The Consequences of Anthropomorphic and Teleological Beliefs in a Global Pandemic

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Abstract

To describe something in terms of its purpose or function is to describe its teleology.

Previous studies have found that teleological beliefs are positively related to anthropomorphism, and that anthropomorphism decreases the perceived unpredictability of non-human agents. In the current study, we explore these relationships using the highly salient example of beliefs about the coronavirus pandemic. Results showed that both anthropomorphism and teleology were negatively associated with perceived uncertainty and threat, and positively associated with self-reported behavioural change in response to the pandemic. These findings suggest that highly anthropomorphic and teleological individuals may view coronavirus as agentic and goal directed. While anthropomorphic and teleological beliefs may facilitate behavioural change in response to the pandemic, we found that the associated reduction in uncertainty and threat may be detrimental to behavioural change. We discuss the implications of these findings for messaging about global events more broadly.

Keywords: Teleology, Intentional Stance, Anthropomorphism, Dual-Process Theory, Coronavirus.

The Consequences of Anthropomorphic and Teleological Beliefs in a Global Pandemic

Why has coronavirus spread throughout the world? One answer to this question is that coronavirus spreads when enough individuals fail to maintain adequate social distancing or wear protective masks, thereby propagating the cycle of infection (World Health Organization, 2020). An alternative answer to this question is that coronavirus spreads throughout the world so that the virus can replicate and survive. While both answers purport to explain the spread of coronavirus, they differ in an important way. The first explanation answers what Dennett (2017) refers to as a *mechanistic why*, and the second explanation answers a *teleological why*. Whereas the mechanistic why explains the spread of coronavirus in terms of the causal factors which precede the spread of the virus, the teleological why explains the spread of coronavirus in terms of a future event which has yet to occur (Hempel & Oppenheim, 1948).

From a scientific perspective, some teleological explanations are considered controversial, and some are not. It is uncontroversial to use teleology to explain the existence of human-made artefacts. For example, “the chair exists for sitting on” would be widely accepted as true, as all human-made artefacts exist to serve whatever function they were intentionally created for (Bloom, 1996; Kelemen, 1999a; Wright, 1976). It is also uncontroversial to use teleology to explain the existence of biological traits, as such explanations are based on a consequence aetiology (Dennett, 2017; Lombrozo & Carey, 2006; Wright, 1976). For example, “eyes are for seeing” would be accepted as true by most philosophers and biologists (e.g., Dennett, 2017), because the function of “seeing”, which early eye-like structures afforded, allowed certain organisms to survive and reproduce more successfully than others. Therefore, we could say that eyes are *for* seeing, because the function of sight is the very reason why the genes for eyes spread throughout the population (Wright, 1976). Despite teleological explanations for biological traits being widely accepted

as true due to the consequence aetiology upon which they are based, most individuals tend to misunderstand natural selection as being purposeful and goal-directed (Brumby, 1984), suggesting that in many instances, acceptance of such teleological explanations may actually reflect a misbelief that eyes were *designed* to serve the future function of sight (Roberts et al., 2020).

From a scientific perspective, it is controversial to use teleology to explain biological or non-biological natural entities, for which no prior intention or consequence aetiology exists. For example, it would be controversial to claim that “rivers flow downstream to get to the ocean”, as rivers do not intend to get to the ocean, rivers were not designed to get to the ocean, and rivers do not currently flow downstream because they previously got to the ocean more successfully than other rivers. Despite the fact that teleological explanations for biological and non-biological natural entities are controversial, such explanations are widely accepted by children (Kelemen, 1999b, but see Greif et al., 2006; Keil, 1992), and to a lesser extent, adults (Kelemen et al., 2013; Roberts et al., 2020; Willard & Norenzayan, 2013). Rates of acceptance for teleological explanations about biological and non-biological natural entities have been shown to increase under time pressure to respond (Kelemen et al., 2013; Kelemen & Rosset, 2009; Mills & Frowley, 2014; Roberts et al., 2020), in the absence of formal education (Casler & Kelemen, 2008), or when semantic knowledge is impaired as a result of neurodegeneration (Lombrozo et al., 2007). Coupled with findings that rates of acceptance for teleological explanations about biological and non-biological natural entities are negatively related to the tendency to inhibit intuitively appealing yet incorrect responses to simple reasoning problems on the Cognitive Reflection Test (CRT; Roberts et al.¹, in press; Zemla et al., 2012)², this suggests that the expression of such teleological beliefs can

¹ A blinded copy of the accepted manuscript is available on OSF.

² For example, “A bat and a ball cost \$1.10 in total. If the bat costs \$1 more than the ball, how much does the ball cost?”. The intuitive but incorrect answer is that the ball costs \$0.10. However, the correct answer is that the ball costs \$0.05.

be conceptualised within a dual-process framework. According to this view, although teleological beliefs about the natural world may be inhibited through effortful thought, they remain intuitively appealing and somewhat of a default mode of explanation (Kelemen et al., 2013).

According to Kelemen (1999a, 1999b), the reason why such explanations are intuitively appealing is because teleological reasoning results from an early-developing ability to understand that intentional agents have purposes. Put another way, teleological beliefs result from the use of a predictive strategy known as the *intentional stance*, whereby beliefs and desires are attributed to an agent, and an assumption is made that the agent will act rationally in accordance with those beliefs and desires (Dennett, 1987). If an intentional stance were used to explain a person crossing the road, for example, we would assume that crossing the road is a rational course of action given the beliefs and desires of that individual. As such, we would attribute to the individual the desire of “getting to the other side”, thereby resulting in a teleological explanation of “they crossed the road to get to the other side”.

Due to an inherent need to make sense of the world, Kelemen (1999a) argues that from an early age, an intentional stance is also used to explain things other than the actions of intentional agents, resulting in teleological beliefs about things which, from a scientific perspective, lack intentions of their own. The idea that people attribute human-like motivations, intentions, and emotions to the real or imagined behaviour of non-human agents as a way to make sense of the world, is paralleled in Epley et al.'s (2007) three-factor theory of anthropomorphism. According to Epley et al. (2007), the tendency to anthropomorphise depends on the extent to which stimuli elicit knowledge about human agents, the desire for social connection, and importantly, the need to understand, predict, and control one's environment. Waytz, Morewedge, et al. (2010) found that when presented with descriptions of gadgets that performed their functions either predictably or unpredictably, participants

anthropomorphised the unpredictable gadgets significantly more than the predictable gadgets. However, while anthropomorphism can be conceptualised as a response to unpredictability in the environment, it can also be conceptualised as a trait which leads to an increase in perceived predictability. Consistent with theoretical accounts of an intentional stance being a predictive strategy used to make sense of the world (Dennett, 1987; Epley et al., 2007; Kelemen, 1999a), anthropomorphising the actions of non-human agents causes them to be viewed as more predictable (Waytz, Morewedge, et al., 2010).

Evidence suggests that the tendency to anthropomorphise facilitates teleological beliefs about biological and non-biological natural entities. Acceptance of such beliefs is positively predicted by belief in the intrinsic agency of nature (Kelemen et al., 2013), the belief that supernatural agents act intentionally (Roberts et al., 2020), and by scores on a validated measure of anthropomorphism (Roberts et al., in press; Willard et al., 2020; Willard & Norenzayan, 2013). An implication of these findings for the coronavirus pandemic, is that driven by a need to understand, predict, and control the environment, people may anthropomorphise the virus, thereby attributing it with the “goal” of spreading and causing sickness. This may have consequences for how predictable and threatening they perceive the virus to be, which ultimately, may affect their behaviour.

Just as the tendency to anthropomorphise positively predicts rates of teleological acceptance, evidence tentatively suggests that so too does belief in God. In children, there is a positive relationship between belief in intelligent design and acceptance of teleological explanations of natural phenomena (Kelemen & DiYanni, 2005). In adults, there is a positive relationship between belief in God and acceptance of teleological explanations for life events (Banerjee & Bloom, 2014; Heywood & Bering, 2014). Furthermore, after controlling for anthropomorphism and the tendency to inhibit intuitively appealing yet incorrect responses to simple reasoning problems on the CRT, there is a weak but significant positive relationship

between belief in God and acceptance of teleological explanations about biological and non-biological natural entities (Roberts et al., in press). The difference between anthropomorphism and belief in an intending creator (i.e., God), is that whereas the former reflects the use of an intentional stance, the latter may reflect the use of a design stance (Roberts et al., in press). Broadly speaking, this distinction relates to whether individuals view the natural world as an agent with intentions of its own, or as an artefact designed to serve a specific function by an intending creator. Adopting either stance could lead to the belief that “viruses mutate in order to survive”. However, the implication differs depending on the stance. If this belief results from an intentional stance, this implies that mutating to survive is something which the virus intends. Conversely, if this belief results from a design stance, this implies that mutating to survive is something which viruses were designed to do. While the result of either stance may be a belief that “viruses mutate in order to survive”, the intentional stance and design stance arguably represent distinct pathways to this belief.

Current Study

The primary aim of the current study was to investigate the consequences of anthropomorphic and teleological beliefs in relation to perceptions of threat and uncertainty about the coronavirus pandemic. If teleological reasoning results from taking an intentional stance (Kelemen, 1999a), this suggests that highly teleological individuals may be more inclined to view the virus as agentive. Anthropomorphism can increase the perceived predictability of non-human agents (Waytz, Morewedge, et al., 2010), but anthropomorphism can also increase in response to perceived unpredictability (Epley et al., 2007). In the current study, we conceptualise anthropomorphism as a trait which *shapes* our perception of the world, rather than as a state which changes *in response* to perceptions of the world. If teleological beliefs about biological and non-biological natural entities result from the use of this predictive strategy (Kelemen, 1999a; Kelemen et al., 2013; Roberts et al., in press), and

if this predictive strategy is associated with a reduction in perceived uncertainty, then by extrapolation, teleological beliefs may also be associated with reduced uncertainty.

As people find randomness and uncertainty highly aversive (e.g., Landau et al., 2015; Laurin et al., 2008; Ma & Kay, 2017), individuals who perceive the outcomes of coronavirus to be less uncertain should also perceive the outcomes as less threatening. This leads to two possibilities regarding the indirect relationships between anthropomorphic and teleological beliefs, and perceived threat. If anthropomorphic and teleological beliefs are associated with a reduction in perceived uncertainty, then conceivably, anthropomorphic and teleological beliefs may also be associated with a reduction in perceived threat. However, it is also conceivable that the opposite is true. That is, viewing coronavirus as agentic and goal-directed may be associated with increased levels of perceived threat due to the nature of that goal (i.e., spreading).³ We also investigate how teleological beliefs about biological and non-biological natural entities relate to behavioural change in response to the coronavirus pandemic (e.g., voluntarily avoiding risky social situations). It was predicted that individuals who perceived the virus as highly threatening should be more likely to self-report behavioural change in response to the pandemic.

Prior to addressing this aim, we first sought to replicate several key findings about the foundations of teleology to test the validity of a short form of the Teleological Beliefs Scale (TBS: Roberts et al., in press). The TBS is based on items originally used by Kelemen and colleagues (Kelemen et al., 2013; Kelemen & Rosset, 2009), and successfully discriminates between the teleological beliefs of religious and non-religious individuals. Using the TBS, it has been shown that teleological beliefs about biological and non-biological natural entities are positively predicted by anthropomorphism (and to a lesser extent, belief in God), and

³ Although the primary aim of this study was to explore how anthropomorphic and teleological beliefs relate to uncertainty and threat, this was also exploratory in nature due to the possible bidirectionality surrounding uncertainty and threat.

negatively predicted by the tendency to inhibit intuitions (Roberts et al., in press). Despite the positive relationship between anthropomorphism and teleological beliefs being consistent with theoretical accounts (Kelemen, 1999a), a limitation of previous findings is the measure of anthropomorphism used. Previous studies have explored the relationship between anthropomorphism and teleological beliefs using the Individual Differences in Anthropomorphism Questionnaire (IDAQ: Waytz, Cacioppo, et al., 2010), which has been criticised for its high face validity and use of abstract philosophical concepts (Neave et al., 2015). For example, one question reads “to what extent does a tree have a mind of its own?”. Although it is highly anthropomorphic to believe that a tree “has a mind of its own”, this question requires reflection on what it means to “have a mind”. In the current study, we aimed to replicate previous findings (Roberts et al., in press; Willard et al., 2020; Willard & Norenzayan, 2013) by using a shortened version of the TBS, and to extend these findings by including an additional measure of anthropomorphism - the Anthropomorphism Questionnaire (AQ: Neave et al., 2015) - which focuses on childhood and adulthood experiences rather than abstract philosophical concepts. We also sought to test whether these same predictors of teleological beliefs about biological and non-biological natural entities (i.e., anthropomorphism, belief in God, and inhibition of intuitions), predict acceptance of teleological statements about the coronavirus specifically.

Methods

Ethical Statement and Data Availability

This study was granted ethical clearance by the Macquarie University Human Research Ethics Committee (protocol number 5201949787325), under the project titled “The Intentional Stance and Teleological Endorsement”. The preregistration, materials, data, analysis code, and codebook for interpreting the data file are stored on OSF (see anonymised link on title page).

Participants

We recruited 306 participants through the online recruitment service, Prolific. In earlier work, we found a partial R^2 of .100 for the effect of anthropomorphism in a model with belief in God and inhibition of intuitions predicting teleological acceptance (Roberts et al., in press). An a-priori power analysis using G-Power 3.1.9.7 (Erdfelder et al., 2009; Faul et al., 2007), indicated that a sample size of 119 would be required to detect an effect of this size using a two-tailed test with power of .95 and an alpha of .05. However, as there were several novel aspects to the current study (i.e., the additional measure of anthropomorphism and investigation of how anthropomorphic and teleological beliefs relate to perceived uncertainty, threat, and behavioural change in response to the coronavirus pandemic), there was little prior research on which to base other estimates of effect size. Therefore, we took a conservative approach and aimed for a high-powered study with the final sample size determined by budgetary constraints. Our target sample size was pre-registered at (see anonymised link on title page).

The study took approximately 25 minutes to complete, and participants were paid at the rate of £6.36 per hour. All participants were native English speakers and current residents of the United Kingdom. To ensure that the religious beliefs of participants in this sample were not confounded by beliefs related to the intrinsic agency of nature, only individuals who identified as non-religious or from an Abrahamic affiliation were eligible to participate. According to our pre-registered criteria (masked link provided on title page), four participants were excluded for answering less than 80% of control items correctly, and four were excluded for indicating a religious affiliation other than non-religious or Abrahamic. A further nine participants were excluded for providing extreme responses ($Z > \pm 4$) to questions about perceived uncertainty and threat. The final sample included 289 participants

(97 males and 192 females), comprised of 65 Agnostics, 109 Atheists, 108 Christians, three Jews, and four Muslims. Ages ranged from 18 to 78 ($M = 35.64$, $SD = 12.70$).

Materials

Teleological and Causal Beliefs

Teleological Beliefs Scale. Participants responded to a shortened version of the Teleological Beliefs Scale (TBS; Roberts et al., in press). The s-TBS contains 48 statements, including 14 test statements about non-biological natural entities (e.g., “Rocks roll downhill in order to come to rest at the bottom”), 14 test statements about biological entities (e.g., “Earthworms tunnel underground in order to aerate the soil”), five true causal control statements (e.g., “Objects fall downwards because they are affected by gravity”), five false causal control statements (e.g., “Cars use petrol because they have four wheels”), five true teleological control statements (e.g., “Children wear mittens in the winter in order to keep their hands warm”), and five false teleological control statements (e.g., “Noses exist in order to support glasses”). Participants responded *True* or *False* to each statement, and a total score for each category was calculated as the proportion of statements endorsed. The difference between the shortened and full versions of the TBS is that the full version contains an additional 50 control statements to balance the number of “True” and “False” responses, as well as the number of teleological and causal statements. The teleological test statements displayed excellent internal consistency ($\alpha = .93$).

Beliefs about COVID-19. Participants were presented with seven teleological statements specific to COVID-19 (e.g., “The goal of some viruses, such as COVID-19, is to make people sick”), and five causal statements specific to COVID-19 (e.g., “Viruses, such as COVID-19, survive because they mutate”)⁴. All statements were scored on a scale from 0

⁴ Although COVID-19 is the disease caused by SARS-CoV-2, we chose to refer to the virus as “COVID-19” rather than “coronavirus”. We did this because there are many coronaviruses and we wished to focus on the specific coronavirus which caused the pandemic. The high rates of agreement for both teleological and causal statements suggest participants interpreted these statements as intended.

(*Strongly disagree*) to 6 (*Strongly agree*). Total scores for teleological and causal statements were obtained by taking the mean of all relevant items. Scores for each statement type therefore had a potential range of 0 to 6, with higher scores representing greater acceptance of teleological and causal beliefs about COVID-19.

Foundations of Teleological Beliefs

Anthropomorphism. To measure the extent to which anthropomorphism predicts teleological beliefs, participants responded to two scales measuring different aspects of trait anthropomorphism.

Individual Differences in Anthropomorphism Questionnaire. The Individual Differences in Anthropomorphism Questionnaire (IDAQ; Waytz et al., 2010) includes 15 questions assessing the extent to which people believe that non-human entities have cognition, free-will, consciousness, intentionality, and emotions (e.g., “To what extent does a tree have a mind of its own?”). All questions are scored on a scale from 0 (*Not at all*) to 10 (*Very much*). A total score is obtained by summing all 15 items, such that scores have a potential range of 0 to 150. The IDAQ displayed good internal consistency ($\alpha = .87$).

Anthropomorphism Questionnaire. The Anthropomorphism Questionnaire (AQ; Neave et al., 2015) includes 20 items assessing anthropomorphic thoughts and behaviours during childhood (e.g., “As a child, I felt at times that some of my toys were in a bad mood”) and adulthood (e.g., “I sometimes wonder if my computer deliberately runs more slowly after I have shouted at it”). All items are scored on a scale from 0 (*Not at all*) to 6 (*Very much so*). A total score is obtained by summing all 20 items, such that scores have a potential range of 0 to 120. Internal consistency for the AQ was excellent ($\alpha = .93$).

Religious Belief. Participants were presented with a reduced version of the Centrality of Religiosity Scale (r-CRS; Huber & Huber, 2012; Roberts et al., in press). Whereas the full version of the CRS contains 15 questions across five subscales, the r-CRS contains nine

questions across three subscales: Ideology (e.g., “To what extent do you believe that God or something divine exists?”), Experience (e.g., “How often do you experience situations in which you have the feeling that God or something divine intervenes in your life?”), and Private Practise (e.g., “How often do you pray?”). The two subscales not included in the r-CRS are Intellect (e.g., “How often do you think about religious issues?”), and Public Practise (e.g., “How often do you take part in religious services?”). The reason for using the reduced scale is that people could plausibly score high on questions from the Intellect and Public Practice subscales without believing in God (Roberts et al, in press). For two of the questions in the Private Practise subscale, responses were made on an eight-point scale from 1 (*Never*) to 8 (*Several times a day*), and then recoded to a five-point scale. The remaining seven questions were scored on a five-point scale from 1 (*Never / Not at all*) to 5 (*Very often / Very much so*). A total score is obtained by taking the mean of all items. The r-CRS displayed excellent internal consistency ($\alpha = .96$).

Inhibition of Intuitions. To measure the extent to which the tendency to inhibit intuitions negatively predicts teleological acceptance, participants completed an extended version of the Cognitive Reflection Test (CRT). This extended version of the CRT includes slightly re-worded versions of the original three-item CRT (Frederick, 2005), plus four less math-focused questions (Thomson & Oppenheimer, 2016). The reason for using the extended CRT with re-worded versions of the original items, is that prior exposure to the original CRT is common (Haigh, 2016). Each question has an intuitively appealing, yet incorrect answer (e.g., “The ages of Mark and Adam add up to 28 years. Mark is 20 years older than Adam. How many years old is Adam?”), which must be inhibited to arrive at the correct response. The final score on the CRT is obtained by summing the number of correct responses, such that scores have a possible range of 0 to 7, with higher scores indicating a

greater tendency to inhibit intuitions. The internal consistency of the CRT was adequate ($\alpha = .68$).

Consequences of Teleological Foundations for the Pandemic

Threat. To measure the level of perceived threat, participants were presented with five free-response questions (e.g., “Over the next seven days, how many deaths do you think there will be in the United Kingdom as a result of COVID-19?”). As some questions asked about the number of predicted deaths, whereas others asked about the number of predicted cases (e.g., “In your opinion, across the entire world, how many million cases of COVID-19 will there have been once this is all over?”), responses to each question were not comparable in terms of magnitude. Although we originally planned to analyse perceived threat and uncertainty using a rank-sum approach, we instead generated standardised scores for each response and summed these to create a total score for each measure. The reason for this deviation from the preregistration was that standardised scores better capture the true distribution of responses. At the time this study was conducted (May 8th, 2020), there had been approximately 200,000 cases and 30,000 deaths attributable to COVID-19 in the United Kingdom.

Uncertainty. After answering each free-response threat question, participants were reminded of their answer and were asked to predict the lowest and highest plausible numbers around their initial response (e.g., “You indicated that over the next seven days, you think there will be _____ deaths in the United Kingdom as a result of COVID-19. In the spaces below, please indicate what you think the lowest and highest number of deaths could plausibly be over the next seven days.”). Confidence intervals for each question were then calculated by subtracting the low from the high response. Standardised scores were calculated for each question, and a total score was obtained by summing the standardised scores. We also collected subjective certainty ratings, where participants were asked how

certain they felt about their initial free-response on a scale from 0 (*Absolutely uncertain*) to 10 (*Absolutely certain*). However, here we report the results from the confidence interval questions, as we believe these are a better indicator of uncertainty.⁵

Behavioural Change. Participants were asked nine questions about the extent to which they changed their behaviour in response to the pandemic (e.g., “Have you voluntarily changed your social activities – e.g., avoiding face-to-face interaction?”). All questions were scored on a scale from 0 (*Not at all*), to 6 (*Very much so*), and a total score was calculated by summing responses to all nine questions.⁶ Scores had a potential range of 0 to 54, with higher scores representing greater behavioural change in response to the pandemic. The questions on behavioural change displayed acceptable internal consistency ($\alpha = .75$).

Procedure

After providing informed consent, participants first responded to the COVID-19 teleological and causal belief questions. Next, participants responded to the questions about perceived threat and uncertainty. Each threat question was immediately followed by the relevant free-response uncertainty question. Participants then responded to the questions about behavioural change, the shortened-Teleological Beliefs Scale, Anthropomorphism Questionnaire, Individual Differences in Anthropomorphism Questionnaire, Cognitive Reflection Test, reduced-Centrality of Religiosity Scale, and finally, provided demographic information. We report all manipulations, measures, and exclusions in this study. Unless stated otherwise, analyses were performed using SPSS Version 27 (IBM Corp, 2020).

Results

⁵ As participants provided a single number in response to the threat questions, we decided it was not plausible they could feel “absolutely certain” about their response. For example, if asked to judge the number of beads in a jar, it is unlikely that someone could feel “absolutely certain” that the correct answer was 1608 beads. In contrast, someone might feel confident that the correct answer was between 1000 and 2000 beads. Similarly, it seems unlikely that someone would provide a free response which they felt “absolutely uncertain” about. As such, responses to the Likert scale uncertainty questions are not discussed further.

⁶ Participants were also asked where they got most of their coronavirus-related news from, and to specify what other behaviours, if any, they had changed. These were included for exploratory purposes only and are not discussed further.

Scale Reliability and Discriminant Validity

We first investigated the psychometric properties of the s-TBS. Due to the binary response options on the s-TBS, to ensure the internal consistency of the teleological test statements in the scale, tetrachoric correlations were calculated (e.g., Woods, 2002) and a Principle Components Analysis (PCA) was conducted on each category of test statements separately. The PCAs revealed that both categories of test statements loaded strongly onto single components. For biological test statements, the eigenvalue for the first component (7.43) was substantially larger than the second (1.28). Likewise, for non-biological test statements, the eigenvalue for the first component (8.07), was substantially larger than the second (1.01). As shown in Figure 1., the point of inflection was on the second component for both categories of test statements, suggesting the assumption of unidimensionality was met. The biological ($\alpha = .85$) and non-biological test statements ($\alpha = .88$) displayed excellent internal consistency. A summary of the minimum, maximum, and mean endorsement for each category of statements is shown in Table 1.

Figure 1

Component Loadings of Biological and Non-Biological Test Statements

Table 1*Minimum, Maximum, and Mean Endorsement of the Shortened-Teleological Beliefs Scale*

	Min	Max	<i>M</i>
Non-Biological	0.20 (0.40)	0.64 (0.48)	0.37 (0.29)
Biological	0.24 (0.43)	0.77 (0.42)	0.45 (0.27)
True Causal	0.96 (0.19)	0.99 (0.08)	0.98 (0.07)
True Teleological	0.98 (0.14)	1.00 (0.06)	0.99 (0.05)
False Causal	0.00 (0.06)	0.06 (0.24)	0.03 (0.09)
False Teleological	0.00 (0.06)	0.01 (0.10)	0.01 (0.04)

Note. Min and Max represent the means for the item with the lowest and highest endorsement in each category, respectively. $N = 289$.

To ensure the s-TBS successfully discriminates between the teleological beliefs of religious and non-religious individuals, we conducted a 2 (religious group) x 6 (s-TBS statement-type) mixed ANOVA. For comparability across statement types, responses to test statements and false control statements were reverse-coded, such that higher scores represented greater accuracy rather than greater acceptance. The main effects of religious group, $F(1, 287) = 9.36, p = .002, \eta^2 = .032$, and statement-type, $F(5, 1435) = 538.28, p < .001, \eta^2 = .652$, were both significant, but as shown in Figure 2, were qualified by a significant religious group by statement-type interaction, $F(5, 1435) = 7.07, p = .002, \eta^2 = .024$.

This interaction revealed that the difference in accuracy between the religious ($M = .52, SD = .26$) and non-religious group ($M = .62, SD = .27$) on test statements $95\%CI_{diff} [.03, .16]$, was significantly larger than the difference between the religious ($M = .98, SD = .04$) and non-religious group ($M = .98, SD = .03$) on control statements on average, $95\%CI_{diff} [-.004, .01], F(1, 287) = 8.83, p = .003, \eta^2 = .030$. The difference between groups on test statements was also significantly larger than the difference between the religious ($M = .99, SD = .05$) and non-religious group ($M = .99, SD = .03$) on teleological control statements,

95% CI_{diff} [-.002, .01], $F(1, 287) = 8.16$, $p = .005$, $\eta p^2 = .028$, and significantly larger than the difference between the religious ($M = .98$, $SD = .05$) and non-religious group ($M = .98$, $SD = .05$) on false control statements, 95% CI_{diff} [-.01, .01], $F(1, 287) = 10.14$, $p = .002$, $\eta p^2 = .034$. This shows that group differences on test statements are not explained by general inaccuracy, a difficulty in responding to teleological control statements, or by a tendency to accept explanations which are objectively false.

Predictors of Teleology

Next, we sought to replicate the positive relationship between anthropomorphism (IDAQ) and teleological beliefs about biological and non-biological natural entities, and to extend these findings by using the AQ. As scores on the teleological test statements were

correlated with accuracy for false control statements ($r = -.24, p < .001$) but not true control statements ($r < .01, p = .989$), we ran a one-way repeated-measures ANCOVA comparing accuracy for teleological test statements and false control statements, with anthropomorphism, belief in God (r-CRS), and inhibition of intuitions (CRT) as predictors.⁷

In the model using the IDAQ, the main effect of statement-type was highly significant, with higher accuracy for false control ($M = .98, SE < .01$) than teleological test statements ($M = .58, SE = .01$), $95\%CI_{diff} [.38, .43]$, $F(1, 285) = 61.40, p < .001, \eta^2 = .177$. The effects of anthropomorphism, $F(1, 285) = 16.16, p < .001, \eta^2 = .054$, and inhibition of intuitions were also significant, $F(1, 285) = 39.22, p < .001, \eta^2 = .121$, whereas the effect of belief in God was non-significant, $F(1, 285) = 3.31, p = .070, \eta^2 = .011$. There were significant interactions between statement-type and anthropomorphism, $F(1, 285) = 20.79, p < .001, \eta^2 = .068$, statement-type and inhibition of intuitions, $F(1, 285) = 37.94, p < .001, \eta^2 = .117$, and statement-type and belief in God, $F(1, 285) = 4.01, p = .046, \eta^2 = .014$. Examination of parameter estimates in Table 2 revealed that anthropomorphism negatively predicted accuracy for teleological test statements but not false control statements, whereas inhibition of intuitions positively predicted accuracy for teleological test statements but not false control statements. The effect of belief in God was marginally significant for teleological test statements, and trending in the expected direction.

⁷ We also explored whether anthropomorphism, belief in God, and inhibition of intuitions predicted teleological beliefs about COVID-19. Using both the IDAQ and AQ, agreement with teleological statements was positively predicted by anthropomorphism and negatively predicted by inhibition of intuitions. These results are shown in the Supplementary Materials (Tables S1 to S4).

Table 2*Parameter Estimates from ANCOVA with s-TBS Statement-Type, IDAQ, r-CRS, and CRT*

	Teleological Test Statements					False Control Statements				
	<i>Beta</i>	<i>SE</i>	<i>t</i>	<i>p</i>	<i>95%CI</i>	<i>Beta</i>	<i>SE</i>	<i>t</i>	<i>p</i>	<i>95%CI</i>
IDAQ	-.24	<.01	-4.36	<.001	-.34, -.13	0.02	<.01	0.39	.699	-.10, .14
r-CRS	-.11	<.01	-1.94	.053	-.22, <.01	0.98	<.01	0.03	.980	-.12, .12
CRT	.34	.01	6.10	<.001	.23, .44	0.09	<.01	1.68	.094	-.02, .22

Note. Coefficients and confidence intervals are standardised to allow for comparison across predictors.

The results using the AQ were similar to those using the IDAQ. The main effect of statement-type was highly significant, with higher accuracy for false control ($M = .98$, $SE < .01$) than teleological test statements ($M = .57$, $SE = .01$), $95\%CI_{diff} [.38, .43]$, $F(1, 285) = 99.93$, $p < .001$, $\eta^2 = .260$. The effects of anthropomorphism, $F(1, 285) = 13.06$, $p < .001$, $\eta^2 = .044$, and inhibition of intuitions were significant, $F(1, 285) = 34.73$, $p < .001$, $\eta^2 = .106$, whereas belief in God was non-significant, $F(1, 285) = 2.21$, $p = .138$, $\eta^2 = .008$. Again, there were significant interactions between statement-type and anthropomorphism, $F(1, 285) = 15.58$, $p < .001$, $\eta^2 = .052$, and statement-type and inhibition of intuitions, $F(1, 285) = 32.94$, $p < .001$, $\eta^2 = .104$. In contrast to the previous analysis, there was no significant interaction between statement-type and belief in God, $F(1, 285) = 2.76$, $p = .097$, $\eta^2 = .010$. Examination of parameter estimates in Table 3 revealed that the AQ negatively predicted accuracy for teleological test statements but not false control statements, whereas the CRT positively predicted accuracy for teleological test statements but not for false control statements. The r-CRS was non-significant for both statement-types.

Table 3*Parameter Estimates from ANCOVA with s-TBS Statement-Type, AQ, r-CRS, and CRT*

	Teleological Test Statements					False Control Statements				
	<i>Beta</i>	<i>SE</i>	<i>t</i>	<i>p</i>	<i>95%CI</i>	<i>Beta</i>	<i>SE</i>	<i>t</i>	<i>p</i>	<i>95%CI</i>
AQ	-.22	<.01	-3.84	<.001	-.33, -.11	<0.01	<.01	0.01	.990	-.12, .12
r-CRS	-.09	<.01	-1.60	.110	-.20, .02	0.01	<.01	0.10	.923	-.12, .13
CRT	.32	.01	5.93	<.001	-.33, -.11	0.10	<.01	1.68	.095	-.02, .22

Note. Coefficients and confidence intervals are standardised to allow for comparison across predictors.

Consequences of Anthropomorphic and Teleological Beliefs

The primary aim of the current study was to explore the consequences of anthropomorphic and teleological beliefs in the context of the coronavirus pandemic. Bivariate correlations (Table 4) revealed that both measures of anthropomorphism (IDAQ and AQ) displayed significant negative relationships with perceived uncertainty and threat. Both the IDAQ and AQ also displayed significant positive relationships with behavioural change. Unexpectedly, COVID-19 teleological beliefs were not significantly correlated with perceived uncertainty or threat, but were positively related to behavioural change. Importantly, in support of an intention-based theory of teleology and the potential utility of the s-TBS, teleological beliefs about biological and non-biological natural entities displayed significant negative correlations with perceived uncertainty and threat, and a significant positive correlation with behavioural change.

Table 4*Correlations Between Anthropomorphism, Teleology, and Outcomes for the Coronavirus Pandemic*

	1	2	3	4	5	6	7
1. IDAQ	-						
	-						
2. AQ	.551*** [.47, .63]	-					
3. s-TBS	.260*** [.15, .37]	.274*** [.16, .38]	-				
4. COVID-T	.135* [.02, .25]	.186*** [.07, .30]	.291*** [.18, .39]	-			
5. Uncertainty	-.160** [-.27, -.05]	-.193*** [-.30, -.08]	-.231*** [-.34, -.12]	-.018 [-.13, .10]	-		
6. Threat	-.166** [-.28, -.05]	-.157** [-.27, -.04]	-.164** [-.28, -.05]	.043 [-.07, .16]	.488*** [.40, .57]	-	
7. Behaviour	.125* [.01, .24]	.253*** [.14, .36]	.219*** [.11, .33]	.304*** [.20, .41]	-.034 [-.15, .08]	.139* [.02, .25]	-

Note. Pearson's r shown with 95% confidence intervals below [L, U]. $N = 289$ for all correlations. s-TBS and COVID-T refer to endorsement of teleological test statements on the s-TBS, and agreement with teleological statements about COVID-19, respectively.

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

The significant negative relationships between both measures of anthropomorphism and perceived uncertainty and threat are consistent with findings that anthropomorphism can increase the perceived predictability of non-human agents (Waytz, Morewedge, et al., 2010), and suggest that highly anthropomorphic individuals view coronavirus as more predictable and less threatening. The significant negative relationships between teleological beliefs on the s-TBS and perceived uncertainty and threat provide support for an intention-based theory of teleology (Kelemen, 1999a), by suggesting that highly teleological individuals also tend to view coronavirus as agentive, predictable, and less threatening. As a stronger test of our hypothesis that anthropomorphic and teleological beliefs may have behavioural consequences in the context of the pandemic, we investigated whether perceived uncertainty and threat mediate the relationships between both anthropomorphism and behavioural change, and

teleology (s-TBS) and behavioural change. This analysis was performed using Stata Version 16 (StataCorp, 2019).

As the IDAQ and AQ were both significant predictors of teleological beliefs about biological and non-biological natural entities (Tables 2 & 3), and as they were strongly and significantly correlated with each other (Table 4), a combined anthropomorphism score was calculated by standardising both scales and taking the mean. The model was an excellent fit for the data, $\chi^2(3) = 4.23, p = .232$; RMSEA = 0.039, $p_{close} = .500$; CFI = 0.990; TLI = 0.971; SRMR = 0.030. As shown in Figure 3, the direct effects of anthropomorphism and teleology on behavioural change were highly significant and positive. There were also significant negative indirect effects of teleology and anthropomorphism on behavioural change. While anthropomorphic and teleological beliefs have positive direct effects on behavioural change, due to the reduction in perceived uncertainty and threat associated with anthropomorphic and teleological beliefs, they also have negative indirect effects on behavioural change.

Figure 3. Path diagram showing relationships between anthropomorphism (standardised mean of IDAQ and AQ), teleological beliefs about biological and non-biological natural entities (s-TBS), perceived uncertainty, threat, and behavioural change. All coefficients are standardised.

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

Discussion

An intention-based theory of teleology suggests that the tendency to explain the world in terms of function, is based on an understanding that intentional agents have purposes (Kelemen, 1999a). The coronavirus pandemic provides an opportunity to test not only the theoretical foundations, but the consequences of teleological beliefs within an intention-based framework. In terms of the foundations of teleological beliefs, consistent with previous findings (Roberts et al., in press), after controlling for belief in God and inhibition of intuitions, the tendency to anthropomorphise was a significant positive predictor of teleological beliefs about biological and non-biological natural entities. This same pattern of results held for teleological beliefs relating specifically to the coronavirus pandemic, suggesting that the tendency to attribute human-like motivations, intentions, and emotions to the real or imagined behaviour of non-human agents (i.e., the tendency to anthropomorphise: Epley et al., 2007), relates strongly to the formation of teleological beliefs. While the relationship between anthropomorphism and teleological beliefs about biological and non-biological natural entities has been reported elsewhere using the IDAQ (Roberts et al., in press; Willard et al., 2020; Willard & Norenzayan, 2013), this scale has been criticised for requiring reflection on abstract philosophical concepts (e.g., "free will"; Neave et al., 2015). Furthermore, as it relates to teleological beliefs about the natural world, a potential criticism of the IDAQ could be that some of the questions measure anthropomorphic beliefs about the natural world (e.g., "To what extent does the ocean have consciousness?"). That the AQ produced similar results to the IDAQ, strengthens confidence in previous findings that anthropomorphism facilitates teleological beliefs about the natural world.

Consistent with previous research using the CRT (Roberts et al., in press; Zemla et al., 2012), the tendency to inhibit intuitions was a significant negative predictor both of teleological acceptance on the s-TBS, and of agreement with teleological explanations

specifically about COVID-19. Together with results showing that rates of teleological acceptance increase in the absence of formal education (Casler & Kelemen, 2008), when semantic knowledge is impaired as a result of neurodegeneration (Lombrozo et al., 2007), or when participants are under time pressure to respond (Kelemen et al., 2013; Kelemen & Rosset, 2009; Mills & Frowley, 2014; Roberts et al., 2020), this provides strong converging evidence in support of the idea that an intention-based theory of teleology can be conceptualised within a dual-process framework. According to this view, teleological beliefs result from fast, automatic cognitive processes, and to inhibit these beliefs requires engagement of slower, effortful cognitive processes. Indeed, so intuitively appealing are teleological beliefs about biological and non-biological natural entities, that they have even been described as a “developmentally persistent cognitive default” (Kelemen et al., 2013, p. 1075). The current results support this view, by showing that individuals with a greater tendency to inhibit their intuitions on the CRT, are also less accepting of teleological test statements on the s-TBS.

Although some studies have found that belief in God positively predicts teleological acceptance (Banerjee & Bloom, 2014; Heywood & Bering, 2014; Kelemen & DiYanni, 2005; Roberts et al., in press), in the current study, the evidence was mixed. In a model with anthropomorphism and inhibition of intuitions, belief in God was a marginally significant predictor of teleological beliefs when anthropomorphism was measured using the IDAQ. However, when measuring anthropomorphism using the AQ, belief in God was non-significant. This is not the first study to find only weak evidence for the unique effect of belief in God in predicting teleological beliefs about biological and non-biological natural entities. For example, after controlling for belief in natural selection and belief in the existence of souls, Kelemen and Rosset (2009) found no evidence that belief in God predicted teleological acceptance. Likewise, after controlling for a belief that “Nature is a

powerful being”, Kelemen et al. (2013) found no evidence to suggest that belief in God predicted teleological acceptance in professional scientists or humanities academics. However, these researchers did find a relationship between belief in God and teleological acceptance in an undergraduate and community sample. While the inconsistencies across studies may be partly due to sampling error or cross-cultural differences, in combination, they seem to suggest that anthropomorphism is a stronger predictor of teleology than a belief in God is. However, this variation across studies further highlights a need for the consistent use of one scale to measure teleological beliefs. By providing evidence for the reliability and validity of a shortened version of the Teleological Beliefs Scale, the current study helps to address this need.

It is worth noting that the current study only recruited individuals residing in the United Kingdom. It was necessary to restrict participation to a single country due to variability in the severity of the pandemic and governmental responses across nations – both of which may affect perceptions of uncertainty and threat (Kay et al., 2008). However, given the consistency with previous findings relating to the foundations of teleological beliefs in North American (e.g., Kelemen et al., 2013; Kelemen & Rosset, 2009; Zemla et al., 2012) and Australian samples (Roberts et al., 2020), this suggests our results may be generalisable beyond United Kingdom residents. It could be argued that a further limitation of the current study is that not all the teleological statements about COVID-19 were controversial from a scientific perspective. For example, the belief that “COVID-19 spreads throughout the population in order to infect new hosts”, could be based on an understanding that teleological explanations can result from a function-driven causal process (i.e., natural selection; Lombrozo & Carey, 2006). However, as the majority of individuals misunderstand natural selection as being goal-directed and purposeful (Brumby, 1984), it is likely that agreement with such statements was based on a misbelief that coronavirus spreads with the *intention* of

infecting new hosts, rather than an understanding of the function-driven causal process of natural selection. The positive relationship between anthropomorphism and agreement with these teleological statements suggests this is the case.

A major strength of the current study was to expand upon previous research by focussing not only on the foundations of teleological beliefs, but also on the real-world outcomes of anthropomorphism, and indeed, of teleological beliefs themselves. Consistent with an intention-based theory of teleology (Kelemen, 1999a), the three-factor theory of anthropomorphism (Epley et al., 2007; Waytz, Morewedge, et al., 2010), and philosophical accounts (Dennett, 1987), anthropomorphism was associated with lower perceived uncertainty and threat in relation to the coronavirus pandemic. These findings strongly support the view that such teleological beliefs reflect an anthropomorphic view of nature, and provide evidence for the utility of the s-TBS.

The real-world importance of the relationships between anthropomorphism, teleology, and perceived uncertainty and threat, is in the manifestation of behaviour. Consistent with research showing that people find uncertainty and randomness highly aversive (e.g., Landau et al., 2015; Laurin et al., 2008; Ma & Kay, 2017), we found a strong positive relationship between perceived uncertainty and threat. That is, the less certain participants were about the possible range of positive cases, number of deaths, or duration of the pandemic, the more severe they believed each of these outcomes to be. Furthermore, the significant positive relationship between perceived threat and behavioural change, suggests that anthropomorphic and teleological beliefs have indirect effects on behavioural change through perceived uncertainty and threat. Due to the negative relationships between both anthropomorphism and uncertainty, and teleological beliefs and uncertainty, these indirect effects are such that viewing the natural world as agentic and goal-directed is associated with a more predictable and less threatening view of coronavirus, which in turn, is associated with less behavioural

change. However, we also found significant direct effects between both anthropomorphism and behavioural change, and teleology and behavioural change. In contrast to the negative indirect effects, this suggests that highly anthropomorphic and teleological individuals are more likely to change their behaviour in response to the pandemic.

Although anthropomorphic and teleological beliefs may encourage behavioural change in response to the coronavirus pandemic, the reduction in perceived uncertainty and threat associated with anthropomorphic and teleological beliefs may be detrimental to behavioural change. Therefore, while encouraging agentive views of coronavirus may benefit public health efforts in response to the pandemic, given that anthropomorphism increases the perceived predictability of non-human agents (Waytz, Morewedge, et al., 2010), such efforts should be careful not to downplay the unpredictability or threat of the virus in the process of encouraging an anthropomorphic perspective. A promising avenue of future research may be to investigate how anthropomorphic and teleological beliefs, as measured by the s-TBS, directly and indirectly relate to behavioural responses to the threat of climate-change. Scores on the IDAQ positively correlate with environmental concern (Waytz, Cacioppo, et al., 2010), suggesting that highly anthropomorphic individuals may be more willing to change their behaviour to protect the environment. However, given the theoretical (Dennett, 1987; Epley et al., 2007) and empirical evidence (Waytz, Morewedge, et al., 2010) suggesting that anthropomorphic and teleological beliefs may be associated with a reduction in perceived uncertainty and threat in relation to climate-change, it is crucial to explore the outcomes of anthropomorphic and teleological beliefs in this context.

In summary, the current study builds on previous work (e.g., Banerjee & Bloom, 2014; Heywood & Bering, 2014; Kelemen et al., 2013; Kelemen & Rosset, 2009; Roberts et al., in press) by providing evidence for the reliability, validity, and utility of a shortened version of the Teleological Beliefs Scale. Our results suggest that teleological beliefs about

the natural world are facilitated by anthropomorphism and are constrained by the extent to which individuals inhibit their intuitions. Furthermore, consistent with theoretical accounts (e.g., Dennett, 1987; Epley et al., 2007) and prior empirical work (Waytz, Morewedge, et al., 2010), we found that anthropomorphism and teleological beliefs were associated with lower perceived uncertainty and threat, but greater self-reported behavioural change in response to the coronavirus pandemic. These findings highlight both the complexity of how anthropomorphic and teleological beliefs can manifest in behaviour, as well as the importance of understanding such processes. The cognitive foundations of teleological beliefs, and indeed, teleological beliefs themselves, not only shape our perception of the world, but may also affect our behaviour in response to it.

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