Religion-related values differently influences moral attitude for robots in the US and Japan

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29 **Abstract:** Increasing evidences report that people show moral concern for robots, non-
30 human entities. People's attitudes toward new automation technologies such as robots and
31 AI are influenced by their social backgrounds, including religion. Religion-related values,
32 animism and anthropocentrism, has been recognised to be influential on
33 preference/familiarity toward robots. However, how they affect moral care for robots under
34 different religious tradition has not been studied. Here, we empirically examined how moral
35 care for robots is influenced by religiosity and religion-related values with US and Japanese
36 samples, cultures that are Abrahamic and Shinto-Buddhist traditions respectively (N = 3781).
37 Overall, moral care for robots was higher in Japan than in the US, matching descriptions by
38 previous authors. Moral care for robots was negatively associated with religiosity in the US
39 and positively in Japan, although its variance was better explained by religion-related value
40 than by religiosity itself. Further, moral care for robots had a negative association with
41 anthropocentrism in the US, while, in Japan, it had a positive association with animism. The
42 finding demonstrates how religious tradition could influence moral attitudes for robots, and
43 might suggest the realm of moral consideration could be shaped by cultural traditions.

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45 **Keywords:** human-robot interaction, religion, moral foundation theory, care, cross-cultural
46 study

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Introduction

In 2015, the robotic company Boston Dynamic launched a video of the robotic dog, ‘Spot’, being kicked by the company's staff. This video was intended to demonstrate its ability to maintain stability under unstable physical conditions. Instead, this video evoked a variety of moral and ethical concerns on social media, with some sympathizing with Spot and condemning the perceived violence against the robot, and others ridiculing this reaction (Parke, 2015). Similarly, when hitchhiking humanoid ‘hitchBOT’ broke down on its journey, some blamed an unspecified person (or people) who broke the robot as morally wrong, while others did not (Fraser et al., 2019). Bartneck and Keijsers (2020) reported that people viewed abuse toward robots as similarly unacceptable as abuse toward humans.

Research about whether robots deserve moral consideration or whether robots can be a “moral patient” (i.e., target of moral consideration) is receiving increasing attention (Shevlin, 2021). However, the effect of cultural background on one’s views about moral attitudes toward robots has not been well explored. The importance of social and cultural background has been suggested, as Coeckelberg (2018) argues that to understand moral consideration toward robots (hereafter we call this type of moral consideration “moral care”), we should look beyond mere individual differences, but attend also to the relational and historical aspects of ethics, such as social and cultural background. This paper is an effort to do so, by comparing Japanese and American moral attitudes toward robots.

Religion-related values are often an important source of moral attitudes and may therefore affect moral attitudes toward robots (MacDorman et al., 2009; Halpern & Katz, 2012; Shaw-Garlock, 2009). The current study examined this idea, focusing on a specific moral attitude, that views harming of robots as morally wrong, as some people did for Spot and/or hitchBot (i.e., *care* foundation in the Moral Foundations Theory; Graham et al., 2013). In doing so, we will explore the role of values motivated by religions: anthropocentrism and animism in

particular, since previous literature suggested those two factors influence attitude toward robots (Fortuna et al., 2021; Okanda, 2019).

Anthropocentrism, religion, and moral care for robots

Anthropocentrism is "a doctrine or theory which elevates man [sic] as the center of the world and sees the well-being of humanity as the ultimate purpose of things" (Reinhardt, 1972, p.62). Christianity—and indeed Abrahamic religions more broadly—are arguably anthropocentric religions. Both in the book of Genesis (1.26-27), shared by Jews and Christians, and in the Muslim hadith, God is said to have made human beings in his own image (Melchert, 2011); the book of Genesis also mentions that human beings have been given dominion over all creatures, and this is also echoed in the Qu’ran (35.39), which calls human beings Allah’s vice-regents. The characterization of Abrahamic religions as anthropocentric is not novel, and there is some evidence for such an association. For example, Chandler (1981) reported that US Catholic participants scored significantly higher anthropocentrism scale than nonreligious participants did. Also, Fortuna et al. (2021), used a different single-factor scale and found that anthropocentrism positively correlates with religiosity in Italy, whose population is predominantly Catholic. Anthropocentrism does not per se entail that *only* human beings are worthy of moral care, but the prioritization of human beings at least risks the deprioritization of others’ moral welfare. Environmental and animal rights ethicists have already made similar criticisms of specifically Christian anthropocentrism (e.g., White, 1967). There is also some empirical evidence for this association: Fortuna et al.’s (2021) afore-mentioned study in Italy did find that anthropocentrism predicted negative attitudes toward robots.

Animism, religion, and moral care for robots

Animism has been discussed in relation to attitude toward robots (e.g., MacDorman et al., 2007). Animism is the attitude of treating inanimate objects as living. This view has been

104 closely associated with religion: among with earlier theories (e.g., Tylor, 1889),
105 anthropologists have hypothesized animistic roots in religion, or animism itself as a religious
106 phenomenon (Guthrie, 1995; Hunter & Whitten 1976:12). Furthermore, as with
107 anthropocentrism, animism is associated with some religious and cultural traditions more
108 than others. Christianity, Judaism, and Islam are not typically considered to be animistic
109 religions. In contrast, traditional Japanese religion is often considered to be animistic (Abe
110 1997; Hosaka, 2003; Allison 2006). Following this assumption, Allison (2006) provided an
111 idea that high acceptance of robots in Japan stems from Japanese cultural acceptance of
112 animism. This is a tradition under which robots are attributed life just like natural creatures
113 hence not alien to people (Gygi, 2018). A study in Japan showed that beliefs about
114 friendship and morality toward robots are positively associated with animism (Okanda,
115 2019). In the US, however, attitudes toward robots have not been empirically studied in
116 relation to animism.

119 ***The current study***

120 In the current study, we focus on whether people regard robots being harmed—like Spot and
121 hitchBOT—as morally wrong. Following MacDorman et al. (2009) we compare American
122 and Japanese attitudes, adding to this comparison Katz and Halpern’s (2013) interest in
123 religiosity. We predict that Japanese people are more likely to show more moral care for
124 robots than US Americans (H1). We also examine the effect of religiosity and religion-related
125 anthropocentrism and animism. In doing so, we expect the cross-cultural effect of religiosity,
126 which is suggested to be associated with non-acceptance of robots in the US and acceptance
127 of robots in Japan as discussed above, on moral care for robots: religiosity will affect moral
128 care for robots positively in Japan and negatively in the US (H2), anthropocentrism
129 suppresses (H3), and animism promotes moral care for robots (H4).

Method

Pre-registration and ethical approval

Hypothesis, materials and analysis plans were pre-registered at [blinded]. Following pre-registration, we made several changes to treatments of variables and analysis plans based on further literature surveys (see Appendix A1 The current research was approved by [blinded].

Participants

As pre-registered, we targeted 2000 participants in both Japan and the US with a variety of backgrounds, aiming to have as large a sample as possible to obtain validity. Quality checks by Qualtrics (excluding participants who filled the questionnaire too fast and those who failed an attention check question) resulted in 2,024 US and 2,025 Japanese participants. Further, participants (1) who have missing values (2) whose country of citizenship and residency is not US or Japanese, and (3) whose entry in one of input fields to answer the country of citizenship, religion, or occupation are irrelevant (e.g., “11579”, “I like”, “Yes”) are excluded by the researchers (222 US and 46 Japanese participants). The final sample size is $N = 1,802$ for the US participants (941 *female* (52.2%), 6 *others* (0.3%)) and $N = 1,979$ for the Japanese participants (1015 *female* (51.3%), 14 *others* (0.7%)). Means of age in the US and Japanese participants were 37.8 years ($SD = 11.61$) and 38.5 years ($SD = 11.86$). The demographic information is shown in Table 1.

Materials

Moral care for robots

The measure of moral care for robots was developed by adopting the *care* foundation items of the Moral Foundation Vignette (Clifford et al., 2015), which consists of short vignettes where people hurt or defame others. By replacing the harmed *person* with a *robot*, we assembled 13 items (e.g., “A person continues to fire a pellet gun at a robot placed in the

woods.”). Participants were asked to rate how acceptable these situations are to them using a seven-point Likert-type scale from 1 (Completely acceptable), 4 (Neutral), to 7 (Definitely unacceptable). A picture of humanoid robots (Appendix A2) was presented in the beginning of the section and participants were asked to assume the “robot” in the questionnaire was something like the one shown in the picture. Consistencies within the US and Japanese participants were $\alpha = .96$ and $.95$, respectively (α denotes Cronbach's alpha, calculated from the present research).

Religiosity

As some measures of religiosity are tailored for very specific audiences (e.g., Christian Orthodoxy Scale; Fullerton & Hunsberger, 1982) (Jong, 2013), to ensure the validity of cross-cultural study of religion, it is important to focus on pan-cultural phenomena, such as beliefs in supernatural agents (religious beliefs hereafter) and events and participation in ritual or prayer (Jong et al., 2013). We adopted the following two measurements:

Religious beliefs: Supernatural Belief Scale (Jong, 2013; e.g., “There exists an all-powerful, all-knowing spiritual being, whom we might call God.”). The scale has both English and Japanese versions. We used the latest version of the Japanese translation (version 2., Kavanagh, & Jong, 2020). Participants responded to each item on a nine-point Likert-type scale from -4 (Strongly disagree), 0 (Neither agree nor disagree), to 4 (Strongly agree) with the US participants $\alpha = .91$ and the Japan participants $\alpha = .92$.

Religious attendance: Following Kavanagh & Jong (2020), we asked participants how often they usually (i.e. before COVID 19 pandemic) visit a religious place (temple, shrine, church etc.). Participants responded in the following ordinal scale: from 1 (0 time), 2 (once), 3 (twice), to 11 (10 times or more).

Following pre-registration, whether to merge those two measures into one variable was determined after data collection. Since the consistency of the two measures was not high in Japan (Spearman's $\rho = .43$ in US and $.15$ in Japan), we did not merge them.

Anthropocentrism

We used the first factor (*Pure Anthropocentrism* vs. *Nonanthropocentrism*, 11 items) of the Anthropocentrism Scale (Chandler, 1981; e.g., "The human species is without a doubt the most advanced form of life on earth"). Chandler (1981) reported that this first factor strongly correlated with a total score on the Anthropocentrism Scale of 30 items ($r = .83$). Participants responded to each item on a seven-point Likert-type scale from 1 (Strongly disagree), 2 (Moderately disagree), 3 (Slightly disagree), 4 (Neutral; Cannot agree or disagree), 5 (Slightly agree), 6 (Moderately agree), to 7 (Strongly agree) with the US participants $\alpha = .85$ and the Japan participants $\alpha = .85$.

Animistic habits and anthropomorphism

Two subscales (*Other self* and *Personification of nonhuman objects*) of the Animism Scale for Adults (Ikeuchi, 2010; e.g., "I feel that hand-made objects acquire part of the soul of the one that made it"; "There are times when we feel attachment to things around us like we do to people.") were used for animism. This scale was designed to measure the degree to which we attribute life to objects and interact with them as we do with living things (i.e. animistic habits). Since *Divinity in nature* was strongly tuned to Japanese religious belief in Shinto (see Abe, 1997), we exclude this subscale to avoid measuring animistic belief specifically tied to Shinto beliefs. Participants responded to each item on a five-point Likert-type scale from 1 (Strongly disagree), 3 (Neutral), to 5 (Strongly agree) with the US participants $\alpha = .86$ and the Japanese participants $\alpha = .86$.

The Individual Differences in Anthropomorphism Quotient (IDAQ) was used (Waytz et al., 2010; e.g., “To what extent does the ocean have consciousness?”) for *Anthropomorphism*. Participants responded to each item on an eleven-point Likert-type scale from 0 (Not at all), 5 (Neutral), to 10 (Very much) with the US participants $\alpha = .92$ and the Japan participants $\alpha = .91$.

Note that animism is often compared with anthropomorphism, which refers to the cognitive inference that inanimate objects are *human*. Although attribution of life and human characteristics are conceptually different, people often conflate them with each other (Karpinska-Krakowiak & Eisend, 2021) including researchers in human-robot interaction (Beran et al., 2011) . Because of this, whether or not to consider these as a single measure was determined after data collection. We merged them into one explanatory variable because Cronbach’s α of aggregated scale were .92 and .90 for the US and Japanese participants, respectively. Since the quantification and number of items were different between the two scales, we added them after normalization within each scale, then re-normalized the summed scale.

Covariates

The following variables were controlled in the regression analyses (below): *Perspective taking (PT)* and *Empathic concern (EC)* factors of the Interpersonal Reactivity Index (IRI; Davis, 1980; Japanese version: Himichi et al., 2017). Here, we did not include reversed items of *PT*, since inclusion of them made the reliability of the scale worse ($\alpha = .69$ in the US and $= .66$ in Japan). After this manipulation, $\alpha = .83$ in the US and $= .81$ in Japan for *PT*, and $\alpha = .74$ in the US and $= .77$ in Japan for *EC*, respectively). *Exposure to robot-related media* was adopted from MacDorman et al (2009)’s study ($\alpha = .78$ in the US and $= .64$ in Japan). *Typical image of robots* by choosing one of the pictures from humanoid or mechanical arm

(presented picture can be found in Appendix A2). Along with those items, demographic variables (age, gender, and education) were also controlled as covariates.

Analyses

In accordance with the hypotheses (H1 to H4), we conducted the following analyses.

H1: cultural difference in moral care for robots. To test the cultural difference in ratings of the *Moral care for robots* between the US and Japan, unpaired *t*-test was applied.

H2-4: effects of religion (H2) and religion-related values (H3, H4) on moral care for robots. By each country, multiple regression analysis was performed independently to test hypotheses: the objective variable was *Moral care for robots*, and the explanatory variables were religiosity (H2, *Religious attendance* and/or *Religious beliefs*) and religion-related values (H3, *Anthropocentrism*; H4, *Animism*). Since we were not certain of the relationship between religiosity and religion-related values, we avoided including them together for hypothesis testing. Instead, we separately tested the hypotheses by evaluating the magnitude and significance of the regression coefficients in the two models: one with religiosity only (*religion model*) and religion-related values only (*value model*).

The relative goodness of the models were evaluated by the Akaike's Information Criterion (AIC) and the proportion of explained variance (adjusted R^2). The minimum models under AIC model selection by countries (*best model*) were identified to examine which set of variables have explanatory power after accounting for other variables. Analysis employing both religion and religion-related values was shown in Appendix A3.

Results

Cultural difference in moral care for robots (H1) and other measured variables

First, we tested whether cultural differences in moral care for robots could be found between the US and Japan (H1). Ratings in the Japanese participants in *Moral care for robots* ($t(3108.2) = -16.3, p < .001$) matches our hypothesis H1. The effect size was intermediate ($d = 0.54$) and comparable to the previous research reporting US-Japan difference in perceived warmth of robots ($r = .39$; MacDorman et al., 2009). Note that the *Moral care for robots* scale is composed of not only vignettes of physically attacking robots (unlike previous research ; Okanda et al., 2019), but also included ones of defamation of robots. High reliability ($\alpha = .96$ in the US and .95 in Japan) of this index showed that participant's attitudes toward abuse of robots are consistently independent of whether it is physical or social.

Likewise, we also tested cultural differences of other measured variables (later used in regression analysis as explanatory variables). Descriptive statistics of measured variables were shown in Table 2 and a correlation matrix is provided in Appendix A4. No significant cultural differences were found in *Animism* ($t(3306.0) = -0.49, p = .626$), *Anthropomorphism* ($t(3327.9) = 0.84, p = .401$), and *Exposure to robot related media* ($t(3320.9) = -0.16, p = .870$). The US participants rated significantly higher on *Religious beliefs* ($t(3770.5) = -32.8, p < .001$), *Anthropocentrism* ($t(3436.4) = -10.4, p < .001$), and *Empathic concern* ($t(3514.7) = -28.4, p < .001$) and *Perspective taking* ($t(3577.6) = -20.3, p < .001$). Also, significant differences are found in *Religious attendance* ($t(3154.5) = -22.9, p < .001$) and in *Typical image of Robot* (75.7% of the US and 82.9% of the Japanese participants chose "humanoid robot"; $\chi^2(1) = 2.93, p < .001$).

Effects of religion (H2) and religion-related values (H3 and H4) in each country

Next, for each country, we analyzed how religiosity and religion-related values affected the moral care for robots. The result of regression analysis shown in Table 3. We analyzed two types of model using religiosity as explanatory variables: a model that did not include religion-related values (Model1, corresponding to H2) and a model that also included

religion-related values (Model, corresponding to H3 and H4). Below we reported each result of two models and then model comparison analysis. Note that, in addition to the main analyses below, we supplementary conducted path analyses using structural equation modeling (SEM), reported in Appendix A6.

Model1: religiosity as explanatory variables (Religion model). For the US participants , a regression analysis based on Model 1 (AIC = 4609.0, adjusted $R^2 = .25$) showed a significant negative effect of *Religious beliefs* ($\beta = -.07$, $p = .002$), while an effect of *Religious attendance* was not significant ($\beta = -.02$, $p = .509$). For the Japanese participants (AIC = 5331.4, adjusted $R^2 = .14$), the effect of *Religious beliefs* was small but positively significant ($\beta = .08$, $p < .001$), while that of *Religious attendance* was not ($\beta = -.02$, $p = .315$). Although the effect size is rather small, those results supported H2, the cross-cultural effect of religiosity on moral care for robots.

Model2: religion-related values as explanatory variables (Religious value model). For the US participants, a regression analysis based on Model 2 (AIC = 4506.6, adjusted $R^2 = .29$) showed the significant negative effects of both *Anthropocentrism* and *Animism* (anthropocentrism, $\beta = -.22$, $p < .001$; animism $\beta = -.07$, $p = .002$). For the Japanese participants (AIC = 5268.4, adjusted $R^2 = .17$), a significant negative effect of *Anthropocentrism* ($\beta = -.06$, $p = .003$) and a significant positive effect of *Animism* ($\beta = .19$, $p < .001$) were found. Those results supported the negative effects of anthropocentrism (H3), but not the positive effects of animism (H4). The negative association between attitude toward robots and anthropocentrism was consistent with results in Italy (whose population is mostly Catholic) (Fortuna et al., 2021).

The model selection and relative contribution of explanatory variables. We identified the model with the lowest AIC (*best model*) using “dredge” function of MuMIn package

(Bartoń, 2020) in R (here we included the covariate as targets of the variable choices) both in the US (AIC = 4500.1, adjusted R^2 = .29) and Japan (AIC = 5267.9, adjusted R^2 = .17); see Appendix A5. In the *best models*, for both countries, any effects of religiosity were not significant, while effects of religion-related values remained significant (Table 2). The non-significance of religion-related values (Table 2) in the *best models* suggested that the relationship between moral care for robots and religion is mediated by religion-related values (Note that a path analysis using structural equation modeling (SEM) suggested such mediation effects; see Appendix A6).

In both countries, the *religious value model* (Model2) was better in terms of both AIC and adjusted R^2 . This means that religion-related values, rather than religiosity, is associated with an attitude toward moral care for robots. However, the proportion of explained variance (adjusted R^2) showed a difference between countries (US, .29; Japan, .17 in the *best model*). Also, the effect of *Anthropocentrism* was small in Japan, and *Animism* was oppositely associated with *Moral care for robots* (weakly but negatively in the US but positively in Japan). These suggested that culture-specific relationships were present in how anthropocentrism and animism are associated with moral care for robots (see also the path analyses in Appendix 6, which showed the consistent results)

Discussion

The current study found an idiosyncratic moral attitude toward robots between the US and Japan with a large diverse sample. As hypothesized, moral care for robots was higher in Japan. Further analyses revealed the effects of culture-specific association between religion-related values and moral care for robots. Overall, religion-related values, anthropocentrism and animism better explained moral care for robots than religiosity itself. anthropocentrism, which is significantly higher in the US, is the main driver of the cultural difference of moral care for robots (details are discussed below). The current study added to the literature by

shedding light to a newly recognized phenomenon, moral care for robots, and quantitatively described how religion and religion-related values are associated with this phenomenon. Note that none of existing cross-cultural studies of human-robot interaction reviewed by Papadopoulos & Koulouglioti (2018) refer to religions nor to values motivated by religions. What moral responsibility people should have to robots is among modern ethical debates because treating robots without moral constraints may lead to the violation of human rights (e.g., Sparrow, 2017). Although several theoretical solutions have been attempted (Whitby, 2008; Coeckelberg, 2018), they have not reached a concrete framework such as internationally agreed guidelines. By empirically comparing the magnitude of moral consideration for robots across cultures, as in this study, it is possible to make more effective arguments by corresponding theoretical proposals with actual people's responses.

The cultural difference of association between moral care for robots and religion-related values might reflect how robots are represented in each country, especially a boundary between humans and robots. If robots are perceived as sharply distinct from humans, anthropocentrism (a value that prioritizes human's wellness) could more strongly deprioritize moral care for robots; moreover, animism (tendency to see robots as living things in the current context) can cause a rejective reaction to the robot, like the uncanny valley (Mori et al., 2012). Although the current study was not designed to measure such differences, higher perceived similarity between robots and humans in Japan than in western cultures has been pointed out by Gygi (2018). If this is the case, the current results do not contradict with the idea (stronger negative effect of anthropocentrism on moral care for robots in US than Japan, and reversed effect of animism between US and Japan). Given that there is an empirical method in psychology to test how one perceives self and others (e.g., identity fusion measurement that assesses the self-other boundary; Gómez et al., 2011), we consider how familiarity of robots affects moral attitude toward robots should be tested empirically, as well as (if so) how such perception relates to religiosity.

372

373 It may be important to note that the model showed that there was an effect of religious belief
374 and not religious attendance, inconsistent with our hypothesis. The reason that we included
375 religious attendance is that the previous study showed Japanese participants can still be
376 highly involved in religion through religious practices even if participants have lower religious
377 beliefs or identify themselves as non-religious (Kavanagh & Jong, 2022). In fact, Kavanagh
378 & Jong (2022) suggested that Japanese religion is more oriented to practice than beliefs;
379 thus it is possible that one's religious attendance could influence one's religious-oriented
380 values: animism and anthropomorphism. However, our result for Japanese participants
381 showed religious attendance was neither clearly correlated with anthropocentrism ($r = -.029$)
382 nor animism ($r = .129$). Given that religious attendance can be reinforced by social norms
383 (Van Ingen & Moor, 2015) and sightseeing and prayer for families and friends (Kavanagh
384 and Jong, 2022), attendance at religious sites may not strongly reflect a consistent belief or
385 value.

386

387 Finally, we discuss the general implications of the present result for moral and cultural
388 psychology. Previous cross-cultural studies revealed cultural differences in strategies of
389 moral judgements (e.g., Henrich et al., 2015, Gold et al., 2014) or moral development (Blake
390 et al., 2015), and also culturally stable patterns across cultures (Blake et al., 2015; Curry et
391 al., 2019; Hauser et al., 2007; Graham et al., 2013). However, in previous cross-cultural
392 studies, the characteristics of a moral patient have not been considered specifically. For
393 example, in questionnaire studies, moral patients are often described abstractly or vaguely
394 (e.g., 'someone' in Moral Foundation Questionnaires; Graham et al., 2013). Our result
395 showed that the type of moral patients might also be important to consider the role of cultural
396 or social background in moral psychology. In the present study, we focused 'robot' as a
397 moral patient, thus animism and anthropomorphism were taken in accounts; likewise, in the
398 case of other non-human moral patients (e.g., animals or environment), specific religious-

related values can also influence one's moral attitude (e.g., animism might also influence moral care toward trees). Further cross-cultural studies are encouraged to map the relationship between specific types of moral patient and socio-religious oriented values.

Limitations and Future directions

The current study has several limitations. One is that moral care for robots of Japanese people was less explained by our explanatory variables across all models. Other variables not considered in this study, such as perceived cuteness of presented robots, may have explanatory power in Japan. Note that before participants filled the questionnaire we presented three robots (Armar, HRP-2, and Nao; Appendix A1), whose emotional valence (positive/negative impression of robots' appearance) measured by Self-Assessment Manikin (SAM; Lang, 1980, a language-independent method) and perceived human-likeness, had little difference between Japanese and the Western (Ikari et al. 2021). This process should have minimized the possibility of cultural difference in moral care for robots created by the difference in impression of the word "robots". However, it is still possible that emotional impressions of robots differently affected moral care for robots between countries; thus, future studies could be conducted to investigate this aspect.

Another limitation stems from the fact that we treated moral care for robots independently from moral care for humans; thus, the current study is unable to address moral care for robots relative to moral care for humans (those two could share the same cognitive underpinnings; Haidt & Joseph, 2004). We did not include items to ask about moral care for humans since our design is already complex as a cross-cultural study, and thus adding another focus (i.e., moral care for humans vs robots) would make the survey further complicated and difficult to interpret the result. Instead, we assessed the ability to feel others' pain (*Empathic concern* factor of IRI; Davis, 1980; strongly associated with moral

care for humans, Dawson et al., 2021) and controlled this factor in our analyses. Thus, we considered that such a problem unlikely undermined the result of the present study.

Nonetheless, comparing the moral considerations toward humans versus robots is an interesting topic for future direction. One possible experimental method to approach this issue is the moral circle approach (Laham, 2009; Crimston et al., 2016; Waytz et al., 2019). In this method, participants were asked to rank or rate various types of moral targets, typically including several types of humans (e.g., family, in-group members, villains) and non-humans (environment, plants, animals). This approach could assess individual differences in moral circle expansion (i.e., the scope of moral consideration from morally caring only for one's family to everything on the earth) and its determinant factors such as ideology (Waytz et al., 2019) or religious and cultural background as the present research focused. Future research in this direction is encouraged.

Conclusion

The current study is the first to empirically examine moral attitudes toward robots with a large-scale cross-cultural sample ($N = 3781$). We found that Japanese adults valued higher moral care for robots in Japan than in the US, and that it was related to religion-related values. Our study presented the importance of considering religion in psychological human robot interaction research, while providing a framework for future empirical work regarding morality attributions towards non-human agents.

Author's Note

All the data and analysis codes are available at https://github.com/anchor200/robot_moral_care

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Declaration of Conflict of Interest

The authors declare they have no conflict of interest.

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619 Table 1. Demographics of the participants

	US	Japan
Age		
Minimum (years)	20	19
Maximum (years)	60	60
Mean(years)	38.8	38.5
SD	11.6	11.9
Gender		
Male (%)	47.5	48.0
Female (%)	52.2	51.3
Others (%)	0.3	0.7
Religious affiliation		
Christian (%)	62.0	2.2
Buddhist (%)	1.0	19.1
Muslim (%)	5.2	0.0
Jewish (%)	1.2	0.0
Shinto	0.0	2.0
Spiritual but not religious (%)	2.3	0.1
Multiple religion*	0.1	1.1
Other religious (%)	6.5	1.0
Not religious (%)	18.1	74.5
No answer	3.6	0.0
Region		
US		
South (%)	37.5	
Northeast (%)	18.5	
Midwest (%)	21.1	
West (%)	22.9	
Japan		
Hokkaido/Tohoku (%)		10.7
Kanto (%)		43.3
Chubu/Hokuriku (%)		13.7
Kansai		17.4
Chugoku/Sikoku (%)		6.9
Kyushu/Okinawa		8.0
Education		
US		
Elementary school	12	
Junior High School	182	
Vocational School or Technical/Communication College	396	
University or College	553	
Graduate University or Professional School	482	
Others	117	
Japan		
Elementary school		2
Junior high school		60
High school		526
Technical or Short College		354
University or College		901
Graduate University or Professional School		125
Others		11

620

621 *For the Japan sample, 20 participants with multiple religions: Buddhist & Shinto (15/20);

622 Christian & Buddhist (4/20); Christian, Buddhist & Shinto (1/20); For the US sample, 2 are

623 Jewish & Christian

624 Table 2. Descriptive result.

Measure	US sample		Japan sample		t-test				
	Mean	SD	Mean	SD	df	<i>t</i>	<i>p</i>	Cohen's <i>d</i>	95CI
Moral care for robots	-0.27	1.14	0.25	0.77	3108.21	-16.30	<.001	-0.54	(-0.61,-0.48)
Religious attendance	0.37	1.10	-0.34	0.76	3154.54	22.94	<.001	0.76	(0.69,0.83)
Religious beliefs	0.49	0.86	-0.45	0.90	3770.50	32.82	<.001	1.07	(1,1.13)
Anthropocentrism	0.18	1.10	-0.16	0.87	3436.37	10.36	<.001	0.34	(0.28,0.41)
Animism	-0.01	1.14	0.01	0.85	3306.04	-0.49	0.626	-0.02	(-0.08,0.05)
Empathic concern	0.33	1.02	-0.30	0.88	3577.57	20.29	<.001	0.67	(0.6,0.73)
Perspective taking	0.46	0.95	-0.42	0.85	3616.73	29.90	<.001	0.98	(0.91,1.05)
Exposure to robot related experience	0.00	1.14	0.00	0.85	3320.90	0.16	0.870	0.01	(-0.06,0.07)

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626 *Values were calculated after normalization using Mean and SD of whole participants. US
627 and Japan participants' SD differed because the overall SD for a variable do not necessarily
628 match each country's one.

629

630 Table 3. Regression table

631 US

	Religion model				Religious value model				Best model			
	β	SE	<i>t</i>	<i>p</i>	β	SE	<i>t</i>	<i>p</i>	β	SE	<i>t</i>	<i>p</i>
Intercept	-0.03	0.05	-0.51	0.611	-0.09	0.05	-1.69	0.091	-0.12	***	0.03	-3.83 <.001
Religion variables												
Religious attendance	-0.02	0.02	-0.66	0.509								
Religious beliefs	-0.07	**	0.02	-3.13	0.002							
Value variables												
Anthropocentrism					-0.22	***	0.02	-10.14 <.001	-0.22	***	0.02	-10.52 <.001
Animism					-0.07	**	0.02	-3.12 0.002	-0.08	***	0.02	-3.31 <.001
Covariates												
Empathic concern	0.37	***	0.02	14.72 <.001	0.32	***	0.02	13.21 <.001	0.32	***	0.02	13.39 <.001
Perspectiv taking	-0.13	***	0.02	-5.14 <.001	-0.09	***	0.02	-3.60 <.001	-0.09	***	0.02	-3.61 <.001
Typical image of robots	-0.09	*	0.05	-1.98 0.048	0.00		0.05	0.02 0.987				
Robot-related experience	-0.19	***	0.02	-7.93 <.001	-0.14	***	0.02	-5.77 <.001	-0.15	***	0.02	-6.08 <.001
Age	0.01		0.02	0.58 0.563	0.01		0.02	0.59 0.554				
Gender1	0.28	***	0.05	6.15 <.001	0.22	***	0.04	4.93 <.001	0.22	***	0.04	5.10 <.001
Gender2	0.27		0.36	0.75 0.455	0.06		0.35	0.17 0.865				
Education	-0.08		0.05	-1.79 0.074	-0.04		0.04	-1.02 0.308				
Adj. R-squared	0.25				0.29				0.29			
AIC	4609.00				4506.64				4500.07			

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633 JP

	Religion model				Religious value model				Best model			
	β	SE	<i>t</i>	<i>p</i>	β	SE	<i>t</i>	<i>p</i>	β	SE	<i>t</i>	<i>p</i>
Intercept	-0.23	***	0.06	-3.84 <.001	-0.22	***	0.06	-3.62 <.001	-0.21	***	0.06	-3.55 <.001
Religion variables												
Religious attendance	-0.02		0.02	-1.01 0.315								
Religious beliefs	0.08	***	0.02	3.54 <.001								
Value variables												
Anthropocentrism					-0.06	**	0.02	-3.00 0.003	-0.06	**	0.02	-3.07 0.002
Animism					0.19	***	0.02	8.29 <.001	0.19	***	0.02	8.31 <.001
Covariates												
Empathic concern	0.26	***	0.02	10.60 <.001	0.25	***	0.02	10.47 <.001	0.25	***	0.02	10.47 <.001
Perspectiv taking	-0.03		0.03	-1.04 0.300	-0.06	*	0.03	-2.52 0.012	-0.06	*	0.03	-2.50 0.013
Typical image of robots	0.14	*	0.06	2.41 0.016	0.15	**	0.06	2.74 0.006				
Robot-related experience	-0.05	*	0.02	-2.26 0.024	-0.08	***	0.02	-3.58 <.001	-0.08	***	0.02	-3.60 <.001
Age	0.05	*	0.02	2.08 0.038	0.05	*	0.02	2.18 0.029				
Gender1	0.38	***	0.05	8.28 <.001	0.35	***	0.05	7.55 <.001	0.34	***	0.05	7.47 <.001
Gender2	0.36		0.25	1.42 0.155	0.30		0.25	1.20 0.230				
Education	-0.15	***	0.04	-3.56 <.001	-0.17	***	0.04	-4.06 <.001				
Adj. R-squared	0.14				0.17				0.17			
AIC	5331.41				5268.43				5267.88			

634

635 Each value of ratings except categorical variables were standardized using their Mean and

636 SD within each country. Categorical variables were included via dummy variables: Gender

637 (male: *Gender1* = 0, *Gender2* = 0; female: *Gender1* = 1, *Gender2* = 0; and others: *Gender1*

638 = 0, *Gender2* = 1), *Education* (college graduates or higher: 1, others: 0); * $p < .05$. ** $p < .01$,
639 *** $p < .001$.

Appendix A1. Deviation from pre-registration.

The current paper included the following deviation from pre-registration of the study plan (Ikari et al., 2020). First, we integrated variables Animism (measured by Animism Scale for Adults; Ikeuchi, 2010) and Anthropomorphism (measured by IDAQ Waytz et al., 2010) into one variable (called Animism in the main text). This was because consistency of the two variables are very high (Cronbach's α of an aggregated variable were 0.92 and 0.90 for the US and Japanese participants, respectively), maybe due to difficulty to distinguish conceptualization behind two variables (see Karpinska-Krakowiak & Eisend, 2021).

Second, we ran regression analyses separately by countries, rather than treating countries as a categorical variable in regressions. Since the correlation structure of the variables differed between the two countries, we decided that it would be easier to interpret the results if the regression analysis was performed separately, rather than analyzing the variables simultaneously and ending up with frequent interaction terms

Third, we omitted path analyses from main text. The reason is that we did not have a hypothesis for the causal relationship between religiosity and religion-related values (anthropocentrism and animism). Rather than presenting a hypothesis-testing report, we decided to report the results of the pre-registered model to provide material for future hypothesis development (Appendix A6).

Reference

Ikari, S., Nakawake, Y., Burdett, E., Sato, K., and Jong, J. (2020). The impact of religiously rooted values on empathy toward robot: A comparative study in Japan and the United States. <https://doi.org/10.17605/OSF.IO/HS4EJ>

Appendix A2. Presented images of robots.

To measure participants' typical images of robots, we asked whether of two images of robots, Subfigure (a) or (b), is closer to their typical image of robots.

The image of humanoids (a) is also used for an image presented before participants filled the moral care for robots questionnaire.

Perceived human-likeness of humanoid robots and machine-likeness of machine robots are measured in the pilot experiment with Japanese and Western (American, Canadian, and English) adults and there is little difference in the ratings (Ikari et al., 2021).

Figure A1. Images of robots used.

(a) Humanoid robots

(b) Machine robots

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Appendix A3. Additional regression analyses.

Table A1. Regression analyses where both religiosity and religion-related values were included as explanatory variables.

US

	β		SE	t	p
Intercept	-0.09		0.05	-1.62	0.105
Religion variables					
Religious attendance	0.02		0.02	0.67	0.503
Religious beliefs	-0.02		0.02	-0.82	0.411
Value variables					
Anthropocentrism	-0.22	***	0.02	-9.64	<.001
Animism	-0.07	**	0.02	-2.89	0.004
Covariates					
Empathic concern	0.32	***	0.02	12.99	<.001
Perspectiv taking	-0.09	***	0.02	-3.52	<.001
Typical image of robots	0.00		0.05	0.00	0.998
Robot-related experience	-0.14	***	0.03	-5.77	<.001
Age	0.01		0.02	0.63	0.529
Gender1	0.22	***	0.04	4.98	<.001
Gender2	0.06		0.35	0.18	0.854
Education	-0.05		0.04	-1.16	0.244
Adj. R-squared	0.29				
AIC	4509.80				

JP

	β		SE	t	p
Intercept	-0.21	***	0.06	-3.58	<.001
Religion variables					
Religious attendance	-0.03		0.02	-1.27	0.203
Religious beliefs	-0.01		0.03	-0.27	0.787
Value variables					
Anthropocentrism	-0.06	**	0.02	-3.05	0.002
Animism	0.20	***	0.03	7.50	<.001
Covariates					
Empathic concern	0.25	***	0.02	10.48	<.001
Perspectiv taking	-0.06	°	0.03	-2.52	0.012
Typical image of robots	0.15	**	0.06	2.62	0.009
Robot-related experience	-0.07	**	0.02	-3.25	0.001
Age	0.05	°	0.02	2.32	0.020
Gender1	0.35	***	0.05	7.59	<.001
Gender2	0.30		0.25	1.20	0.230
Education	-0.17	***	0.04	-3.98	<.001
Adj. R-squared	0.17				
AIC	5270.65				

Treatment of continuous/categorical variables were the same as regression in the main text.

Appendix A4. Correlation of variables

Table A2. Correlation matrix (Spearman's ρ) of variables

US

	MR	RA	RB	AC	AN	EC	PT	TYP	EXP	Age	G1	G2	Edu
Moral care for robots (MR)		-0.13	-0.06	-0.35	-0.25	0.35	-0.02	-0.08	-0.35	0.04	0.28	0.03	-0.18
Religious attendance (RA)			0.43	0.34	0.14	0.10	0.19	0.06	0.31	0.05	-0.18	-0.03	0.29
Religious beliefs (RB)				0.28	0.24	0.24	0.30	0.04	0.14	0.06	0.00	-0.02	0.03
Anthropocentrism (AC)					0.22	-0.09	0.14	0.20	0.28	0.06	-0.25	-0.07	0.20
Animism (AN)						-0.09	0.29	0.09	0.46	-0.18	-0.06	0.00	0.17
Empathic concern (EC)							0.47	-0.05	-0.16	0.11	0.19	0.03	-0.09
Perspective taking (PT)								0.00	0.20	0.04	0.01	-0.02	0.07
Typical image of robots (TYP)									0.04	-0.08	0.00	-0.03	0.08
Exposure to robot related experience (EXP)										-0.06	-0.31	-0.02	0.30
Age											-0.15	-0.04	0.00
Gender1 (G1)												-0.06	-0.23
Gender2 (G2)													-0.01
Education (Edu)													

JP

	MR	RA	RB	AC	AN	EC	PT	TYP	EXP	Age	G1	G2	Edu
Moral care for robots (MR)		-0.01	0.16	-0.04	0.24	0.29	0.11	0.08	-0.05	-0.03	0.23	0.01	-0.12
Religious attendance (RA)			0.14	-0.03	0.13	0.10	0.11	-0.11	0.23	0.10	-0.02	0.00	0.08
Religious beliefs (RB)				0.07	0.55	0.28	0.28	0.07	0.13	-0.04	0.09	0.02	-0.07
Anthropocentrism (AC)					0.08	0.07	0.13	0.10	0.09	-0.04	-0.02	-0.04	-0.05
Animism (AN)						0.30	0.41	0.04	0.26	-0.10	0.12	0.02	0.01
Empathic concern (EC)							0.50	0.03	0.12	0.00	0.11	0.01	-0.03
Perspective taking (PT)								-0.01	0.26	-0.04	0.04	0.02	0.08
Typical image of robots (TYP)									-0.07	-0.09	0.08	0.01	-0.02
Exposure to robot related experience (EXP)										-0.08	-0.08	0.00	0.11
Age											-0.37	-0.02	0.03
Gender1 (G1)												-0.09	-0.14
Gender2 (G2)													0.01
Education (Edu)													

Appendix A5. Variable selection of regression analysis.

In regression analysis, we identified the model with the lowest AIC (best model) using “dredge” function of MuMIn package (Bartoń, 2020) in R. This function runs all models with possible sets of variables (In this case 4096 models), then calculate AIC to rank models. Here, β coefficients and AICs of top 30 models are provided. Blank columns indicate that the variables were not included in a model.

Table A3. Top 30 models of model selection.

US

Rank	lept	RA	RB	AC	AN	EC	PT	TYP	EXP	Age	G1	G2	Edu	df	AIC	delta
1	-0.12			-0.22	-0.08	0.32	-0.09		-0.15		0.22			8.00	4500.07	
2	-0.09			-0.22	-0.08	0.32	-0.09		-0.14		0.21		-0.04	9.00	4501.01	9.00
3	-0.12			-0.22	-0.08	0.32	-0.09		-0.15	0.01	0.22			9.00	4501.72	9.00
4	-0.12		-0.01	-0.22	-0.08	0.33	-0.09		-0.15		0.22			9.00	4501.77	9.00
5	-0.12	0.00		-0.22	-0.08	0.32	-0.09		-0.15		0.22			9.00	4502.03	9.00
6	-0.12			-0.22	-0.08	0.32	-0.09		-0.15		0.22	0.05		9.00	4502.05	9.00
7	-0.11			-0.22	-0.08	0.32	-0.09	0.00	-0.15		0.22			9.00	4502.06	9.00
8	-0.09		-0.01	-0.22	-0.07	0.33	-0.09		-0.14		0.22		-0.04	10.00	4502.67	10.00
9	-0.09			-0.22	-0.07	0.32	-0.09		-0.14	0.01	0.22		-0.04	10.00	4502.67	10.00
10	-0.09	0.01		-0.22	-0.08	0.32	-0.09		-0.14		0.21		-0.05	10.00	4502.84	10.00
11	-0.09			-0.22	-0.08	0.32	-0.09		-0.14		0.21	0.05	-0.04	10.00	4502.99	10.00
12	-0.09			-0.22	-0.08	0.32	-0.09	0.00	-0.14		0.21		-0.04	10.00	4503.01	10.00
13	-0.12		-0.01	-0.22	-0.07	0.32	-0.09		-0.15	0.01	0.23			10.00	4503.38	10.00
14	-0.12	0.01	-0.02	-0.22	-0.07	0.33	-0.09		-0.15		0.22			10.00	4503.60	10.00
15	-0.12	0.00		-0.23	-0.08	0.32	-0.09		-0.15	0.01	0.23			10.00	4503.68	10.00
16	-0.12			-0.22	-0.08	0.32	-0.09		-0.15	0.01	0.23	0.06		10.00	4503.69	10.00
17	-0.12			-0.22	-0.08	0.32	-0.09	0.00	-0.15	0.01	0.22			10.00	4503.72	10.00
18	-0.12		-0.01	-0.22	-0.08	0.33	-0.09		-0.15		0.22	0.05		10.00	4503.75	10.00
19	-0.11		-0.01	-0.22	-0.08	0.33	-0.09	0.00	-0.15		0.22			10.00	4503.76	10.00
20	-0.12	0.00		-0.22	-0.08	0.32	-0.09		-0.15		0.22	0.05		10.00	4504.01	10.00
21	-0.11	0.00		-0.22	-0.08	0.32	-0.09	0.00	-0.15		0.22			10.00	4504.02	10.00
22	-0.11			-0.22	-0.08	0.32	-0.09	0.00	-0.15		0.22	0.05		10.00	4504.04	10.00
23	-0.08	0.02	-0.02	-0.22	-0.07	0.32	-0.09		-0.15		0.22		-0.05	11.00	4504.22	11.00
24	-0.09		-0.01	-0.22	-0.07	0.32	-0.09		-0.14	0.01	0.22		-0.04	11.00	4504.28	11.00
25	-0.09	0.01		-0.22	-0.07	0.32	-0.09		-0.14	0.01	0.22		-0.05	11.00	4504.51	11.00
26	-0.09			-0.22	-0.07	0.32	-0.09		-0.14	0.01	0.22	0.06	-0.04	11.00	4504.64	11.00
27	-0.09		-0.01	-0.22	-0.07	0.33	-0.09		-0.14		0.22	0.05	-0.04	11.00	4504.65	11.00
28	-0.09		-0.01	-0.22	-0.07	0.33	-0.09	0.00	-0.14		0.22		-0.04	11.00	4504.67	11.00
29	-0.09			-0.22	-0.07	0.32	-0.09	0.00	-0.14	0.01	0.22		-0.04	11.00	4504.67	11.00
30	-0.09	0.01		-0.22	-0.08	0.32	-0.09		-0.14		0.22	0.05	-0.05	11.00	4504.82	11.00

Rank	Icpt	RA	RB	AC	AN	EC	PT	TYP	EXP	Age	G1	G2	Edu	df	AIC	delta
1	-0.21			-0.06	0.19	0.25	-0.06	0.15	-0.08	0.05	0.34		-0.17	11.00	5267.88	
2	-0.21	-0.03		-0.07	0.20	0.25	-0.06	0.15	-0.07	0.05	0.34		-0.17	12.00	5268.17	12.00
3	-0.22			-0.06	0.19	0.25	-0.06	0.15	-0.08	0.05	0.35	0.30	-0.17	12.00	5268.43	12.00
4	-0.21	-0.03		-0.06	0.20	0.25	-0.06	0.14	-0.07	0.05	0.35	0.30	-0.17	13.00	5268.72	13.00
5	-0.21		-0.01	-0.06	0.20	0.25	-0.06	0.15	-0.08	0.05	0.34		-0.17	12.00	5269.74	12.00
6	-0.21	-0.03	-0.01	-0.07	0.20	0.25	-0.06	0.15	-0.07	0.05	0.34		-0.17	13.00	5270.10	13.00
7	-0.22		-0.01	-0.06	0.20	0.25	-0.06	0.15	-0.08	0.05	0.35	0.30	-0.17	13.00	5270.28	13.00
8	-0.19			-0.07	0.19	0.26	-0.06	0.14	-0.08		0.30		-0.17	10.00	5270.38	10.00
9	-0.21	-0.03	-0.01	-0.06	0.20	0.25	-0.06	0.15	-0.07	0.05	0.35	0.30	-0.17	14.00	5270.65	14.00
10	-0.19			-0.06	0.19	0.26	-0.07	0.14	-0.08		0.31	0.27	-0.17	11.00	5271.21	11.00
11	-0.18	-0.02		-0.07	0.19	0.26	-0.06	0.14	-0.08		0.30		-0.17	11.00	5271.28	11.00
12	-0.19	-0.02		-0.07	0.19	0.26	-0.07	0.14	-0.08		0.31	0.26	-0.17	12.00	5272.13	12.00
13	-0.21			-0.07	0.18	0.23		0.16	-0.09	0.05	0.34		-0.18	10.00	5272.15	10.00
14	-0.19		-0.01	-0.07	0.20	0.26	-0.06	0.15	-0.08		0.30		-0.17	11.00	5272.26	11.00
15	-0.21	-0.03		-0.07	0.18	0.23		0.15	-0.08	0.05	0.34		-0.18	11.00	5272.43	11.00
16	-0.22			-0.07	0.18	0.23		0.16	-0.09	0.05	0.35	0.28	-0.18	11.00	5272.82	11.00
17	-0.19		-0.01	-0.06	0.20	0.26	-0.06	0.14	-0.08		0.31	0.27	-0.17	12.00	5273.09	12.00
18	-0.09	-0.03		-0.06	0.20	0.26	-0.07		-0.08	0.05	0.35		-0.17	11.00	5273.09	11.00
19	-0.21	-0.03		-0.07	0.18	0.23		0.15	-0.08	0.05	0.35	0.28	-0.18	12.00	5273.11	12.00
20	-0.18	-0.02	-0.01	-0.07	0.20	0.26	-0.06	0.14	-0.08		0.30		-0.17	12.00	5273.22	12.00
21	-0.09			-0.06	0.20	0.25	-0.07		-0.08	0.04	0.34		-0.17	10.00	5273.48	10.00
22	-0.10	-0.03		-0.06	0.20	0.26	-0.07		-0.08	0.05	0.35	0.30	-0.17	12.00	5273.57	12.00
23	-0.09			-0.06	0.20	0.25	-0.07		-0.08	0.04	0.35	0.30	-0.17	11.00	5273.95	11.00
24	-0.21		-0.01	-0.07	0.18	0.23		0.16	-0.09	0.05	0.34		-0.18	11.00	5273.97	11.00
25	-0.19	-0.02	-0.01	-0.07	0.20	0.26	-0.06	0.14	-0.08		0.31	0.26	-0.17	13.00	5274.07	13.00
26	-0.21	-0.03	-0.01	-0.07	0.18	0.23		0.15	-0.08	0.05	0.34		-0.18	12.00	5274.34	12.00
27	-0.22		-0.01	-0.07	0.18	0.23		0.16	-0.09	0.05	0.35	0.28	-0.18	12.00	5274.64	12.00
28	-0.19			-0.07	0.18	0.23		0.15	-0.09		0.31		-0.18	9.00	5274.72	9.00
29	-0.21	-0.03	-0.01	-0.07	0.18	0.23		0.15	-0.08	0.05	0.35	0.28	-0.18	13.00	5275.01	13.00
30	-0.09	-0.03	0.00	-0.06	0.20	0.26	-0.07		-0.08	0.05	0.35		-0.17	12.00	5275.08	12.00

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715 Icpt: Intercept; RA: Religious attendance; RB: Religious beliefs; AC: Anthropocentrism; AN:

716 Animism; EC: Empathic concern; PT: Perspective taking; TYP: Typical image of robots; Exp:

717 Robot-related experience; G1: Gender1; G2: Gender2; Edu: Education; See footnote of

718 Table 3 for quantification of gender and education.

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Appendix A6. Path models.

Method

We fit the data to a hypothesis model (Figure A2) and checked its validity. Specifically, we tested the following: In the US, (i) religiosity (*Religious attendance/beliefs*) influences *Anthropocentrism* positively and it negatively influences *Moral care for robots*. (ii) Religiosity influences *Animism* negatively and it positively influences *Moral care for robots*. In Japan, (iii) religiosity influences *Anthropocentrism* negatively and it negatively influences *Moral care for robots*. (iv) Religiosity influences *Animism* positively and it negatively influences *Moral care for robots*. Following our pre-registration, we used a multi-group SEM analysis because it reduces the type-I error rather than doing the analysis for each country. In our analysis, the variance of latent variables were fixed at 1, so that we were able to compare the effect size of paths between latent variables. Participants who answered their gender as others are removed from the SEM analysis, since the number of such participants were very small (0.3% in the US and 0.7% in Japan) and it was not likely for analysis including such a population to yield interpretable results.

We tested the model fit with a maximum likelihood (ML) estimator. Although we did not pre-register the criteria for judging the goodness of fit of the model, we followed previous studies (Willard & Norenzayan, 2019) and referred to RMSEA and CFI as goodness of fit, since the most conservative criterion, χ^2 statistics was less likely to maintain sufficient detection ability with our large sample size, making it too conservative test. As well as the pre-registered analysis, we conducted exploratory tests to examine group invariance of path coefficients by a likelihood ratio test. Analyses were conducted with R 4.0.3 and lavaan 0.6-7 package (Rosseel, 2012).

Result

The hypothesis model fit the data well ($\chi^2 (2670) = 10453.2, p = .000, CFI = 0.96, RMSEA = 0.039$ (95%CI [0.039, 0.040]), $GFI = 0.98, AGFI = 0.96$; Figure A2). The path coefficients are provided in Table A4. In the US, the prediction (i) was supported with positive paths from *Religious attendance/beliefs* to *Anthropocentrism* ($\beta = .126, p < .001$; $\beta = .208, p < .001$), and negative path from *Anthropocentrism* to *Moral care for robots* ($\beta = -.292, p < .001$). However, prediction (ii) regarding *Animism*, was not supported with a weak but positive path from religious attendance to *Animism* ($\beta = .108, p < .001$) and a negative path from *Animism* to *Moral care for robots* ($\beta = -.121, p = .001$). In Japan, prediction (iv) was partly supported with a positive path from *Religious beliefs* to *Animism* ($\beta = .561, p = .001$) and a positive path from *Animism* to *Moral care for robots* ($\beta = .198, p = .001$), although a path from *Religious attendance* to *Animism* was not significant ($\beta = -.006, p = .812$). Contrary, the prediction (iii) was not supported with weak but positive path from *Religious beliefs* to *Anthropocentrism* ($\beta = .125, p < .001$), although *Anthropocentrism* weakly but negatively affected *Moral care for robots* as we predicted ($\beta = -.103, p < .001$). Note that all direct path from religiosity to *Moral care for robots* were very weak ($\beta s < 0.04$), suggesting that religiosity's influences are mediated by religion-related values (*Anthropocentrism/Animism*) rather than behaving directly.

Figure A2 Illustration of hypothesis path model.

768 Figure A3. Illustration of results of the hypothesis path model.
 769 For clarity, covariates are omitted from the figure (see Table A4 for the effect of them).
 770 US

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 772 JP

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 774

775 Table A4. Table of path coefficients.

776 US

	β	SE	z	p
Path coefficients				
Moral care for robots				
Religious attendance	0.03 ***	0.03	1.03	<.001
Religious beliefs	0.00	0.03	0.09	0.925
Anthropocentrism	-0.29 ***	0.03	-9.59	<.001
Animism	-0.12 ***	0.04	-3.38	<.001
Empathic concern	0.06	0.07	0.94	0.861
Perspective taking	0.07 ***	0.06	1.04	<.001
Typical image of robots	0.00 ***	0.06	0.00	<.001
Robot-related experience	-0.25 ***	0.04	-6.81	<.001
Gender	0.36 ***	0.05	6.80	<.001
Education	0.00 ***	0.06	0.08	<.001
Religious attendance				
Gender	-0.24	0.04	-5.36	0.100
Education	0.55 ***	0.05	11.92	<.001
Religious beliefs				
Perspective taking	0.31 ***	0.03	11.20	<.001
Anthropocentrism				
Religious attendance	0.13 ***	0.03	4.80	<.001
Religious beliefs	0.21	0.03	7.64	0.052
Gender	-0.30 ***	0.04	-6.85	<.001
Education	0.16 ***	0.05	3.51	<.001
Animism				
Religious attendance	0.11 ***	0.03	4.13	<.001
Religious beliefs	0.05 ***	0.03	1.64	<.001
Correlation of errors				
Religious attendance				
Religious beliefs	0.43 ***	0.02	20.46	<.001
Religious beliefs				
Empathic concern	0.10 ***	0.02	4.57	<.001
Anthropocentrism				
Animism	0.47 ***	0.02	22.48	<.001
Robot-related experience	0.32 ***	0.02	13.37	<.001
Animism				
Empathic concern	0.05 ***	0.03	1.94	<.001
Perspective taking	0.09 ***	0.02	3.79	<.001
Robot-related experience	0.54 ***	0.02	25.65	<.001

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	β	SE	z	p
Path coefficients				
Moral care for robots				
Religious attendance	0.00	0.03	-0.18	0.861
Religious beliefs	-0.04 *	0.04	-1.06	0.016
Anthropocentrism	-0.10	0.02	-4.24	0.288
Animism	0.20 ***	0.03	6.52	<.001
Empathic concern	0.25	0.08	3.19	0.401
Perspective taking	-0.07 ***	0.07	-0.93	<.001
Typical image of robots	-0.15	0.06	-2.41	0.050
Robot-related experience	-0.17	0.03	-5.02	0.866
Gender	0.43	0.05	8.92	0.284
Education	-0.17 ***	0.05	-3.50	<.001
Religious attendance				
Gender	-0.04 ***	0.05	-0.84	<.001
Education	0.17 ***	0.05	3.77	<.001
Religious beliefs				
Perspective taking	0.33 ***	0.03	11.49	<.001
Anthropocentrism				
Religious attendance	-0.02 ***	0.02	-1.07	<.001
Religious beliefs	0.13 **	0.02	5.62	0.003
Gender	-0.01 ***	0.04	-0.17	<.001
Education	-0.08 ***	0.04	-1.96	<.001
Animism				
Religious attendance	-0.01 ***	0.02	-0.24	<.001
Religious beliefs	0.56 ***	0.03	16.13	<.001
Correlation of errors				
Religious attendance				
Religious beliefs	0.09 ***	0.02	3.95	<.001
Religious beliefs				
Empathic concern	0.17 ***	0.02	6.72	<.001
Anthropocentrism				
Animism	0.13 ***	0.02	5.44	<.001
Robot-related experience	0.21 ***	0.03	8.09	<.001
Animism				
Empathic concern	0.10 ***	0.03	3.02	<.001
Perspective taking	0.20 ***	0.03	6.66	<.001
Robot-related experience	0.23 ***	0.03	8.09	<.001

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

Reference

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