/15248370802248556>.
- Csibra, G., Gergely, G., Bíró, S., Koós, O., & Brockbank, M. (1999). Goal attribution without agency cues: The perception of “pure reason” in infancy. *Cognition*, 72(3),

- 237–267. [https://doi.org/10.1016/S0010-0277\(99\)00039-6](https://doi.org/10.1016/S0010-0277(99)00039-6).
- Dennett, D. C. (1987). *The intentional stance*. Cambridge, Mass: MIT Press.
- Dennett, D. C. (2017). *From bacteria to Bach and back*. New York: W. W. Norton & Company.
- Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives*, 19(4), 25–42. <https://doi.org/10.1257/089533005775196732>.
- Gergely, G., Nádasdy, Z., Csibra, G., & Bíró, S. (1995). Taking the intentional stance at 12 months of age. *Cognition*, 56(2), 165–193. [https://doi.org/10.1016/0010-0277\(95\)00661-H](https://doi.org/10.1016/0010-0277(95)00661-H).
- Gervais, W. M., & Norenzayan, A. (2012). Analytic thinking promotes religious disbelief. *Science*, 336(27), 493–497. <https://doi.org/10.1126/science.1215647>.
- Greif, M. L., Kemler Nelson, D. G., Keil, F. C., & Gutierrez, F. (2006). What do children want to know about animals and artifacts? Domain-specific requests for information. *Psychological Science*, 17(6), 455–459. <https://doi.org/10.1111/j.1467-9280.2006.01727.x>.
- Heider, F., & Simmel, M. (1944). An experimental study of apparent behavior. *The American Journal of Psychology*, 57(2), 243–259.
- Hempel, C. G., & Oppenheim, P. (1948). Studies in the logic of explanation. *Philosophy of Science*, 15(2), 135–175.
- Heywood, B. T., & Bering, J. M. (2014). “Meant to be”: How religious beliefs and cultural religiosity affect the implicit bias to think teleologically. *Religion, Brain & Behavior*, 4(3), 183–201. <https://doi.org/10.1080/2153599X.2013.782888>.
- Huber, S., & Huber, O. W. (2012). The Centrality of Religiosity Scale (CRS). *Religions*, 3, 710–724. <https://doi.org/10.3390/rel3030710>.
- Järnefelt, E., Canfield, C. F., & Kelemen, D. (2015). The divided mind of a disbeliever: Intuitive beliefs about nature as purposefully created among different groups of non-religious adults. *Cognition*, 140, 72–88. <https://doi.org/10.1016/j.cognition.2015.02.005>.
- Järnefelt, E., Zhu, L., Canfield, C. F., Chen, M., & Kelemen, D. (2018). Reasoning about nature’s agency and design in the cultural context of China. *Religion, Brain and Behavior*, 1–23. <https://doi.org/10.1080/2153599X.2018.1449137>.
- Johnson, S. C., Booth, A., & O’Hearn, K. (2001). Inferring the goals of a nonhuman agent. *Cognitive Development*, 16(1), 637–656. [https://doi.org/10.1016/S0885-2014\(01\)00043-0](https://doi.org/10.1016/S0885-2014(01)00043-0).
- Kay, A. C., Gaucher, D., McGregor, I., & Nash, K. (2010). Religious belief as compensatory control. *Personality and Social Psychology Review*, 14(1), 37–48. <https://doi.org/10.1177/1088868309353750>.
- Kay, A. C., Moscovitch, D. A., & Laurin, K. (2010). Randomness, attributions of arousal, and belief in God. *Psychological Science*, 21(January), 8–11. <https://doi.org/10.1177/0956797609357750>.
- Keil, F. C. (1992). The origins of an autonomous biology. In M. R. Gunnar, & M. Maratsos (Eds.). *Modularity and constraints in language and cognition* (pp. 103–137). Hillsdale, New Jersey: Lawrence Erlbaum Associates.
- Keil, F. C. (1995). The growth of causal understandings of natural kinds. In D. Sperber, D. Premack, & A. J. Premack (Eds.). *Causal cognition: A multidisciplinary debate* (pp. 234–267). Oxford: Clarendon Press.
- Kelemen, D. (1999a). Beliefs about purpose: On the origins of teleological thought. In M. C. Corballis, & S. E. G. Lea (Eds.). *The descent of mind: Psychological perspectives on hominid evolution* (pp. 278–310). New York: Oxford University Press.
- Kelemen, D. (1999b). Function, goals and intention: Children’s teleological reasoning about objects. *Trends in Cognitive Sciences*, 3(12), 461–468. [https://doi.org/10.1016/S1364-6613\(99\)01402-3](https://doi.org/10.1016/S1364-6613(99)01402-3).
- Kelemen, D. (1999c). The scope of teleological thinking in preschool children. *Cognition*, 70(3), 241–272. [https://doi.org/10.1016/S0010-0277\(99\)00010-4](https://doi.org/10.1016/S0010-0277(99)00010-4).
- Kelemen, D. (1999d). Why are rocks pointy? Children’s preference for teleological explanations of the natural world. *Developmental Psychology*, 35(6), 1440–1452. <https://doi.org/10.1037/0012-1649.35.6.1440>.
- Kelemen, D. (2003). British and American children’s preferences for teleo-functional explanations of the natural world. *Cognition*, 88, 201–221. <https://doi.org/10.1016/S0.>
- Kelemen, D. (2004). Are children “intuitive theists”? Reasoning about purpose and design in nature. *Psychological Science*, 15(5), 295–301. <https://doi.org/10.1111/j.0956-7976.2004.00672.x>.
- Kelemen, D., & DiYanni, C. (2005). Intuitions about origins: Purpose and intelligent design in children’s reasoning about nature. *Journal of Cognition and Development*, 6(1), 3–31. <https://doi.org/10.1207/s15327647jcd0601>.
- Kelemen, D., & Rosset, E. (2009). The Human function compunction: Teleological explanation in adults. *Cognition*, 111(1), 138–143. <https://doi.org/10.1016/j.cognition.2009.01.001>.
- Kelemen, D., Rottman, J., & Seston, R. (2013). Professional physical scientists display tenacious teleological tendencies: Purpose-based reasoning as a cognitive default. *Journal of Experimental Psychology: General*, 142(4), 1074–1083. <https://doi.org/10.1037/a0030399>.
- Kruglanski, A. W., Atash, M. N., De Grada, E., Mannetti, L., & Pierro, A. (2013). Need for closure scale. *Measurement Instrument Database for the Social Science*. <https://doi.org/10.13072/midss.536>.
- Landau, M. J., Kay, A. C., & Whitson, J. A. (2015). Compensatory control and the appeal of a structured world. *Psychological Bulletin*, 141(3), 694–722. <https://doi.org/10.1037/a0038703>.
- Lanman, J. A. (2012). The Importance of religious displays for belief acquisition and secularization. *Journal of Contemporary Religion*, 27(1), 49–65. <https://doi.org/10.1080/13537903.2012.642726>.
- Lanman, J. A., & Buhrmester, M. D. (2016). Religious actions speak louder than words: Exposure to credibility-enhancing displays predicts theism. *Religion, Brain & Behavior*, 7(February), 1–14. <https://doi.org/10.1080/2153599X.2015.1117011>.
- Liquin, E. G., & Lombrozo, T. (2018). Structure-function fit underlies the evaluation of teleological explanations. *Cognitive Psychology*, 107(October), 22–43. <https://doi.org/10.1016/j.cogpsych.2018.09.001>.
- Lombrozo, T., Bonawitz, E. B., & Scalise, N. R. (2018). Young children’s learning and generalization of teleological and mechanistic explanations. *Journal of Cognition and Development*, 19(2), 220–232. <https://doi.org/10.1080/15248372.2018.1427099>.
- Lombrozo, T., & Carey, S. (2006). Functional explanation and the function of explanation. *Cognition*, 99(2), 167–204. <https://doi.org/10.1016/j.cognition.2004.12.009>.
- Lombrozo, T., Kelemen, D., & Zaitchik, D. (2007). Inferring design: Evidence for a preference for teleological explanations in patients with Alzheimer’s disease. *Psychological Science*, 18(11), 999–1007.
- Ma, A., & Kay, A. C. (2017). Compensatory control and ambiguity intolerance. *Organizational Behavior and Human Decision Processes*, 140, 46–61. <https://doi.org/10.1016/j.obhdp.2017.04.001>.
- Maij, D. L. R., Van Harreveld, F., Gervais, W. M., Schrag, Y., Mohr, C., & Van Elk, M. (2017). Mentalizing skills do not differentiate believers from non-believers, but credibility enhancing displays do. *PLoS ONE*, 12(8), 4–17. <https://doi.org/10.1371/journal.pone.0182764>.
- Meltzoff, A. N. (1995). Understanding the intentions of others: Re-enactment of intentions by 18-months-old children. *Developmental Psychology*, 31(September), 838–850. <https://doi.org/10.1037/0012-1649.31.5.838>.
- Neuberg, S. L., & Newsom, J. T. (1993). Personal need for structure: Individual differences in the desire for simple structure. *Journal of Personality and Social Psychology*, 65(1), 113–131.
- Norenzayan, A., Gervais, W. M., & Trzesniewski, K. H. (2012). Mentalizing deficits constrain belief in a personal god. *PLoS ONE*, 7(5), 1–8. <https://doi.org/10.1371/journal.pone.0036880>.
- Pennycook, G., Cheyne, J. A., Barr, N., Koehler, D. J., & Fugelsang, J. A. (2014). Cognitive style and religiosity: The role of conflict detection. *Memory & Cognition*, 42(1), 1–10. <https://doi.org/10.3758/s13421-013-0340-7>.
- Pennycook, G., Cheyne, J. A., Seli, P., Koehler, D. J., & Fugelsang, J. A. (2012). Analytic cognitive style predicts religious and paranormal belief. *Cognition*, 123(3), 335–346. <https://doi.org/10.1016/j.cognition.2012.03.003>.
- Reddish, P., Tok, P., & Kundt, R. (2016). Religious cognition and behaviour in autism: The role of mentalizing. *International Journal for the Psychology of Religion*, 26(2), 95–112. <https://doi.org/10.1080/10508619.2014.1003518>.
- Rosset, E. (2007). Intentional until proven otherwise: Evidence of an explanatory bias in children and adults. *Boston University*. <https://doi.org/10.3102/00346543067001043>.

- Rosset, E. (2008). It's no accident: Our bias for intentional explanations. *Cognition*, 108(3), 771–780. <https://doi.org/10.1016/j.cognition.2008.07.001>.
- Sánchez Tapia, I., Gelman, S. A., Hollander, M. A., Manczak, E. M., Mannheim, B., & Escalante, C. (2016). Development of teleological explanations in peruvian quechua-speaking and U.S. English-speaking preschoolers and adults. *Child Development*, 87(3), 747–758. <https://doi.org/10.1111/cdev.12497>.
- Tremlin, T. (2006). *Minds and gods*. New York: Oxford University Press.
- Vonk, J., & Pitzén, J. (2017). Believing in other minds: Accurate mentalizing does not predict religiosity. *Personality and Individual Differences*, 115, 70–76. <https://doi.org/10.1016/j.paid.2016.06.008>.
- Wakabayashi, A., Baron-Cohen, S., Wheelwright, S. J., Goldenfeld, N., Delaney, J., Fine, D., ... Weil, L. (2006). Development of short forms of the Empathy Quotient (EQ-Short) and the Systemizing Quotient (SQ-Short). *Personality and Individual Differences*, 41(5), 929–940. <https://doi.org/10.1016/j.paid.2006.03.017>.
- Wright, L. (1976). *Teleological explanations*. University of California Press.
- Zemla, J. C., Steiner, S. M., & Sloman, S. (2012). Analytical Thinking Predicts Less Teleological Reasoning and Religious Belief. *Proceedings of the 38th Annual Meeting of the Cognitive Science Society* (pp. 1217–1222).