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**The association between anthropomorphism of nature and pro-environmental variables: a systematic review**

Marc O. Williams<sup>1</sup>, Lorraine Whitmarsh<sup>2</sup>, Diarmait Mac Giolla Chríost<sup>1</sup>

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Corresponding author: Marc O Williams

Email: [williamsm93@cardiff.ac.uk](mailto:williamsm93@cardiff.ac.uk)

Address: DClinPsy  
School of Psychology  
Cardiff University  
UK  
CF103AT

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<sup>1</sup> Cardiff University, UK  
<sup>2</sup> Bath University, UK

## 24 **Abstract**

25 It is taken for granted that anthropomorphising non-human species promotes pro-environmental  
26 attitudes and behaviours, but the literature appears to be conflicted on this topic. There is also little  
27 discussion in the literature as to whether there are different types of anthropomorphism that may be  
28 particularly associated with pro-environmental attitudes and behaviours. This is the first systematic  
29 review to address the hypothesis that there is a significant association between anthropomorphism of  
30 nature and pro-environmental variables, and that anthropomorphism has a beneficial causal role. This  
31 review synthesises results from 25 studies (18 correlational; seven experimental) in addressing this  
32 hypothesis, weighing its conclusions by an appraisal of study quality. This review presents evidence  
33 from high quality studies that mind attribution to non-human entities is consistently associated with pro-  
34 environmental variables, and that inducing anthropomorphic perceptions of non-human entities can  
35 generate pro-environmental outcomes in some circumstances. The authors also summarise the highest-  
36 quality evidence with regard to the possible mediators of the relationship between anthropomorphism  
37 and pro-environmental variables, and consider the findings through the lens of the theory of planned  
38 behaviour (Ajzen, 1991). The implications of the findings for future research and conservation  
39 campaigns are discussed alongside a note of caution about the limitations and potential disadvantages  
40 of anthropomorphism.

## 41 **Keywords**

42 Anthropomorphism; mind attribution; pro-environmental behaviour; attitudes; conservation; systematic  
43 review

## 44 **1. Introduction**

45 Campaigns commonly present nature in a way that highlights, or fabricates, its similarity to humans,  
46 with the aim of influencing pro-environmental attitudes and behaviours. An emotive advert for the  
47 supermarket chain Iceland in the UK portrayed a talking cartoon Orangutan to warn against the  
48 environmental impact of palm oil cultivation, and was banned for being too political (Butler & Sweney,  
49 2018). In 2006, Al Gore noted on “Good Morning America” that “The Earth has a fever and just like when  
50 your child has a fever, maybe that’s a warning of something seriously wrong,” (“Al Gore: There’s Still  
51 Time To Save the Planet”, 2006). Such messages are conveyed without firm empirical grounding for  
52 their effectiveness, as research on portraying nature as similar to humans, and whether it can lead to  
53 pro-environmental behaviours, is still in its infancy.

54 One approach that researchers have taken to investigate this association is to look at correlations  
55 between human-like characteristics of species and their association with conservation attitudes and  
56 behaviours toward those species. Batt (2009), for instance, generated an overall measure of objective  
57 similarity of species to humans across a range of “biobehavioural” variables (p. 181), which  
58 incorporated, e.g., reproductive strategy and size. Batt reported more positive attitudes among a  
59 university sample toward species that had been deemed objectively similar to humans on these  
60 variables. Understanding the association between pro-environmental variables and species’ objective  
61 similarity to humans may provide empirical basis for the use of flagship species with human-like physical  
62 characteristics, such as forward-facing eyes (Smith, Veríssimo, Isaac, & Jones, 2012).

63 Anthropomorphism, by contrast, is a more subjective assessment of species similarity to humans. Epley,  
64 Waytz, and Cacioppo (2007) define anthropomorphism as “Imbuing the imagined or real behaviour of  
65 nonhuman agents with human-like characteristics, motivations, intentions, and emotions,” (p. 864).  
66 Understanding humans’ subjective assessments of similarity has received very little focus in  
67 environmental research, despite being an important frontier in environmental research for a multitude of  
68 reasons. For one, many species characteristics are imperceptible to the non-expert and must be  
69 inferred, such as consciousness, capacity to feel pain, or to feel emotions (although these capacities  
70 have been revealed by scientific studies; Bekoff, Allen, & Burghardt, 2002). The importance of such

71 inferences for pro-environmentalism is self-evident when one considers linguistic conventions that  
72 personify nature (e.g., “Mother Earth”), and movements such as veganism, which often highlight the  
73 sentience of animals (e.g., Hooley & Nobis, 2015). Second, influencing anthropomorphic perceptions of  
74 non-human species is an under-explored avenue for encouraging pro-environmental attitudes and  
75 behaviours among the public.

76 Researchers have found anthropomorphism of nature to be positively correlated with pro-environmental  
77 attitudes (e.g., Apostol, Rebeaga, & Miclea, 2013) and there is some experimental evidence that  
78 manipulating anthropomorphism leads to increases in pro-environmental attitudes (e.g., Wang, Ming, &  
79 Zhang, 2020). Some of the evidence has been conflicting, however; Tam (2015a), for example, presents  
80 experimental evidence that the influence of anthropomorphism on pro-environmental outcomes can be  
81 contingent on participants’ pre-existing need for social connection, and can be counterproductive for  
82 those with low need.

83 There are theoretical reasons why anthropomorphism may, in different contexts, help or hinder the pro-  
84 environmental cause. While Chan (2012) theorises that anthropomorphism of species should lead to  
85 greater desire to save their lives via an increase in empathy, this author also cautions against the  
86 indiscriminate use of anthropomorphism, which could, for instance, lead to inadvertent support for the  
87 killing of a predator to that species. Indeed, Root-Bernstein, Douglas, Smith, and Verissimo (2013)  
88 provide empirical evidence that anthropomorphism can have adverse consequences for environmental  
89 attitudes, citing a study by Knight (2005) in which Japanese zoo visitors who perceive monkeys’ feeding  
90 interactions to be akin to human gift-giving behaviour come to be disappointed in behaviour that violates  
91 perceived norms, such as stealing and fighting between the monkeys.

92 It may be that different sorts of perceived similarity are particularly important when considering pro-  
93 environmental variables. Although researchers have not explicitly specified subtypes of  
94 anthropomorphism, mind attribution is one type of perceived similarity that has been given special focus  
95 (e.g., Higgs, Bipin, & Cassaday, 2020). This entails ascribing mental capacities to non-human entities,  
96 such as emotions, thoughts, and consciousness, and might be considered in contrast to perceiving more  
97 superficial similarities between humans and nature/species, such as observable behaviours.

98 Settling the question of anthropomorphism and the contexts in which it might be a useful tool for pro-  
99 environmental campaigns is further impeded by study quality. Correlational studies that measure the  
100 associations between anthropomorphism and other variables often do not control for the influence of  
101 related variables that might explain the association, such as age and gender, and there are few  
102 experiments that manipulate anthropomorphism to assess its impact, although these are growing in  
103 number. At this juncture it would be sensible to summarise the findings from highest quality studies on  
104 this topic, which may allow for a more scientifically-informed use of anthropomorphism in pro-  
105 environmental campaigns.

106 The theory of planned behaviour (TPB; Ajzen, 1991) is a helpful theoretical framework for selecting pro-  
107 environmental variables of interest, as it has been shown to be valid in explaining the occurrence of  
108 conservation and other pro-environmental behaviours (De Leeuw, Valois, Ajzen, & Schmidt, 2015).  
109 Therefore, in addition to pro-environmental behaviours, the researchers were interested in how  
110 anthropomorphism might be associated with the psychological variables that the TPB holds to be  
111 predictive of behaviour: beliefs (behavioural, normative, control), attitude (toward the behaviour,  
112 species, and the environment), subjective norms, perceived and actual behavioural control, and  
113 intention to perform the behaviour.

114 This narrative systematic review aims to summarise the research that has associated perceived  
115 similarity with pro-environmental beliefs, attitudes, norms, behavioural control, intentions, and  
116 behaviours, and addresses two principal questions: 1. is there a significant positive association between  
117 anthropomorphism and these variables, and 2. is there reliable causal evidence from experiments that  
118 anthropomorphism can lead to pro-environmental behaviours and TPB constructs? Results from studies

119 will be synthesised to address three subsidiary questions: 1. Have researchers specified subtypes of  
 120 anthropomorphism when investigating associations with pro-environmental outcomes?; What might  
 121 mediate the association between anthropomorphism and these variables?; 3. What factors might  
 122 moderate the benefits of anthropomorphism for pro-environmental outcomes? Conclusions drawn from  
 123 included studies will be weighted by study quality.

124 **2. Method**

125 **2.1 Searches**

126 Searches were conducted on 28.10.2020 through Web of Science, PubMed, Scopus, PsycINFO, and  
 127 ERIC (see Table 1 for the search terms).

128 Scoping searches provided a survey of the field and different kinds of anthropomorphism that were  
 129 studied, which led to the inclusion of “mind attribution” and “animal mind” as terms to reflect particular  
 130 forms of anthropomorphism.

131 Table 1

132 *Search terms*

Anthropomorphism search terms	Nature and species-related search terms	Variables of interest search terms
anthropomorph* OR “mind attribution” OR “animal mind”	AND species OR wildlife OR animal* OR nature	AND belief* OR attitud* OR norm* OR control OR intention* OR efficacy OR behav*

133 **2.2 Inclusion criteria**

134 Studies were included if:-

- 135 • They reported quantitative analysis (correlation or regression) of the association between a  
 136 measure of anthropomorphism/mind attribution of non-human species and an outcome relating to  
 137 pro-environmental behaviours (belief, attitude, norm, intention, efficacy, behaviour) or attitudes  
 138 toward species/nature

139 OR

- 140 • They reported quantitative analysis of the effect of experimental manipulation of  
 141 anthropomorphism/mind attribution of non-human species on one of these outcomes

142 AND

- 143 • They were written in English.

144 Peer-reviewed published and grey literature were included.

145 **2.3 Quality Appraisal**

146 **2.3.1 Quality Appraisal Method.** Quality appraisal was conducted for each paper to determine internal  
 147 validity (i.e., the results were a true representation of the relationship between variables under study)  
 148 and sources of bias that might misrepresent the population under study. For correlational designs,  
 149 quality could only be assessed with regard to their ability to answer a non-causal hypothesis, i.e., that  
 150 there is a statistical evidence of an association between the variables. For experimental designs, quality  
 151 could be assessed in relation to whether the study results could be relied upon to draw causal  
 152 conclusions.

153 Due to quality appraisal tools having originated in the healthcare field for testing the effectiveness of  
 154 health-related interventions, there are few quality assessment tools designed specifically for  
 155 environmental psychology, and in particular correlational designs. A tool from the National Heart, Lung,  
 156 and Blood Institute (NHLBI; <https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools>) for  
 157 assessing cross-sectional designs was adapted for the purposes of quality appraising papers with  
 158 correlational designs in the present review, as this is the only tool with guidelines that deals with such  
 159 designs to the authors' knowledge. Table 2 shows the items included to assess the correlational papers  
 160 and the reasons for their inclusion (see Table S2 for excluded items).

161 Table 2

162 *Quality criteria for appraisal of correlational papers*

Items for correlational papers	Reasons for inclusion
1. Was the research question or objective in this paper clearly stated?	This implies an a priori hypothesis and increases the likelihood that presented analyses were hypothesis-driven
2. Was the study population clearly specified and defined?	This allows for generalisability to be assessed
5. Was there a sample size justification based on a power analysis, or was an effect size reported for the analyses of interest?	This allows the authors to determine how meaningful the results are, beyond statistical significance
9. Were the measures of interest clearly defined, valid, reliable, and implemented consistently across all study participants? <sup>1</sup>	Unestablished psychometric properties and inconsistent use of measures would detract from the study's internal validity
Additional item: Did relevant correlations control for any other variable(s)?	This item was added as it was deemed an important aspect of testing the validity of a correlation

163 1 Item 9 was derived by collapsing two items and modifying their wording:- 9. Were the exposure measures (independent variables) clearly defined, valid, reliable,  
 164 and implemented consistently across all study participants?; 11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and  
 165 implemented consistently across all study participants?

166 Experimental studies were quality-checked against the first four items as the correlational studies, and  
 167 the fifth item (relating to whether correlations controlled for any other variable(s)) was not deemed as  
 168 relevant to experimental studies which can control for extraneous variables through randomisation and  
 169 testing for equivalence of baseline group characteristics. Four additional quality appraisal items were  
 170 applied to experimental studies, which were derived from the NHLBI's tool for the "Quality Assessment  
 171 of Controlled Intervention Studies" (see Table S3 for excluded items.) A fifth item was added by the  
 172 researchers for assessing experimental study quality, which related to manipulation checks. Table 3  
 173 shows the four additional items for rating study quality, and the reasons for their inclusion.

174 Table 3

175 *Quality criteria for appraisal of experimental papers*

Items for experimental papers	Reasons for inclusion
1. Were participants randomised to groups? (original wording: "Was the study described as randomized, a randomized trial, a randomized clinical trial, or an RCT?")	Randomisation limits the risk of group differences post-manipulation being attributable to important differences in non-manipulated variables that existed at baseline
2. Was the method of randomisation adequate (i.e., use of randomly generated assignment)?	It is important to use a truly random method for the process of randomisation

6. Were the groups similar at baseline on important characteristics that could affect outcomes (e.g., demographics, risk factors, co-morbid conditions)?

Similarity of baseline characteristics allows for more confidence that any observed effect can be attributed to the experimental manipulation

Additional item: Did a manipulation check show that the manipulation had the intended effect?

This item was added by the researchers as an important aspect of social psychology experiments that allow a causal hypothesis to be answered more reliably

176 Two independent raters (the study authors) assessed each of the included 18 studies against the above  
 177 criteria, with four possible response options to indicate whether the criterion was fulfilled: Yes, could not  
 178 determine, or no. For calculation of inter-rater reliability of scores, responses were transformed into  
 179 three categories (Yes = 1; Partial = 0.5; No/could not determine = 0). A response option of 'Partial' was  
 180 added for item 4 only (good quality measures and consistent implementation) as it was found that  
 181 studies frequently included a mixture of validated and non-validated measures, and including a 'partial'  
 182 response allowed for more nuance in the reporting of study quality on this criterion.

183 A Kappa value of .78 was calculated based on the categories of the two raters' quality appraisals, which  
 184 is in the "substantial" agreement range (i.e., between 0.61 - 0.80; Landis & Koch [1977]). Reviewers  
 185 reached agreement through negotiation with regard to items where their ratings conflicted, and  
 186 generated an overall rating of study quality by summing the scores on each criterion for each study  
 187 based on the following criteria:-

188 For correlational studies, the score boundaries of categories was: Poor = below 3; Fair = between 3 and  
 189 4.49; Good = 4.5 and above.

190 For experimental studies, the score boundaries of categories was: Poor = below 5; Fair = between 5  
 191 and 5.99; Good = 6 and above

192 Quality category score boundaries for correlational and experimental studies were chosen first by  
 193 deciding on the quality cut-off where studies' results were deemed unreliable, and then the score  
 194 boundaries for the 'Fair' and 'Good' categories were chosen to provide maximal diversity in quality  
 195 categories whilst maintaining sufficient quality standards.

196 **2.3.2 Quality Appraisal Results.** See Tables 4 and 5 for results of quality appraisal for correlational  
 197 and experimental studies, respectively. It should be noted that this is not an overall judgement of the  
 198 study, but an estimation of the strength of the study's results as evidence relating to the present review's  
 199 question.

200 Table 4

201 *Quality Appraisal for Correlational Studies*

Authors	1. Question clearly stated	2. Population clearly specified	3. Power analysis/ effect size	4. Good quality measures and consistent implementation	5. Correlations controlled for other variable(s)	Overall quality rating
Apostol et al. (2013)	Yes	Yes	Yes	Partial	Yes	Good
Díaz (2016)	No	Yes	Yes	Yes	Yes	Fair

Hawkins et al. (2020)	Yes	Yes	Yes	Partial	No	Fair
Higgs et al. (2020)	No	No	Yes	Yes	Yes	Fair
Knight et al. (2004)	Yes	Yes	Yes	Partial	No	Fair
Maguire et al. (2020)	Yes	Yes	Yes	Partial	Yes	Good
Manfredo et al. (2020)	Yes	Yes	Yes	Yes	Yes	Good
Riepe & Arlinghaus (2014)	Yes	Yes	Yes	Partial	Yes	Good
Tam (2013, Study 5)	Yes	Yes	Yes	Yes	Yes	Good
Tam et al. (2013, Study 1)	Yes	Yes	Yes	Partial	No	Fair
Tam (2014, Study 1)	Yes	Yes	Yes	Partial	Yes	Good
(Study 2)	Yes	Yes	Yes	Partial	Yes	Good
Tam (2015b, Study 1)	Yes	Yes	Yes	Partial	Yes	Good
(Study 2)	Yes	Yes	Yes	Partial	Yes	Good
(Study 3)	Yes	Yes	Yes	Partial	Yes	Good
Tam (2019, Study 1)	Yes	Yes	Yes	Partial	Yes	Good
(Study 2)	Yes	Yes	Yes	Yes	Yes	Good
(Study 3)	Yes	Yes	Yes	Partial	Yes	Good

202 Table 5

203 *Quality Appraisal for Experimental Studies*

Authors	1. Question clearly stated	2. Population clearly specified	3. Power analysis/effect size	4. Good quality measures and consistent implementation	5. Randomisation	6. Adequate randomisation	7. Baseline equivalence of confounding variables	8. Checks confirming effectiveness of manipulation	Overall quality rating
Brown & McLean (2015, Study 2)	Yes	No	Yes	Partial	Yes	CND	No	No	Poor
Butterfield et al. (2012, Study 1)	Yes	No	Yes	Partial	Yes	CND	No	No	Poor
(Study 2)	Yes	No	Yes	Partial	Yes	CND	No	No	Poor
Laksmidewi & Soelasih (2019, Study 2)	Yes	No	No	Partial	Yes	CND	No	Yes	Poor
Tam et al. (2013, Study 3)	Yes	Yes	Yes	Yes	Yes	CND	No	Yes	Good
Tam (2014, Study 3)	Yes	Yes	No	Partial	Yes	CND	No	No	Poor
Tam (2015a, Study 1)	Yes	Yes	Yes	Partial	Yes	CND	No	No	Fair
(Study 2)	Yes	Yes	Yes	Partial	Yes	CND	No	No	Fair
Wang & Basso (2019, Study 2)	Yes	Yes	Yes	Partial	Yes	CND	No	Yes	Fair

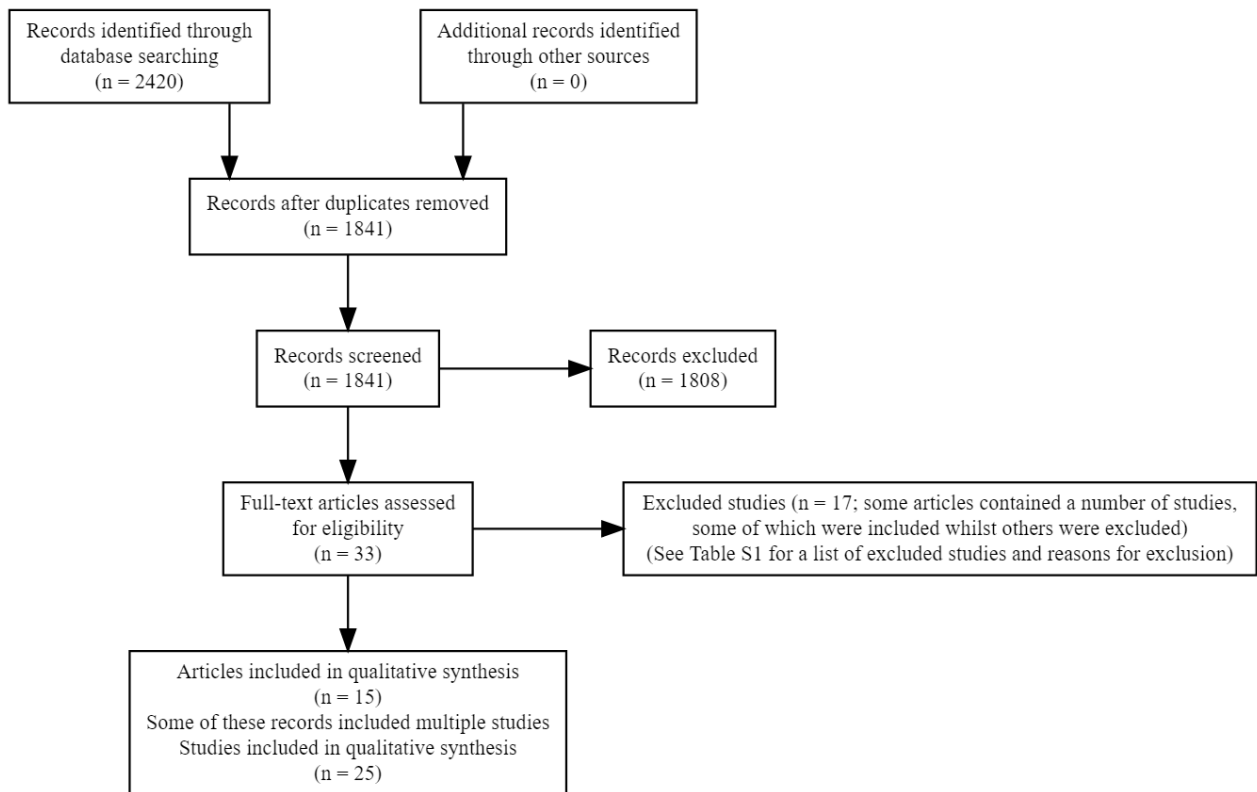


(Study 3a)	Yes	Yes	Yes	Partial	Yes	CND	No	Yes	Fair
(Study 3b)	Yes	Yes	Yes	Partial	Yes	CND	No	Yes	Fair
(Study 3c)	Yes	Yes	Yes	Partial	Yes	CND	No	Yes	Fair
Wang et al. (2020, Study 1)	Yes	No	No	Partial	No	CND	No	No	Poor
(Study 2)	Yes	No	No	Partial	No	CND	No	No	Poor
(Study 3)	Yes	No	No	Partial	Yes	CND	No	Yes	Poor

204 Due to the above ratings, eight experimental studies (rated “Poor”) were excluded from further  
 205 consideration in this review: Brown & McLean (2015, Study 2), Butterfield et al. (2012, Studies 1 & 2),  
 206 Laksmidewi & Soelasih (2019, Study 2), Tam (2014, Study 3), and Wang et al. (2020, Studies 1 - 3).

207 **2.4 PRISMA Flowchart**

208 Figure 1 shows the PRISMA flowchart of the total papers obtained from searches and their exclusion at  
 209 each stage.



210  
 211 *Figure 1. PRISMA flowchart*

212 **3. Results**

213 See Tables 6 and 7 for a summary of the findings from the correlational and experimental studies,  
 214 respectively, following quality appraisal. When statements are made about a finding, these all relate to  
 215 significance in which  $p < .05$ . It should be noted that, although some studies were reported in the same  
 216 paper, all studies reported results from different datasets.

217 Table 6

218 *Summary of findings from retained correlational studies.*

Authors	Country	Participant population	Sample Size (N)	Measure of Anthropomorphism	Measures of Outcomes/ Controlled Variables	Findings & Effect Sizes
Apostol et al. (2013)	Romania	General population, (adults and children, mean age = 36.54, SD = 12.63, range = 14 - 77)	2,683	Belief in Animal Mind Questionnaire (Hills, 1995)	Empathy: Empathy to Animals Scale (Powell, 2010); Attitudes: Attitudes to Animals Scale (Herzog Jr, Betchart, & Pittman, 1991)	Significant positive correlations were found between belief in animal mind and more positive attitudes toward animals ( $r = .297$ ); a hierarchical regression showed belief in animal mind to be significantly predictive of positive attitudes toward animals (adjusted $R^2 = 0.09$ ) even when gender, age pet ownership, education, residence, empathy to animals, empathic concern, and perspective taking were included in the analysis (although belief in animal mind was the third-strongest predictor after empathic concern and perspective taking)
Díaz (2016)	Spain	University students (mean age = 23.26; SD = 6.1)	481	Items from the Attributes Questionnaire (Herzog & Galvin, 1997) to measure five attitudes/beliefs toward species: affection for species and belief in animal consciousness	A shorter version of the Attitudes Toward the Use of Animals (adapted from Meng, 2009); questions about diet (e.g., meat-eater / vegan); questions about intention to 1. become vegetarian and 2. become vegan in the next two years	Of the five types of attitude, deservingness of moral consideration showed the strongest and highest number of correlations with beliefs in the use of animals (higher moral consideration associated with lower belief in use of animals), in which 20/21 uses of animals showed correlations with moral consideration; affection toward species and three beliefs about animal mentation (they are conscious, can feel emotions and can suffer) together predicted moral consideration of species ( $R^2 = 0.47$ ). When all variables were included together, only affection toward species and moral concern predicted intention to become vegetarian and vegan, albeit with low variance explained by

				ess, ability to suffer, to feel emotions, and worthiness of moral consideration, applied to 13 different animal species		the model (vegetarian: $R^2 = 0.09$ ; vegan: $R^2 = 0.15$ )
Hawkins et al. (2020)	Scotland	Primary school children (mean age = 9.7; SD = 1; range = 6.4 - 12.2)	1,217	Children's Beliefs about Animal Minds (Hawkins & Williams, 2016)	Children's Attitudes towards Animal Cruelty Questionnaire (both intentional and unintentional cruelty; adapted from Connor, Currie, & Lawrence, 2018)	Lower belief in animal mind was associated with higher acceptance of animal cruelty as a whole ( $r = 0.14$ ) and higher acceptance of intentional cruelty specifically ( $r = 0.11$ )
Higgs et al. (2020)	United Kingdom	General population (snowball sampling; mean age = 38; SD = 15.98; range = 18 - 80)	317	Belief in Animal Mind Questionnaire (adapted from Hills, 1995)	Animal Purpose Questionnaire (developed as part of the study)	Belief in animal mind was found to be significantly predictive of lower agreement with the killing of animals even after controlling for gender, age, ethnicity, religion, eating orientation, education, working with animals, and being a scientist, contributing $R^2 = 0.10$ additional variance to the model
Knight et al. (2004)	United Kingdom	General population (mean age = 39.3; SD = 13.9)	96	Belief in Animal Mind Questionnaire (adapted	A questionnaire about six different types of animal use (no reference is provided for this measure)	Higher belief in animal mind was associated with lower support for animal experimentation and less support for animal use (for personal decoration, entertainment, financial gain, animal management issues, and using animals in the classroom (lowest $r = 0.46$ , highest $r = 0.53$ ), even when

				from Hills, 1995)		controlling for other factors (age, gender, pet ownership, meat eating, political stance, and living area)
Maguire et al. (2020)	Australia and Kingdom of Tonga	General population (mean age = 33.93; SD = 13.98)	45	Adapted Individual Differences in Anthropomorphism Questionnaire (Waytz, Cacioppo, & Epley, 2010) to ask questions about anthropomorphism of whales	Empathy: Interpersonal Reactivity Index adapted for animals (Norring, Wikman, Hokkanen, Kujala, & Hänninen, 2014); conservation behaviours: Conservation Behavior Scale (Schultz, 2000); connectedness to nature: Connectedness to Nature Scale (Mayer & Frantz, 2004)	Anthropomorphism was not uniquely predictive of conservation behaviour when nature connection, perspective-taking and empathic concern were included in the regression model (only nature connection was a unique predictor)
Manfredo et al. (2020)	United States	General population (no summary of sample age provided)	43,939	Adapted Individual Differences in Anthropomorphism Questionnaire (Waytz et al., 2010) to ask questions about anthropomorphism of wildlife; added two	Values: 19-index survey about mutualism and wildlife values (Teel & Manfredo, 2010); Attitudes toward carnivores involved in human-wildlife conflict situations: bespoke items	A mediation analysis was consistent with a hypothesised model in which anthropomorphism reduces support for lethal management of carnivores largely via mutualism values

				items to ask participants about extent to which they believe wildlife have consciousness and have free will	
Riepe & Arlinghaus (2014)	Germany	General population (adults and children, age range = 14 - 92 [no mean age provided])	1,043	Attributes Questionnaire (Herzog & Galvin, 1997)	Values and Beliefs Relating to Recreational Fishing: Two Wildlife Values Orientation scales (Teel, Dayer, Manfredo, & Bright (2005); Manfredo, Teel, & Henry (2009), adapted to ask specifically about values and beliefs pertaining to recreational fishing; Support for Animal Rights: adaptation of the Animal Rights Scale (Wuensch, Jenkins, & Poteat, 2002)
Tam (2013, Study 5: "Tam 1") <sup>1</sup>	Hong Kong	Undergradates (mean age = 20.55, SD = 1.51)	78	Individual Differences in Anthropomorphism Questionnaire (Waytz et al., 2010)	Anthropomorphism of animals, nonanimal natural entities, and nature, were associated with green behaviour frequency and environmental movement support (correlations ranging from $r = 0.23$ to $r = 0.36$ ); statistical support was reported for empathy to nature mediating the association between anthropomorphism and conservation behaviour (full mediation for anthropomorphism of natural entities and
					Anthropomorphism did not predict variance in attitudes toward recreational fishing, and the hypothesis therefore that anthropomorphism would mediate the association between wildlife value orientations and attitudes toward recreational fishing was not supported

Tam et al. (2013, Study 1: "Tam 2")	Singapore	Undergraduates (mean age = 21; SD = 3.1; no age range given)	50	Amount of anthropomorphic content in pro-environmental posters generated by participants (who had been given no instructions to anthropomorphise in their posters)	Private Behaviour: asking participants to indicate how likely they were to try green products and tell others about them; Environmental Indicator of National Development (bespoke item)	nature; partial for anthropomorphism of animals)	Those grouped as having produced an anthropomorphic poster had stronger product use intention ( $d = 0.58$ ) and support for one indicator of nation development (environmental impact; $d = 0.72$ ) than those who were grouped as having produced a less anthropomorphic poster, and these two outcomes were also correlated with degree of researcher-rated "human-ness" of natural entities on the posters (product use intention: $r = .29$ ; environmental impact: $r = .30$ ). As would be expected, the two groups did not differ in their support for the other three indicators of nation development (economic output, life expectancy, and life satisfaction)
Tam (2014, Study 1: "Tam 3")	Hong Kong	Undergraduates (mean age = 21.10; SD = 1.13)	239	Anthropomorphism of Nature Scale (Tam, 2013)	Efficacy: bespoke items asking participants to rate their understanding of the environmental crisis, how predictable they believe the future of the environmental crisis to be, and how predictable they believe the future of nature to be; Action Efficacy: bespoke items asking participants to rate their beliefs about how impactful and effective their actions can be in helping nature/resolving the environmental crisis, and how	Anthropomorphism of nature was correlated with perceived capacity to understand ( $r = .21$ ) and predict ( $r = .16$ ) the environmental crisis, action efficacy ( $r = .33$ ), environmental movement support ( $r = .19$ ), green behaviour frequency ( $r = .22$ ), and product use intention ( $r = .26$ ); statistical evidence was provided in support of a hypothesised model in which action efficacy and capacity to understand the environmental crisis were full mediators between anthropomorphism of nature and environmental movement support as well as green behaviour frequency, and a partial mediator between anthropomorphism and product use intention	

confident they feel in their ability to help nature; Public Conservation Behaviour: 10 items to assess for environmental movement participation, adopted from the Environmental Attitudes Inventory (Milfont & Duckitt, 2010); Private Conservation Behaviour: one measure asking participants how frequently they performed 12 green behaviours (adapted from previous studies such as Kaiser et al. (2003), and one bespoke measure in which participants were shown four “green” products on the market and asked how much they would like to try/to tell their family and friends about each product

(Study 2: “Tam 4”)	United States	General population (mean age = 32.03; SD = 12.37; range = 13 - 71) recruited via online jobs website	177	Anthropomorphism of Nature Scale (Tam, 2013)	Personal Action and Action Efficacy: bespoke items, in which personal action efficacy items were changed from “I” to “humans” to assess collective action efficacy (e.g., “What I/human beings do can be effective in protecting nature”); Public Conservation Behaviour: 10 items to assess for environmental movement participation, adopted from the Environmental Attitudes Inventory (Milfont & Duckitt, 2010); Private Conservation	Individual differences in anthropomorphism were correlated with environmental movement support ( $r = .18$ ), green behaviour frequency ( $r = .18$ ), intention to use green products ( $r = .16$ ), personal action efficacy ( $r = .14$ ), but not collective action efficacy. The authors reported statistical evidence in support of a hypothesised model in which personal action efficacy, but not collective action efficacy, is a full mediator between anthropomorphism of nature and all conservation behaviours (support for environmental movements; green behaviour frequency; intention to use green products)
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					Behaviour: one measure asking participants how frequently they performed 12 green behaviours (adapted from previous studies such as Kaiser et al. (2003), and one bespoke measure in which participants were shown four “green” products on the market and asked how much they would like to try/to tell their family and friends about each product	
Tam (2015b, Study 1: “Tam 5”)	Hong Kong	Undergraduates (mean age = 19.87; SD = 0.84)	126	Anthropomorphism of Nature Scale (Tam, 2013)	Bespoke measure of pro-environmental behaviours asking for frequency of each of eight behaviours; Values: Schwartz Values Questionnaire (Schwartz, 1992); Personality: BFI = Big Five Inventory (John, Donahue, & Kentle, 1991)	Mind attribution to nature was correlated with self-reported pro-environmental behaviours ( $r = .24$ ), and improved the prediction of self-reported pro-environmental behaviours beyond personality traits and values ( $R^2$ change = .16)
(Study 2: “Tam 6”)	Hong Kong	University staff members (mean age = 32.82; SD = 8.39)	181	Anthropomorphism of Nature Scale (Tam, 2013)	Social Desirability Scale (Stöber, 2001); observed pro-environmental behaviour	Mind attribution to nature was correlated with observed pro-environmental behaviour (participants’ donations to World Wide Fund for Nature Hong Kong; $r = .21$ ), and improved the prediction of observed pro-environmental behaviours beyond social desirability and demographic variables ( $R^2$ change = .16)
(Study 3: “Tam 7”)	Hong Kong	Undergraduates (mean age = 20.69; SD = 1.58)	62	Anthropomorphism of Nature Scale (Tam, 2013)	Bespoke measures of: pro-environmental behaviour intention and empathy toward nature (with two subcomponents: empathic concern and perspective-taking)	Mind attribution to nature was correlated with pro-environmental behaviour intention ( $r = .29$ ). Results of a mediation analysis provided support for the empathy being a full mediator of the association between mind attribution to nature and pro-environmental behaviour intention



Tam (2019, Study 1: "Tam 8")	Hong Kong	University staff members (mean age = 32.86; SD = 8.37; range = 22 - 60)	176	Anthropomorphism of Nature Scale (Tam, 2013)	Two items to assess environmental guilt; two bespoke measures of participation in Earth Hour: 1. assessing intention to turn lights off during Earth Hour, and 2. assessing participation in Earth Hour in the past	Anthropomorphism of nature was found to be correlated with intention to participate in Earth Hour ( $r = 0.23$ ), and there was support for environmental guilt as a mediator between these variables
Tam (2019, Study 2: "Tam 9")	Hong Kong	Undergraduates (mean age = 20.73; SD = 1.20; range = 18 - 25)	168	Anthropomorphism of Nature Scale (Tam, 2013); Individual Differences in Anthropomorphism Questionnaire (Waytz et al., 2010)	Bespoke scale of degree of emotional response to photos of environmental problems (nine emotions, including guilt, anger, and shame); three measures of pro-environmental behaviour intention: one measures of private-sphere pro-environmental behaviours (adopted from Tam, 2013); two measures of collective pro-environmental behaviours (the two subscales of the Environmental Action Scale; (Alisat & Riemer, 2015)	Anthropomorphism as measured by the Anthropomorphism of Nature Scale was correlated with pro-environmental behaviour intention (private-sphere: $r = 0.24$ ; participatory actions: $r = 0.27$ ; leadership actions: $r = 0.35$ ), and for the Individual Differences in Anthropomorphism Questionnaire, anthropomorphism of nature was the most consistent correlate with these variables and anthropomorphism of animals and inanimate devices less so. There was support for a mediational model in which environmental guilt mediated the association between anthropomorphism and pro-environmental behaviour intention
Tam (2019, Study 3: "Tam 10")	United Kingdom	General population (recruited from a participant panel website; mean age = 25.64; SD = 5.55; range = 18 - 70)	255	Anthropomorphism of Nature Scale (Tam, 2013)	A scale to assess participants' levels of 11 different emotions; two measures of pro-environmental behaviour intention: a private-sphere and public-sphere pro-environmental measure (adapted from Bain et al., 2016); one measure of actual behaviour, in which participants had the option to	Anthropomorphism was correlated with behaviour intention (private-sphere: $r = 0.23$ ; public-sphere: $r = 0.27$ ) but not actual behaviour (donation: $r = 0.04$ ); a mediation analysis supported environmental guilt as a mediator between anthropomorphism and both intention and donation

donate to an environmental organisation

219 <sup>1</sup>The authors chose a number system to refer to Tam’s studies in the text for ease of reading.

220 *Table 7*

221 *Summary of Findings from retained experimental studies*

Authors	Country	Participant population	Sample Size (N)	Measure(s) of Anthropomorphism	Measures of Outcomes/ Controlled Variables	Findings & Effect Sizes
Tam et al. (2013, Study 3: “Tam 11”) <sup>1</sup>	Hong Kong	Undergraduates (mean age = 20.88; SD = 1.3; no age range given)	73	N/A	Connectedness to Nature: Connectedness to Nature Scale (Mayer & Frantz, 2004); Private Conservation Behaviour: bespoke items asking participants to indicate how likely they were to try green products and tell others about them; Support for Environmental Indicator of National Development (bespoke item)	Participants randomly assigned to read an anthropomorphised pro-environmentalism poster vs the control condition who read a non-anthropomorphised version had stronger product use intention (d = .48), and stronger support for country’s adoption of an environmental impact indicator of nation development (d = .51); statistical evidence was provided in support of a hypothesised model in which connectedness to nature is a full mediator between anthropomorphism of nature and 1. product use intention; 2. environmental indicator support
Tam (2015a, Study 1: “Tam 12”)	Online	Online study recruiting Americans on an online jobs site (mean age = 31.92; SD = 12.07)	314	N/A	Desirability of Control Scale (Burger, 2013); 10 items to assess for environmental movement participation, adopted from the Environmental Attitudes Inventory (Milfont & Duckitt, 2010); items to assess participants’ likelihood of	Participants were randomised either to read an article about the environmental crisis referring to “Mr. Nature” (experimental condition) or “Nature” (control condition); while there was no main effect of Condition on the two outcomes (environmental movement participation and green

					performing 12 pro-environmental behaviours, adopted from previous studies (e.g., Tam (2013)	behaviour intention), desire for control was a moderator of the relationship between Condition and these outcomes, i.e., there was an interaction effect in which anthropomorphised language led to an increase in these outcomes for those with high desire for control and a decrease in those with low desire for control ( $\eta^2p = .02$ )
(Study 2: "Tam 13")	Hong Kong	Undergraduates (mean age = 20.45; SD = 1.68)	101	N/A	10 items to assess for environmental movement participation, adopted from the Environmental Attitudes Inventory (Milfont & Duckitt, 2010); items to assess participants' likelihood of performing 12 pro-environmental behaviours, adopted from previous studies (e.g., Tam (2013)	Participants viewed a poster with anthropomorphised content (experimental condition), compared with neutral content (control condition); while there was no main effect of Condition on the two outcomes (environmental movement participation and green behaviour intention), attachment style was a moderator of the relationship between Condition and these outcomes, i.e., there was an interaction effect in which anthropomorphised language led to an increase in these outcomes for those with strong attachment anxiety (without attachment avoidance) whereas the opposite was true for those with weak attachment anxiety ( $\eta^2p = .17$ ). Attachment avoidance did not have a moderating effect
Wang & Basso (2019, Study 2)	United States	General population, recruited from online jobs website (mean age = 33.44, SD = 11.25)	162	N/A	Two bespoke items to assess: how tasty and how enjoyable the meat would be from a restaurant depicted in a vignette; a bespoke	Participants randomised to read one of the anthropomorphic vignettes of pigs (depicting pigs' friendships with each other, or with humans) had lower attitudes toward meat ( $d = 0.76$ )

					item to assess intention to purchase the meat product	and $d = 1.06$ , respectively) and lower intention to purchase meat ( $d = 0.60$ and $d = 0.98$ , respectively) than in the control condition (a vignette in which pigs were depicted in a free-range scenario), and the two anthropomorphic conditions were not different from each other on these outcomes; statistical evidence was provided in support of a hypothesised model in which attitudes to meat mediated the effect of the experimental manipulation on purchase intentions ( $R^2 = 0.66$ )
(Study 3a)	United States	General population, recruited from online jobs website (mean age = 37.53, SD = 10.67)	111	N/A	Two bespoke items to assess: how tasty and how enjoyable the meat would be from a restaurant depicted in a vignette; a bespoke item to assess intention to purchase the meat product; four items to assess anticipatory guilt and responsibility from imagining eating the depicted meat product (how guilty, accountable, responsible and ashamed they would feel; adapted from (Ahn, Kim, & Aggarwal, 2014))	Participants randomised to read the anthropomorphic vignettes of pigs (depicting pigs' friendships with each other) had lower attitudes toward meat ( $d = 0.59$ ) and lower intention to purchase meat ( $d = 0.45$ ) than in the control condition; support was found for a mediation model in which being exposed to anthropomorphism led to increased anticipatory guilt, leading to less favourable attitudes toward eating meat, which led to lower purchase intentions ( $R^2 = 0.56$ )
(Study 3b)	United States	General population, recruited from online jobs website (mean age = 35.12, SD = 9.16)	108	N/A	Two bespoke items to assess: how tasty and how enjoyable the meat would be from a restaurant depicted in a vignette; a bespoke item to assess intention to purchase the meat product; four items to assess anticipatory guilt and responsibility from imagining eating the depicted meat product	No differences were found between those randomised to read the anthropomorphic vignette (depicting cows as having friendships with other cows) and those who read a control vignette, on attitudes toward meat or purchasing intentions

(how guilty, accountable, responsible and ashamed they would feel; adapted from (Ahn et al., 2014))

(Study 3c)	United States	General population, recruited from online jobs website (mean age = 38.93, SD = 13.05)	167	N/A	Two bespoke items to assess: how tasty and how enjoyable the meat would be from a restaurant depicted in a vignette; a bespoke item to assess intention to purchase the meat product; four items to assess anticipatory guilt and responsibility from imagining eating the depicted meat product (how guilty, accountable, responsible and ashamed they would feel; adapted from (Ahn et al., 2014))	Participants randomised to read one of the anthropomorphic vignettes of pigs (depicting pigs' friendships with humans) had lower attitudes toward meat ( $d = 0.76$ ) and lower intention to purchase meat ( $d = 0.69$ ) than in the control condition; support was found for two mediation models: 1. being exposed to anthropomorphism led to less favourable attitudes toward eating meat, which led to lower product use intentions; 2. being exposed to anthropomorphism led to increased anticipatory guilt, leading to less favourable attitudes toward eating meat, which led to lower purchase intentions (the model as a whole of both mediation paths accounting for $R^2 = 0.67$ of the variance)
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222 <sup>1</sup>The authors chose a number system to refer to Tam's studies in the text given for ease of reading.

## 223 4. Narrative Synthesis

224 Tam's studies will henceforth be described according to the naming system used in Tables 6 and 7, for  
225 ease of reading.

226 Twenty-five studies were included in this review. They were carried out between 2004 and 2020, taking  
227 place across four continents and several countries: Hong Kong, Singapore, Australia and the Kingdom  
228 of Tonga, United Kingdom, Germany, Spain, Romania, and United States. One study did not report a  
229 country in which it took place, only reporting that data collection proceeded via an online jobs site (Tam  
230 12).

231 Thirteen studies investigated a general population sample, one included primary school children, eight  
232 included undergraduates, one included university students more broadly, and two included university  
233 staff members. Results will now be presented separately for correlational studies in order to address  
234 the first question of this review, and experimental studies to address the second.

### 235 4.1 Study Quality

236 After the studies rated "Poor" in quality were excluded, the quality ratings for remaining studies were  
237 "Good" (12 correlational; one experimental) and "Fair" (six correlational; six experimental).

238 All of the correlational studies provided some measure of effect size, all but one specified their  
239 population clearly, and all but two were deemed to have stated a clear question. Thirteen studies were  
240 deemed to have partially fulfilled the criterion of using good quality measures for relevant variables (in  
241 all cases this was due to at least one measure not having its psychometric properties [reliability/validity]  
242 described). Five studies were deemed to have exclusively reported good quality measures with  
243 consistent implementation. Fifteen papers were deemed to have controlled for variables other than  
244 anthropomorphism in their analyses (through regression/mediation).

245 Of the experimental studies, all were deemed to have stated a clear hypothesis, specified their  
246 population clearly, provided a power analysis/reported effect sizes, and reported randomisation of  
247 participants into the experimental/control groups. No studies reported how participants were  
248 randomised, and whether therefore this was adequate. No studies reported on the baseline  
249 characteristics of the experimental/control groups, and therefore whether randomisation had achieved  
250 the desired effect. Six studies were deemed only to have partially reported good quality measures with  
251 consistent implementation, and two were deemed to have exclusively reported good quality measures  
252 with consistent implementation. Five studies conducted a check on whether the manipulation was likely  
253 to have influenced anthropomorphism.

### 254 4.2 Question 1: *Is there a reliable association between anthropomorphism and pro-* 255 *environmental variables?*

256 Eighteen studies reported correlational analyses. One study did not find anthropomorphism to be  
257 associated with any expected measures (Riepe & Arlinghaus, 2014) and another found it not to be  
258 predictive of conservation behaviour when other variables were controlled for (Maguire et al., 2020);  
259 both studies were rated "Good" quality. The remaining 16 studies found anthropomorphism to be  
260 associated with all expected pro-environmental variables, with the exception of Díaz (2016; "Fair"  
261 quality) and Tam 4 ("Good" quality), who found support for the association of anthropomorphism with  
262 some, but not all, expected variables.

263 Of the 16 studies finding at least some support for associations between anthropomorphism and  
264 expected variables, six controlled for at least one other variable in analyses, either with mediation or  
265 regression analyses. Variables controlled for in regression analyses were as follows for "Good" quality  
266 studies: Apostol et al. (2013), controlling for gender, age pet ownership, education, residence, empathy  
267 to animals, empathic concern, and perspective-taking; Tam 5, controlling for personality traits and

268 values; Tam 6, controlling for social desirability and demographic variables. For “Fair” quality studies,  
269 variables controlled for in regressions were as follows: Díaz (2016), controlling for different kinds of  
270 anthropomorphism; Higgs et al. (2020), controlling for gender, age, ethnicity, religion, eating orientation,  
271 education, working with animals, and being a scientist; Knight et al. (2004), controlling for age, gender,  
272 pet ownership, meat eating, political stance, and living area. Nine studies controlled for variables with  
273 mediation analyses (see Section 4.2.1, below).

274 Correlational studies measured dispositional anthropomorphism, i.e., individuals’ natural tendency to  
275 perceive non-human entities as having humanlike characteristics. All correlational studies (except for  
276 Tam 2, to be discussed below) measured mind attribution, i.e., perceiving nature/species to have mental  
277 experiences and capacities. One measure of mind attribution is the Anthropomorphism of Nature Scale  
278 (ANS; Tam, 2013), in which respondents are asked to what extent nature has a mind of its own, free  
279 will, consciousness, intentions, and emotional experience. This scale has been reported to have good  
280 internal consistency and predictive validity (Tam, 2013). Eight studies by Tam used the ANS (Tam 3 –  
281 10). These were all rated “Good” quality and controlled for other variables. These studies found that  
282 mind attribution to nature is associated with pro-environmental behaviour intention (five studies), action  
283 efficacy (two studies), and environmental movement support (two studies). Four studies found mind  
284 attribution to nature to be associated with self-reported pro-environmental behaviour. As for observed  
285 pro-environmental behaviour (in the form of donations made by participants during the study), whereas  
286 one study found mind attribution to be associated with this (Tam 6), one did not find evidence for this as  
287 a main effect (Tam 10; but see Section 4.2.1 for a mediation analysis that revealed an association).

288 Tam 9 used another measure alongside the ANS: the Individual Differences in Anthropomorphism  
289 Questionnaire (IDAQ; Waytz et al., 2010), which looks at people’s beliefs about whether a target has  
290 five different mental states/capacities (“a mind of its own”, “free will”; “consciousness”, “intentions”, and  
291 “can experience emotions”, p. 229). The IDAQ applies these states to devices (e.g., a computer), nature  
292 (e.g., the ocean), and animals (e.g., an insect). This measure has demonstrated good construct validity  
293 and reliability (internal consistency and temporal stability; Waytz et al., 2010). Tam 9 found the IDAQ-  
294 nature and the ANS to have the highest correlations with pro-environmental behaviour intention, and  
295 IDAQ-animals/devices less so. Correlations were found to be high between the IDAQ-nature and the  
296 ANS ( $r = 0.78$ ) and low between the ANS and IDAQ-animals ( $r = 0.35$ )/IDAQ-devices ( $r = 0.42$ ),  
297 suggesting that the IDAQ-nature and the ANS might measure the same construct. This paper also  
298 revealed a three-factor solution to the IDAQ according to its proposed subscales, providing statistical  
299 support that the tendency to attribute a mind to one kind of target is not necessarily associated with  
300 mind attribution to another kind.

301 The IDAQ was used by another study (Tam 1, rated “Good” quality which found IDAQ-nature and IDAQ-  
302 animals both to be associated with green behaviour frequency and environmental movement support.)  
303 The IDAQ was adapted by two other studies (rated “Good” quality) in which items were reworded to  
304 relate to wildlife (Manfredo et al., 2020; e.g., whether wildlife “have intentions”, p. 3) and a specific animal  
305 species - whales (Maguire et al., 2020; e.g., “to what extent do whales have free will”, p. 110). The first  
306 found a significant role for mind attribution to wildlife in a mediation model (see Section 4.1.2). The  
307 second did not find mind attribution to whales to be associated with conservation behaviour when other  
308 variables were included.

309 Another measure used by studies to assess mind attribution to animals was the Belief in Animal Mind  
310 Questionnaire (BAMQ; Hills, 1995), which was used by Apostol et al. (2013); Hawkins and Williams  
311 (2016); Higgs et al. (2020); and Knight et al. (2004). The BAMQ asks four questions about belief that  
312 most animals are aware, can think and solve problems, and can feel emotions, and has high internal  
313 consistency ( $\alpha = .90$ ; Hills). Of these studies the highest quality (Apostol et al., 2013; “Good” quality),  
314 showed mind attribution to animals to be associated with attitudes toward animals when the researchers  
315 controlled for other variables. The three remaining papers (“Fair” quality) found those with higher mind  
316 attribution to animals to be less accepting of behaviours toward animals that would entail harming or  
317 using them in some way.

318 Two studies analysed mind attribution to animals by adapting the Attributes Questionnaire (Herzog &  
319 Galvin, 1997), which the authors validated through factor analysis and has been shown to have high  
320 internal consistence ( $\alpha = .94$ ; e.g., Díaz, 2016). Riepe and Arlinghaus (2014; “Good” quality) analysed  
321 mind attribution to nine animals (collapsed across all species) by assessing beliefs in these animals’  
322 capacity to feel fear, pain, and suffering, and did not find support for mind attribution’s association with  
323 attitudes toward recreational fishing. Díaz (2016; “Fair” quality) assessed three subcomponents of mind  
324 attribution (presence of consciousness, ability to suffer/feel pain, and ability to experience emotions)  
325 and analysed them separately. They also measured another attribute that they classed as a kind of  
326 anthropomorphism: animals’ worthiness of moral consideration. When collapsed across 13 species, the  
327 three mind attribution subcomponents, combined with participants’ ratings of affection toward animals,  
328 predicted participants’ beliefs in animals’ worthiness of moral consideration. When the three mind  
329 attribution subcomponents, affection, and moral consideration were entered into a model to predict  
330 behaviour intention (to become vegetarian / vegan), only moral consideration and affection explained  
331 unique variance in the model.

332 Finally, Tam 2 (“Fair” quality) did not use a questionnaire-based measure of anthropomorphism, but  
333 rated the amount of anthropomorphic content in pro-environmental posters generated by participants.  
334 Examples of anthropomorphic posters generated by participants showed physical elements similar to  
335 humans (e.g., a drawing of the Earth depicted with eyes and a mouth) and those that may have implied  
336 mind attribution (the Earth expressing emotion through frowning).

337 **4.2.1 Mediation.** Nine correlational studies conducted mediational analyses to investigate variables that  
338 might mediate the association of anthropomorphism with pro-environmental variables, all rated “Good”  
339 quality. Manfredo et al. (2020) reported a mediation analysis in which mind attribution to wildlife reduced  
340 support for lethal management of carnivores largely via mutualism values. Riepe and Arlinghaus  
341 (2014)’s study did not find support for mind attribution to trout as a mediator of value orientation toward  
342 wildlife and attitudes toward fishing.

343 Tam’s correlational studies (1; 3 – 4; 7 – 10) found the following mediations: empathy to nature as a  
344 mediator between mind attribution to nature and animals (separately) and conservation behaviour;  
345 empathy to nature as a mediator between mind attribution to nature and pro-environmental behaviour  
346 intention; environmental guilt as a mediator between mind attribution to nature and intention to engage  
347 in pro-environmental behaviour; environmental guilt as a mediator between mind attribution to and pro-  
348 environmental behaviour; environmental guilt as a mediator between mind attribution to nature and both  
349 public/private-sphere pro-environmental behaviour intention and actual behaviour (donation).

### 350 ***4.3 Is there reliable evidence that manipulating anthropomorphism leads to pro-environmental*** 351 ***outcomes?***

352 Different methods were used for manipulating anthropomorphism among the seven experimental  
353 studies. Tam 11 manipulated anthropomorphism by showing participants either an anthropomorphised  
354 or a non-anthropomorphised poster depicting nature (generated by participants in Tam 2; e.g., a cartoon  
355 of the Earth with a human face, frowning). These same posters were shown to participants in Tam 13.  
356 Participants in Tam 12 read an article about the environmental crisis describing nature as “Mr. Nature”  
357 and using personal pronouns, whereas the control article used “Nature” and impersonal pronouns  
358 instead. In the four studies by Wang and Basso (2019), participants either read an anthropomorphic  
359 vignette of farm animals (pigs in studies 2 and 3a, and 3c; cows in 3b) which entailed describing them  
360 as having friendships with each other or with other humans, or read a control condition (describing the  
361 animals in a free-range scenario).

362 One experimental study was rated “Good” quality (Tam 11), and found the manipulation to lead to  
363 stronger product use intention and stronger support for the nation’s adoption of an environmental impact  
364 indicator of development. One of the remaining six experimental studies (all rated “Fair” in quality) did  
365 not find the expected effect of anthropomorphism on attitudes toward eating meat and intention to



366 purchase meat (Wang & Basso, 2019, Study 3b). This study depicted anthropomorphism of cows,  
367 whereas the remaining studies by these authors depicted anthropomorphism of pigs and did find the  
368 expected effect of the manipulation in leading to lower attitudes toward eating meat and lower intention  
369 to purchase meat. The remaining two studies by Tam (12 & 13) did not find a main effect of the  
370 manipulation on pro-environmental behaviour and behaviour intention, but did find an effect of the  
371 manipulation when attachment anxiety in the absence of attachment avoidance was a moderator and  
372 when desire for control was a moderator, respectively.

373 **4.3.1 Mediation.** Tam 11 conducted a mediational analysis (rated “Good” quality). These authors found  
374 support for a model in which connectedness to nature acts as a full mediator between  
375 anthropomorphism of nature and 1. product use intention; 2. environmental indicator support.

376 The three studies by Wang & Basso (2019) that found positive main effects of anthropomorphism found  
377 additional support for the following mediation models: the effect of anthropomorphism on the intention  
378 to purchase meat was mediated by attitudes to eating meat (Study 2); the same model, but with  
379 anticipatory guilt leading to lower attitudes toward meat (Study 3a); and both of these models (Study  
380 3c).

## 381 **5. Discussion**

382 This study is the first to take a systematic survey of the literature on anthropomorphism and its  
383 association with pro-environmental outcomes. There are experimental studies of at least adequate  
384 quality that agree in broad terms that manipulating anthropomorphism gives rise to expected changes  
385 on measured variables, implying that this could be a beneficial tool in some circumstances. The included  
386 literature was remarkably broad in terms of the countries represented, which enhances confidence in  
387 the generalisability of the findings across cultures.

388 The highest quality experimental study (Tam 11) provides evidence that inducing anthropomorphism  
389 can strengthen pro-environmental behaviour intention (intention to use green products) and attitudes  
390 toward environmental government policies (stronger support for an environmental impact indicator of  
391 nation development) via connectedness to nature. Guilt was another mediator that was reported by both  
392 experimental and correlational studies (of mixed quality). Tam 8 – 10 (rated “Good” quality) found  
393 correlational support for environmental guilt as a mediator between mind attribution to nature and  
394 behavioural intention/observed behaviour, and two of Wang and Basso’s (2019) experimental studies  
395 (3a and 3c, rated “Fair” quality) reported statistical support for a mediation model in which mind  
396 attribution to animals led to anticipatory guilt about eating meat, which led to less favourable attitudes  
397 toward eating meat and then to lower intentions to purchase meat. Empathy received support as a  
398 potential mediator from “Good” quality studies, although these were all correlational in nature. Apostol  
399 et al. (2013) showed empathy to animals to be the highest predictor of positive attitudes toward animals,  
400 above mind attribution to animals. Tam, in two studies, found empathy to nature to mediate the  
401 association between mind attribution to animals/nature and conservation behaviour, and between mind  
402 attribution to nature and pro-environmental behaviour intention (Tam 1 & 3, respectively).

403 These three concepts are related in a variety of ways. For one, Tam (2019) notes that connectedness,  
404 empathy, and guilt are normally experienced in interpersonal relationships. Perceiving non-human  
405 species and nature as a whole to be humanlike may therefore invite these responses. In addition, these  
406 interpersonal responses may all relate to the desire to treat others in a moral way; believing one has  
407 caused another harm leads to guilt (Zeelenberg & Breugelmans, 2008), which requires empathic  
408 capacity (perspective-taking; Leith & Baumeister, 1998), and nature connectedness may allow more of  
409 the natural world to be encompassed within one’s moral circle (Crimston, Bain, Hornsey, & Bastian,  
410 2016). It seems reasonable that any experimental manipulation of anthropomorphism that influences  
411 one of these will influence the other two, yet no experimental study controlled for the other two variables  
412 in mediation analyses. It would be illuminating for future experiments to look at guilt, empathy, and  
413 nature connectedness together to determine whether they are all influenced by anthropomorphism or

414 whether one takes precedence, as well as to investigate the relative strength of each as a mediator  
415 between anthropomorphism and other pro-environmental outcomes. Another analysis of interest would  
416 be to consider the potential moderating role of these variables. While it appears these variables can be  
417 experimentally induced, they can also be considered as dispositional characteristics. This raises the  
418 question of whether the effectiveness of each as a mediator depends on participants' baseline  
419 disposition.

420 It is of note that such diverse ways of inducing anthropomorphism seemed to influence an outcome of  
421 interest. Tam 12 found that merely adding "Mr." to the description of nature had a discernible influence  
422 on pro-environmental outcomes. Although this could be considered a kind of anthropomorphism in terms  
423 of ascribing a human pronoun to nature which would imply similarity of other characteristics, it seems  
424 like a less explicit way of inducing anthropomorphism than the other experiments, which seemed to  
425 describe more explicitly behaviours that implied mental capacities such as motivations and emotions  
426 (e.g., animals forming friendships; a picture of the world frowning). It is therefore notable that this was  
427 one of two studies that did not find a main effect for anthropomorphism, and that the effect on pro-  
428 environmental depended on participants' levels of desire for control. It may be that this 'weaker' form of  
429 anthropomorphism, which does not directly depict humanlike behaviours or characteristics, is what was  
430 responsible for a less robust finding. It is also important to consider the degree to which the pronoun  
431 "Mr." would have been perceived as a realistic depiction of nature's similarity to humans, and whether  
432 a lack of realism may account for some of the unintended effects of the manipulation for some  
433 participants. Regardless of the reasons, these results serve as a reminder that anthropomorphism is a  
434 tool that could be counterproductive for environmental campaigns in some cases.

435 It is also interesting that the suite of studies by Wang and Basso (2019) showed anthropomorphism of  
436 pigs to consistently lead to pro-environmental outcomes, whereas the same was not found with  
437 anthropomorphism of cows. Riepe and Arlinghaus (2014) was the only correlational study not to find  
438 any association between anthropomorphism and pro-environmental variables (in this case, mind  
439 attribution to trout did not to predict variance in attitudes toward recreational fishing). These results  
440 highlight that more work is required to determine the species that may not benefit from anthropomorphic  
441 depictions, and the reasons why.

## 442 **5.1 Theoretical Integration**

443 No study explicitly analysed anthropomorphism through the lens of established theories of behaviour  
444 change; doing so might shed light on its mechanisms of action. As discussed in the introduction, the  
445 TPB (Ajzen, 1991) is an important model with empirically proven predictive power for a range of  
446 behaviours. It is notable that this theory was very seldom referred to in the studies despite many of its  
447 variables being represented across the studies as a whole (attitude toward the behaviour, self-efficacy,  
448 behavioural intention, and actual behaviour). Studies that conducted mediation analyses can be  
449 particularly illuminating here. For example, three experimental studies by Wang and Basso (2019,  
450 Studies 2, 3a, and 3c; all "Fair" quality) reported that the effect of mind attribution to animals on the  
451 intention to purchase meat was mediated by attitudes to eating meat; this is as the TPB would predict.  
452 Tam 3 and 4 ("Good" quality) also found the association between mind attribution to nature and attitudes  
453 toward conservation behaviour/behaviour intention/behaviour frequency to be mediated by action  
454 efficacy. Although linked to a different theory in the paper, action efficacy is conceptually related to the  
455 TPB's behavioural beliefs, as both constructs entail beliefs about the consequences of undertaking a  
456 particular behaviour. As behavioural beliefs are held by the TPB to influence attitudes toward the  
457 behaviour (and, in turn, behaviour intention and actual behaviour), the results of Tam 3 and 4 align with  
458 what the TPB would predict.

459 The role of empathy, nature connectedness, and environmental guilt may also be accommodated within  
460 the TPB. In the reviewed studies, these mediator variables were found to be associated with TPB-related  
461 variables (e.g., nature connectedness explaining the link between mind attribution to nature and  
462 behavioural intention as well as attitude toward a pro-environmental action; Tam 11). The piecemeal

463 treatment of these variables, however, does not allow for the relevance of theories such as the TPB in  
464 this field to be examined, which would require simultaneous inclusion of its constructs in a model to  
465 allow paths of direct and indirect influence to be discerned. One neglected construct in the studies is  
466 that of norms. Moral norms in particular might be beneficial to include in future studies, both for the  
467 aforementioned association of some of the mediator variables with moral concern, as well as the  
468 suggestion of Fishbein and Ajzen (2011) that moral norms be included in models when predicting  
469 behaviours that have a strong moral component (such as pro-environmental behaviours; cf. Steg &  
470 Nordlund, 2018).

## 471 **5.2 Limitations of the literature**

472 No experimental study reported the effects of manipulating anthropomorphism on actual behaviour,  
473 which is an important gap for future experiments to fill. Further work is required to develop more  
474 understanding of the specific effects of anthropomorphism. The experimental studies in this review  
475 generally did not specify in detail the kind of anthropomorphism they intended to manipulate, in contrast  
476 to the correlational studies which clearly focused on mind attribution to animals/wildlife/nature. It is  
477 notable that such an array of methods for inducing anthropomorphic perceptions led to pro-  
478 environmental outcomes – in keeping with the array of mediators and pro-environmental variables found  
479 to be associated with anthropomorphism in the correlational studies – but more clarity in experiments  
480 about the particular type of anthropomorphism being targeted will help with understanding the  
481 mechanisms of action. A related point is about matching anthropomorphism to specific outcomes.  
482 Maguire et al. (2020) found that mind attribution to whales was not uniquely predictive of conservation  
483 behaviour, but as the former was specific to whales and the latter was a measure of generic conservation  
484 behaviour (with only one item out of thirteen pertaining to whales), the lack of an expected finding may  
485 be due to a mismatch between the specificity of the measures. Further research clarifying the contexts  
486 in which anthropomorphism may affect pro-environmental outcomes in a broad or narrow way would be  
487 beneficial. It may be, for example, that mind attribution to nature as a whole is associated with a similarly  
488 generic pro-environmental attitudes and behaviours, whereas mind attribution to specific types of animal  
489 may relate to a more confined set of variables that relate to those species. Indeed, Manfredi et al.  
490 (2020) found mind attribution to wildlife as a whole to be related to attitudes about lethal management  
491 of carnivores.

492 While the majority of correlational studies were considered high quality, the main detractor from quality  
493 was a lack of controlling for other variables in analyses, reducing the confidence in results showing  
494 anthropomorphism to be associated with other variables. Gender, which was not always controlled for  
495 in analyses, is an important variable for future studies in this area to include given its association with  
496 attitudes toward animals and concern/action with regard to animal welfare (Herzog, 2007),  
497 anthropomorphism of nature (Tam, 2014), and pro-environmentalism more broadly (Gifford & Nilsson,  
498 2014). There is also evidence that gender differences in empathy mediate gender differences in  
499 attitudes toward animal exploitation (Graça, Calheiros, Oliveira, & Milfont, 2018). There may be some  
500 benefit to controlling for age in analyses given its associations with pro-environmentalism (Gifford &  
501 Nilsson, 2014); however, compared with gender it appears to have a less consistent association with  
502 empathy and pro-environmental outcomes (e.g., Tam, 2013).

503 While it is encouraging that a diversity of methods for manipulating anthropomorphism led to pro-  
504 environmental outcomes, and that associations were found when anthropomorphism and other  
505 variables were measured in a multitude of ways, building a formal sense of average effect size through  
506 meta-analysis is rendered impossible for these very reasons. The use of bespoke items and adapted  
507 questionnaires to measure constructs is also a clear pattern among included studies, and measures  
508 were often included without any accompanying statements about their validity or reliability. The present  
509 study has attempted to mitigate these challenges by focusing on higher quality papers, but future  
510 reviews will be better placed to draw more definitive conclusions about a wider range of associations  
511 between anthropomorphism and pro-environmental variables if studies address these principal  
512 limitations.

513 Many of the studies included in this review were from the same research group (Tam and colleagues).  
514 These papers were high quality, but it is important to acknowledge that some bias may be introduced in  
515 the review by the preponderance of studies from one subset of individuals, where research interests  
516 may home in on a particular aspect of anthropomorphism and pro-environmentalism. Nonetheless, this  
517 provided some benefit with regard to the consistent use of measures allowing for comparisons across  
518 studies, and this research group did cover a breadth of areas, including empathy, guilt, nature  
519 connectedness, efficacy, and the influence of dispositional traits on the effects of anthropomorphic  
520 manipulations. The review likely introduced some bias with regard to its systematic search on two  
521 additional counts. First, only English-text articles were included, which did not allow results from non-  
522 English language publications to be considered. Second, while some of the databases that were  
523 searched do include grey literature such as conference abstracts, the fact that the review did not entail  
524 a more systematic search for any unpublished works introduces the potential for publication bias.

### 525 **5.3 Conclusions**

526 This review summarises the highest quality evidence for anthropomorphism of non-human species and  
527 its associations with pro-environmental variables. There is relatively good evidence that  
528 anthropomorphism increases connectedness to nature and that this in turn increases other pro-  
529 environmental attitudes and behaviours. Empathy and guilt have also received consistent support for  
530 their association with anthropomorphism, although experiments are needed to confirm whether the  
531 former is causally associated with anthropomorphism and has any mediating role. The findings suggest  
532 that anthropomorphism may be a helpful tool for achieving public support for conservation in some  
533 circumstances, although more evidence is needed as to the limitations of this strategy in terms of which  
534 species or elements of nature may be associated with pro-environmental outcomes when they are the  
535 focus of anthropomorphism, and whether anthropomorphism may backfire for some people, when  
536 presented in a certain way. Future work is needed to clarify any differential benefit of manipulating  
537 anthropomorphism in relation to pre-existing levels of dispositional nature connectedness, guilt, and  
538 empathy toward nature. To improve the quality of studies for any future reviews, correlational studies  
539 should focus on statistically controlling for correlations in relation gender and possibly age, and  
540 experiments should employ manipulation checks.

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