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Are Humans Part of the Natural World? U.S. Children's and Adults' Concept of Nature and its Relationship to Environmental Concern

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Abstract

Understanding factors that promote conservation attitudes is essential given ongoing environmental crises and the need for sustainability. Our research adopted various close- and open-ended tasks to explore: the extent to which U.S. urban adults (Study 1) and children (Study 2) have a basic conception of humans as part of nature, cognitive factors that predict more human-inclusive concepts of nature, and, finally, the relationship of their nature concepts and other individual differences to environmental moral concern and biocentric reasoning. General environmental moral concern and biocentric moral reasoning were a focus because both variables have previously been linked to sustainable attitudes. Across studies, adults and children did not tend to categorize humans as part of nature except when induced or disposed to attribute mind or life to nature. Among adults, a human-inclusive nature concept did not predict environmental moral concern or biocentrism. However, the degree of exposure to nature was positively predictive while a cluster of beliefs about humans as intrinsically unique, superior, and influential (human exceptionalism) was negatively predictive. Among children, a basic human-inclusive concept of nature was related to environmental concern but only among children who also tended to reason in ecological terms. These findings have important implications for sustainability efforts: They suggest that environmental moral concern and biocentric attitudes may be enhanced over-development by nature exposure and interventions that enduringly promote human-inclusive concepts of nature and ecological-systems understanding. Such intervention effects might be achieved by selectively inducing individuals to attribute mind and life to non-human natural phenomena and scaffolding

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accurate mechanistic understanding of evolution and common ancestry, which may also help to inhibit the development and deleterious effects of human exceptionalism.

Keywords: Nature; Human; Environmental moral concern; Biocentrism; Anthropocentrism; Exceptionalism; Ecosystem; Children

1. Introduction

Imbalances between economic development and environmental conservation have generated a global crisis that calls for changes in education and policy toward greater sustainability (Agbedahin, 2019). According to prior research, feelings of moral obligation to the natural world strongly predict pro-environmental behaviors (Bouman et al., 2020; Geiger, Steg, van der Werff, & Ünal, 2019; Gifford & Nilsson, 2014; Liu & Li, 2021). Research on how children and adults conceive of the natural environment—and build a morally concerned relationship with it—is therefore fundamental to informing the design of interventions that effectively promote more sustainable lifestyles from early in development, as well as in the creation of policies that prevent environmental degradation and environmental injustice in the long term.

One conception that has particularly been argued to represent an impediment to moral concern about nature, and a barrier to more sustainable decision-making, is the basic notion that humans represent a category that is separate from all other natural categories (e.g., Bang, Medin, & Atran, 2007; Hawkins, 1998; Plumwood, 1993). Specifically, even without corollary assumptions that humans are superior or have outsized influence over nature—ideas that are central to a specific cluster of beliefs known as "human exceptionalism" (e.g., Betz & Coley, 2022; Kim, Betz, Helmuth, & Coley, 2023, this TopiCS issue; Vargas Roncancio et al., 2019)—the basic tendency to view the human category as existing independent of the natural sphere may have at least two undermining effects. First, it may have the effect of reducing the general sense that it is morally wrong to damage natural ecosystems. This is because, in treating the human species as apart from, rather than embedded alongside, other constituents of natural systems, it places humans at a physical or psychological distance from the consequences of environmental harms.

Second, in addition to affecting general moral concern, it may also have the more specific effect of decreasing biocentric moral reasoning. Biocentric moral reasoning ascribes inherent value to all living and non-living natural things and has been found to robustly predict not only environmentalist values but concrete sustainable behavior (e.g., reduced car use, reduced household water consumption; e.g., Ajibade & Boateng, 2021; DeGroot & Steg, 2007, 2009; Jakovcecic & Steg, 2013; Kelemen, Brown, & Pizza, 2023; Rottman, 2014; Washington, Taylor, Kopnina, Cryer, & Piccolo, 2017). Specific effects on biocentrism may occur because classifying humans as separate from nature may reflect assumptions that the human category is intrinsically distinct from all other natural categories and is thus in need of special treatment. This essentialist construal is more consistent with anthropocentric moral reasoning,[1] which prioritizes human welfare and utility as a moral rationale for conservation.

By contrast with biocentrism, anthropocentric moral reasoning can sometimes have negative impacts on conservationist ideas and sustainable practices (e.g., Rottman, 2014; Schultz et al., 2005; Steg, 2016).

The basic tendency to view humans as part of nature may therefore represent a very primary influence on environmentalism and sustainable action. However, to our knowledge, there has been no prior research specifically exploring urban children's and adults' tendencies to hold human-inclusive conceptions of nature—and what predicts them—that also systematically explores the impact of having a basic human-inclusive concept of nature on environmental moral concern generally and biocentric moral reasoning specifically (but see Kim et al., 2023, for review on impacts of human exceptionalism in adults). To date, work on whether individuals conceive of humans as part of nature has often been associated with more global characterizations of environmental attitudes in communities with nature-centred epistemologies (e.g., Medin & Bang, 2014). Alternatively, it has probed the slightly different and more specific question of whether children or adults perceive similarities between humans and non-human animals or include humans in the superordinate category "animal" (e.g., Anggoro, 2014; Busch, Watson-Jones, & Legare, 2018; Coley, 2007; Leddon et al., 2012). Any studies that have explored children's or adults' definitions of "nature" in a broader sense have generally focussed more on the affective correlates of these ideas rather than homed in on relationships to environmental moral reasoning (Aaron & Witt, 2011; Collado, Íñiguez-Rueda, & Corraliza, 2016; Tillmann, Button, Coen, & Gilliland, 2019; Wals, 1994).

In this research, we therefore specifically examine whether urban-dwelling U.S. adults (Study 1) and 6- to 7-year-old children (Study 2) include humans in their concept of nature and whether certain cognitive factors (e.g., privileging ecological relationships in biological inductions; attributions of mind or life to the Earth) positively predict children's and adults' tendencies to have a more human-inclusive conception. In addition, in both Studies 1 and 2, we also explored the potential consequences of a human-inclusive concept of nature—whether it predicts general environmental moral concern and, more specifically, whether it predicts biocentric moral reasoning and decision-making. Our studies focus on U.S. urban-dwelling children and adults because their immersion in predominantly artificial environments makes them an interesting test case for understanding the conditions under which human-inclusive nature concepts can occur. Furthermore, prior research suggests that urban-dwellers are particularly likely to voice non-conservationist attitudes and engage in unsustainable behaviors so understanding predictors of environmental attitudes in this group is important (e.g., Chawla, 2020; Collado et al., 2016; Duron-Ramos, Collado, García-Vázquez, & Bello-Echeverria, 2020; Kelemen et al., 2023). In the next sections, we further outline why we adopted particular methods and explored the factors that we did.

1.1. Concepts of nature in children and adults

Contemporary neo-Darwinian science characterizes "nature" as a measurable system comprised non-human-made phenomena (Arias-Maldonado, 2015; May, 1992): that is, as a system that includes every living and non-living physical thing aside from the artifacts that humans create. Although distinctions between the natural and the artificial can be blurred

sometimes (e.g., human-made ponds or natural entities used as human tools; Johnson, 2006), it remains that humans are living things and are thus part of nature due to their common evolutionary ancestry with other non-human living things and their interdependence with other components of natural ecosystems. But do lay people conceptualize humans and nature in the same "human inclusive" way that science does?

Qualitative research certainly reveals that among cultural communities who live in close proximity to nature (e.g., U.S. rural Indigenous groups like the Menominee), there is a tendency to talk about humans as though they are part of nature (e.g., Bang et al., 2007). However, scarce quantitative research has explored children's or adults' tendencies to categorize humans as part of the natural world. Prior work has found that when asked to spontaneously name words related to natural environments, urban and rural U.S. adults tend to associate nature with peaceful, undisturbed places and often perceive of themselves as part of those environments, even if they simultaneously view nature as independent of human influence (Vining, Merrick, & Price, 2008; see also Coley et al., 2021). By contrast, when children (especially 9- to 13-year-old urban-dwellers) are asked to spontaneously respond to questions like "what is nature to you?," they typically exclude humans but instead list other natural elements (e.g., animals, plants, and non-urbanized outdoor areas; Aaron & Witt, 2011; Tillmann et al., 2019; Wals, 1994).

These findings are informative especially given their hints of different and less human-inclusive patterns in children than adults. However, as reflections of how people—especially children—categorize humans, these results may also represent a skewed picture. Productive language demands in open-ended tasks can cause individuals, especially children, to abbreviate their answers or fail to retrieve stored category knowledge due to cognitive load (see Carey, 1985b). It thus remains an unanswered question whether children or adults might reveal different, or more inclusive conceptions of nature when also tested with close-ended methods (e.g., forced-choice sorting tasks) that have fewer productive language demands, a lower cognitive load, and thus allow for more reflection.

1.2. Predictors of a human-inclusive concept of nature

In addition to being interested in U.S. urban-dwellers' tendencies to view humans as part of nature under different task demands, we were also curious about individual difference factors that might predict children's and adults' tendencies to be more human-inclusive. Prior research has found that groups who have greater informal experiential knowledge of the natural world (e.g., landscapers, fishermen, and rural Menominee adults and children) often form categories or draw inferences by attending to ecological rather than taxonomic relationships between living things (e.g., Coley, 2012; Medin, Ojalehto, Marin, & Bang, 2014; Proffitt, Coley, & Medin, 2000; Unsworth et al., 2012). That is, relative to urban-dwellers, members of groups who know more about functional interdependencies in local environments (e.g., habitat or predator–prey relationships) often privilege those functional relationships when reasoning about properties that are likely to be shared between living things (e.g., shared disease susceptibility; Coley, 2012). Because a tendency to adopt an ecological reasoning strategy may reflect a greater general sensitivity to functional interconnections

between apparently disparate parts of a system (see Grotzer & Solis, 2023, this TopiCS issue), it seemed possible that urban-dwelling children and adults with greater ecological reasoning tendencies might also have more integrated human-inclusive concepts of nature.

Prior research has also suggested that Indigenous communities with cosmologies that invite attributions of mind or life to non-human natural entities also tend to view humans as part of nature (e.g., Bang & Marin, 2015; Medin & Bang, 2014). A cognitive propensity to ascribe mind or life to a broad range of living and non-living entities (e.g., Epley, Waytz, & Cacioppo, 2007) might therefore predict a more human-inclusive concept of nature. One rationale for this expectation is that the process of extending "familiar" human mental or biological characteristics to other natural kinds might reduce feelings of psychological distance that can otherwise inhibit recognition of the human category's intrinsic commonalities with other natural categories. In turn, this might facilitate subsumption under a common superordinate: "nature."

1.3. Human-inclusive concepts of nature as predictors of environmental moral concern and biocentric moral reasoning

Environmental moral concern refers to a general sense of moral obligation to conserve and sustain nature. Given the abstractness, uncertainties, and distal nature of environmental problems, it can be hard to provoke people to environmental moral concern, in general, and to engage in sustainable action, in particular (Rottman, Kelemen, & Young, 2015; Van Lange & Huckelba, 2021). However, when environmental moral concern does occur, it is associated with two specific forms of moral reasoning: Anthropocentric moral reasoning about nature focuses on human welfare and the idea that we are morally obliged to protect natural entities because of their benefits for people. By contrast, biocentric reasoning is more global. It focuses on the welfare of larger ecological communities and ascribes intrinsic value and rights to the constituents of ecosystems without prioritizing humans or their needs (Kahn, 1999, 2006).

As noted earlier, prior research has found that people who express general environmental moral concern are more likely to act in pro-environmental and sustainable ways (e.g., Liu, Teng, & Han, 2020; Markowitz, 2012). Furthermore, individuals who express biocentric reasons for their environmental moral concern are more likely to engage in conservationism and environmentalist actions (e.g., De Groot & Steg, 2007; Gagnon Thompson & Barton, 1994; Kelemen et al., 2023; Rottman, 2014; Stern, Kalof, Dietz, & Guagnano, 1995). By contrast, anthropocentric moral reasoning—which can sometimes incorporate explicit human exceptionalist ideas about intrinsic human superiority—has been linked to lower engagement with environmental issues and sustainable behavior (Ajibade & Boateng, 2021; Betz & Coley, 2022; Kim et al., 2023).[2]

Viewing the human category as part of nature might enhance general environmental moral concern and the more equitable attitude associated with biocentric moral reasoning and decision-making. We therefore explored whether a human-inclusive concept of nature is predictive of these outcomes in children and adults. These questions were particularly interesting in elementary-aged children given suggestions that, even if children express general

moral concern about the environment, it is not usually for spontaneous biocentric moral reasons until adolescence (e.g., Kahn & Lourenço, 2002; but see Kelemen et al., 2023; Pizza & Posada, 2020).

1.4. Current studies

To summarize, in two studies, we explored whether U.S. urban adults (Study 1) and children (Study 2) include humans in their concept of nature. In order to tap adults' and children's concepts of nature more comprehensively, we probed them using an open-ended questioning method (to tap a more spontaneous definition) and a closed-ended categorization task (to tap a more reflective concept). To explore what cognitive factors predict a more human-inclusive concept of nature, we also measured ecological reasoning tendencies and attributions of mind and life to the Earth given reasons to believe they might be predictive.

In addition to exploring the nature and extent of U.S urban adults' and children's tendencies to hold human-inclusive concepts of nature, we also explored the implications of more human-inclusive concepts for environmental moral concern, in general, and tendencies to reason in biocentric moral terms, more specifically. General moral concern was measured by participants' ratings of moral wrongness when presented with a set of environmental harm scenarios. Biocentrism was measured in multiple ways: by participants' tendencies to spontaneously mention a biocentric justification for their moral judgments in the environmental harm scenarios (even if they also mentioned an anthropocentric reason); via a close-ended task that offered a forced-choice between a biocentric versus anthropocentric explanation for the moral wrongness of the set of environmental harms; and via close-ended task that tapped more active decision-making by offering a forced-choice between a biocentric versus anthropocentric motivation for donating to a conservation cause.

Across these tasks, we hypothesized that urban-dwelling adults and children with more human-inclusive concepts of nature might show greater general moral concern for the environment and greater generation or endorsement of biocentric moral reasoning. We also predicted that greater ecological reasoning tendencies might enhance environmental moral reasoning. Although our adult and child testing protocols differed sufficiently that formal child–adult comparisons were not appropriate, at the end of Study 2—with important caveats—we do report exploratory comparisons to guide future developmental research.

2. Study 1

2.1. Method

In Study 1, all adults consented following Institutional Review Board (IRB) requirements as part of a larger online Qualtrics study. The larger study explored the impact of multiple variables (including knowledge of Earth's geo-history) on adults' environmental moral reasoning and is preregistered at: https://osf.io/2kf5q/?view_only=830ae1e8b4f5468ab1c7064b8d238b59. In this article, we focus only on the subset of tasks

that were specifically designed to explore the nature of adults' concepts of nature and their relationship to general environmental moral concern and biocentrism.

2.1.1. Participants

Participants were U.S. residents and native English speakers between 18 and 25 years, recruited through the online platform Prolific ($7 compensation). Participants were excluded if they failed more than one of 10 attention checks distributed throughout the larger study or more than three comprehension test questions. The final sample was 189 adults (M age = 20.41, SD = 1.57; 52% self-identified women; 13% self-identified as East Asian, 2% South Asian, 15% Black or African American, 4% Hispanic/Latinx, 15% multiracial, and 50% White). Most were college educated (89%), leaned liberal on a 7-point scale (7 = *extremely conservative;* M = 2.83, SD = 1.55), and about half were religiously affiliated (49%). Although income and location information were not collected, most participants self-identified as dwelling in urban or suburban (rather than rural) areas, and for simplicity, we henceforth refer to them as urban. Consistent with this characterization, participants tended to report approximately less than monthly exposure to nature (M = 3.27, SD = 1.01) in a composite score that averaged participants' self-reported time spent in nature and their engagement with nature media (both scales: 1 = *almost never;* 2 = *3–4 times a year;* 3 = *less than once a month;* 4 = *every month;* 5 = *every week*; and 6 = *every day*).

2.1.2. Materials and procedures

This study comprises seven sections of the larger 14-section Qualtrics study. Sections were in the fixed order listed below. Online administration took about 30 min. Supplementary Materials provide further details on some tasks not fully elaborated in the main text.

2.1.2.1. Open-ended concept of nature task: To measure participants' spontaneous concept of nature, we asked, "When you use the word 'nature' what do you mean—what kinds of things are you talking about? Please write all the things that come to your mind when you think of the word 'nature'." Participants could write as many things as they wanted. Coding of this task had a strong intercoder agreement (Cohen's $\kappa = .92$, $p < .001$) and yielded two scores. First, we dichotomously scored the presence or absence of four natural kind categories (plants, animals, humans, and non-living natural things) in each participant's report, regardless of the number of specific exemplars named (report of natural kinds score: 0–4). Second, we dichotomously categorized whether participants did or did not spontaneously mention humans when defining "nature." Those who mentioned humans were dichotomously categorized as having a spontaneous human-inclusive concept (0 or 1).

2.1.2.2. Close-ended concept of nature task: Participants performed a sorting task to measure whether they more reflectively categorized humans as part of nature. They were shown 10 cards consisting of two artifacts (scissors and bike) and four natural kind subcategories (two items each): humans (baby, adult), animals (worm, squirrel), plants (tree, flower), natural non-living things (cloud, rock). The two cards depicting artifacts served

as control items to ensure that participants were not categorizing everything as part of nature. Cards were presented serially in random order and participants were asked to drag each card to one of two boxes: one for items that are "part of nature" and another one for items that are "not part of nature." Box presentation was counterbalanced so that half of the participants saw the "part of nature" box on the right side. Participants could score from 0 to 2 for each subcategory including the human subcategory. Furthermore, participants who classified both human items (baby and adult) as "part of nature" were dichotomously categorized as having a reflective human-inclusive concept of nature (0 or 1).

2.1.2.3. Human exceptionalism questionnaire: Because human exceptionalism represents a specific cluster of explicit beliefs implicated in adults' views of distinctions between humans and nature—a cluster of beliefs with relevance to environmental moral concern—out of curiosity, we administered a subset of 10 items that focussed on qualities of human superiority and intrinsic (biological) uniqueness from the exceptionalism questionnaire by Betz and Coley (2022). Participants rated their agreement with statements such as "Humans are the most highly evolved species" and "Humans are at the top of the food chain" on a 7-point Likert scale (7 = *strongly agree*). See Supplementary Materials for the items. Ratings were averaged with higher scores indicating greater exceptionalism (0–7; see Supplementary Materials).

2.1.2.4. Ecological reasoning task: To measure ecological reasoning tendencies, we used a subset of five randomly presented trials from the triad induction task created by Coley (2012). Participants saw three drawings of living things: one base (e.g., oak tree) and two targets. One target was ecologically related to the base (e.g., squirrel), and the other was taxonomically related (e.g., grass). Participants were told that the base had a novel disease. They then chose which target was most likely to share the sickness. Participants scored 1 each time they choose the ecological over the taxonomic target. Total ecological reasoning scores thus ranged from 0 to 5 (see Supplementary Materials for items).

2.1.2.5. Attribution of mind and life to the Earth questionnaire: To measure tendencies to attribute mind or life to natural phenomena, participants answered 14 "yes/no" questions about the Earth in random order: Five items measured their tendencies to attribute life to the Earth (e.g., Does the Earth need food?); five items measured their tendencies to attribute mind to the Earth (e.g., Can the Earth feel disrespected?). There were also four control items (e.g., Is the Earth round?), which were included to ensure participants did not adopt a "no" response set (see Supplementary Materials). Attribution of life (0–5) and mind (0–5) scores were calculated.

2.1.2.6. Environmental moral concern task: In random order, participants morally judged four environmental harm scenarios pertinent to sustainability issues such as logging, water pollution, air pollution, and waste management. For instance, in the logging situation, participants were told: "When people started to live in cities, they cut down many of the trees

in the forest so that they could make things out of wood, like wheels, tables, and houses. Because they used so many trees, now most of the forests on earth have disappeared and won't come back" (see Supplementary Materials for other scenarios). After hearing each scenario, participants were first asked to render a general moral judgment on the environmentally damaging act: for example, "Do you think it was okay or wrong that people cut down most of the forests on Earth?" If participants selected OK (score = 0), they were directed to the next question. If they selected wrong, they then rated how wrong the action was from a little wrong (1) to very, very wrong (3). The environmental moral concern score for each scenario therefore ranged from 0 to 3.

2.1.2.7. Biocentric moral reasoning measures: Participants were also asked to justify their moral judgments about the environmental harm scenarios. Following Kahn's (1999) coding scheme, their spontaneous justifications were coded as either biocentric or anthropocentric. Spontaneous biocentric moral reasoning was coded if adults appealed to the value and welfare of living and non-living nature or to nature's rights. Spontaneous anthropocentric reasoning was identified when participants focused on human welfare or needs. Since participants could show both kinds of reasoning in the same justification (e.g., "(it was wrong because) they destroyed the habitats of many plants and animals [coded as biocentric] and forced societies off of their land [coded as anthropocentric]"), coding of each justification was not mutually exclusive even though the same phrase could not get both a biocentric and an anthropocentric code. Intercoder reliability showed strong agreement (Cohen's $\kappa = .82$, $p < .001$). Across the four environmental damage scenarios, participants could generate a spontaneous biocentric moral reasoning score from 0 to 4.

Finally, after completing all moral wrongness ratings and justifications for all four environmental harm scenarios, participants completed a close-ended task with the same set of scenarios. They were reminded of each scenario again and given a forced choice between two different people's reasons for viewing each type of environmental harm as wrong. One person had a biocentric moral reason (e.g., (logging) "because now there won't be enough forests for bugs and for flowers to grow in") and the other had an anthropocentric moral reason (e.g., "because now there won't be enough trees for other people to build new houses"). Participants' endorsements of people who offered biocentric reasons lead to a reflective biocentric reasoning score from 0 to 4.

2.1.2.8. Biocentric donation decision-making task: Sustainability efforts not only require avoiding environmental harm but active decision-making in support of conservation efforts. Participants were therefore presented with two trials about two different conservation causes (e.g., cleaning a river) and asked to consider which of two reasons (akin to appeals) would increase their likelihood of giving to each cause. In each trial, two different people voiced each reason for donating to each cause and participants chose between them. One option was biocentric (e.g., "because the water will flow better and the trees and forests around it will grow stronger") while the other was anthropocentric (e.g., "because it will smell better and farmers can use it to water their vegetable crops"; see Supplementary Materials). A total biocentric donation score was computed from 0 to 2.

2.2. Results

2.2.1. Human-inclusive concepts of nature and their predictors

2.2.1.1. Do urban U.S. adults have a human-inclusive open-ended concept of nature? When asked to report what kinds of things are "part of nature," very few adults spontaneously mentioned humans (12%). This urban sample therefore generally lacked a spontaneous human-inclusive concept of nature. Instead, they tended to report, on average, two different kinds of natural entities ($M = 2.49$, $SD = 0.95$), mentioning plants (86%), non-living natural things (76%), and animals (75%) with roughly equal frequency. Participants tended to name plants or animals at the general level (e.g., dog, lion, oak, mango) rather than identifying specific species, and they almost always named non-mammalian categories (e.g., bugs or fish) if they mentioned a kind of animal ($N = 34$, 18%). In addition to naming categories of entities, 15% of participants defined "nature" by mentioning the outdoors, and 27% of participants explicitly stated that nature is everything "untouched" or "not man-made."

2.2.1.2. Do urban U.S. adults have a human-inclusive close-ended concept of nature? Only half of these urban adults (51%) demonstrated a reflective human-inclusive concept of nature by sorting both human items into the "part of nature" box. This was even as members of the other natural subcategories were almost always classified as part of nature. A repeated-measures ANOVA with a Greenhouse–Geisser correction due to a violation of sphericity ($\varepsilon = .41$; $p < .001$) confirmed that each category of non-human natural phenomena was classified as part of nature more than humans, $F(1.62, 305.05) = 541.52$, $p < .001$, $\eta_p^2 = 0.74$. Specifically, post hocs with Bonferroni adjustments revealed that while all natural categories were included more than artifacts ($M = 0.02$, $SD = 0.21$), plants ($M = 1.98$, $SD = 0.21$), animals ($M = 1.95$, $SD = 0.3$), and non-living things ($M = 1.9$, $SD = 0.39$; $ps < .001$) were classified as part of nature more frequently than humans ($M = 1.05$, $SD = 0.99$). U.S. urban participants were more likely to classify humans as part of nature in the more reflective close-ended task than in the more spontaneous open-ended task, McNemar's $\chi 2\,(1, N = 189) = 68.32$, $p < .001$.

2.2.1.3. Do ecological reasoning tendencies predict adults' human-inclusive concepts of nature? Across the five trials, U.S. urban adults tended to choose the ecological target instead of the taxonomic target when generalizing a shared sickness from the base entity ($M = 2.79$, $SD = 1.61$). A Wilcoxon signed-rank test—conducted due to a violation of normality—confirmed adults' significant preference for ecological reasoning, Mdn score = 3; $V = 10766$, $p = .02$, $r = .18$.

Although inferences that privilege ecological relations have generally been found in groups with marked informal knowledge of nature, ecological reasoning biases were not correlated with tendencies to report a greater range of natural kind categories in the open-ended task. Furthermore, contrary to hypothesis, Wilcoxon tests revealed no association between ecological reasoning tendencies and either a spontaneous or a reflective human-inclusive concept of nature, $ps > .05$.

Finally, since it offered another potential proxy measure for ecosystem knowledge, we also explored various associations to participants' exposure to nature score ($M = 3.5$, $SD = 1.01$). Although uncorrelated with ecological reasoning tendencies, greater exposure to nature was positively correlated with tendencies to report a greater range of natural kind categories in the open-ended task, $r(187) = 0.15$, $p = .043$. Furthermore, a logistic regression revealed that exposure to nature predicted a greater likelihood of having a spontaneous human-inclusive concept of nature, albeit with borderline statistical significance ($b = 0.46$, $p = .055$, OR = 1.59, 95% C.I. = [1.01, 2.61]). By contrast, there was no relationship between greater exposure to nature and a reflective human-inclusive concept of nature.

2.2.1.4. Do attributions of mind and life to the earth relate to human-inclusive concepts of nature? Adults showed significant tendencies to attribute life to the Earth (e.g., to endorse Earth needs food), Mdn = 3, $V = 11204$, $p = .002$, $r = .22$, but tendencies against attributing mind to it (e.g., to endorse Earth wants things), Mdn = 2, $V = 4456.5$, $p < .001$, $r = -.44$. People who tended to attribute life to the Earth reported a greater range of natural kinds in the open-ended task ($r_s(187) = .20$, $p = .006$) and were more likely to have a spontaneous human-inclusive concept of nature ($b = 0.53$, $p = .008$, OR = 1.70, 95% C.I. = [1.17, 2.59]). However, no relationship was found between attributions of life or mind to a reflective human-inclusive concept of nature.

2.2.1.5. Do exceptionalist beliefs predict human-inclusive concepts of nature? Participants' human exceptionalism was around the midpoint ($M = 3.93$, $SD = 0.77$). Logistic regressions revealed that greater exceptionalism predicted a lower likelihood of expressing both a spontaneous ($b = -0.61$, $p = .036$, OR = 0.54, 95% C.I. = [0.30, 0.96]) and reflective ($b = -0.84$, $p < .001$, OR = 0.43, 95% C.I. = [0.27, 0.66]) human-inclusive concept of nature.

2.3. Environmental moral concern and biocentric moral reasoning and decision-making

2.3.1. Do human-inclusive concepts of nature predict environmental moral concern and biocentric reasoning?

Averaged moral judgment ratings on the four environmental harm scenarios revealed that urban U.S. adults tended to express low levels of environmental moral concern ($M = 1.44$, $SD = 0.68$). They also displayed little spontaneous biocentric moral reasoning in their justifications of their judgments ($M = 1.67$, $SD = 1.16$). However, on the more reflective close-ended task, they tended to choose biocentric over anthropocentric explanations for why it was moral wrong to do the four environmental harms ($M = 3.25$, $SD = 0.89$).

With respect to our core questions, spontaneous and reflective human-inclusive concepts of nature did not predict general environmental moral concern ratings. They also did not predict tendencies to engage in spontaneous or reflective biocentric reasoning about the environmental harm scenarios ($ps > .05$). We conducted an omnibus linear regression model on environmental moral concern with reflective human-inclusive concept of nature,[3] exception-

alism, ecological reasoning, and exposure to nature scores as predictors of environmental moral concern and spontaneous biocentric moral reasoning. This revealed exposure to nature as the only positive predictor of moral concern ($b = 0.10$, $F(1, 184) = 4.39$, $p = .037$, $\eta_p^2 = 0.02$), with exceptionalism as a negative predictor ($b = -0.18$, $F(1, 184) = 6.85$, $p = .010$, $\eta_p^2 = 0.04$; see Supplementary Materials for a correlation matrix of continuous variables).

The parallel model on spontaneous biocentric moral reasoning revealed the same pattern: Exposure to nature was the sole positive predictor ($b = 0.18$, $F(1, 184) = 4.54$, $p = .034$, $\eta_p^2 = 0.02$), and exceptionalism was a negative predictor ($b = -0.31$, $F(1, 184) = 7.54$, $p = .007$, $\eta_p^2 = 0.04$).

A final analysis on reflective biocentric reasoning used quantile regression due to normality violations. The overall model was not significant but, again, revealed hints of a solitary positive effect of exposure to nature ($b = 0.19$, $p = .05$).

2.3.2. Do human-inclusive concepts of nature predict biocentric decision-making?

Most adults preferred to donate money to conservation causes based on biocentric ($M = 1.54$, $SD = 0.66$) rather than anthropocentric moral motivations. However, biocentric donation tendencies were not significantly predicted by participants' spontaneous or reflective human-inclusive concepts of nature ($ps > .05$). Likewise, a quantile regression model regressing biocentric donation on reflective human-inclusive concept of nature, ecological reasoning, exceptionalism, and exposure to nature scores did not reveal any significant effects.

2.4. Discussion

In Study 1, we explored U.S. urban adults' concepts of nature and the extent to which they influence general environmental moral concern about harm to nature and more specific tendencies to engage biocentric moral reasoning. Findings across both our open- and close-ended measures revealed that U.S. urban adults do not generally conceive of humans as part of nature and instead view plants, non-mammalian animals, and non-living natural phenomena as core constituents. Exposure to nature and dispositions to view the Earth as "alive" predicted greater human-inclusive nature conceptions—perhaps because both enhance capacities to see commonality across disparate categories. By contrast, human exceptionalism was negatively predictive, presumably because conceptions of humans as more highly evolved pinnacles of the food chain do not just place humans as special entities at the top of a natural hierarchy but outside of that hierarchy entirely.

With regards to moral reasoning about nature, the results were not encouraging in terms of factors that have previously been found to dispose individuals to pro-environmentalism and sustainable practices. Our sample expressed low levels of general environmental moral concern and was also not spontaneously biocentric, despite reflectively endorsing biocentric justifications in forced-choice tasks. Furthermore, the tendency to view humans as part of nature—either spontaneously or reflectively—had no influence on moral concern or biocentric tendencies, with the only positive predictor being greater (direct or media-based) exposure to nature. This is perhaps because among urban populations, rare exposures to green spaces facilitate a sense of connectedness and sensitivity to the complexity of non-human life, with

nature media additionally enhancing understanding of environmental threat. Taken together, these experiences operate to promote awareness and intrinsic valuing of other natural things (see Supplementary Materials for correlations). Importantly, however, human exceptionalism consistently had countervailing effects, predicting decreased environmental moral concern and biocentrism.

Among U.S. urban adults then, viewing humans as uniquely superior appears to have a distinctive undermining influence on environmental values—an influence not predicted by the basic tendency to view humans as existing apart from nature, which was probed by our open- and close-ended concept of nature tasks. In consequence, the present results suggest that for U.S. urban adults, interventions to enhance sustainable attitudes need at least a two-pronged approach. First, they need to engage urbanites—via informal, formal, or media-based experiences—in personally meaningful learning about specific natural spaces, directly presenting them with ways that their own sustainable practices can help preserve those ecosystems and, in turn, other ecosystems given complex global interconnections. Second, such interventions need to directly challenge notions of human superiority and dominance by clarifying that even if human communities often live in highly manufactured and engineered urban spaces, they still share the same water, air, and land as other living things and have shared biological and behavioral complexity with them. Indeed, promoting acceptance of common descent and biological continuity (and implicitly challenging notions of scala naturae) via causal-explanatory teaching about evolutionary mechanisms may offer one promising strategy for reducing hierarchical notions of human uniqueness associated with human exceptionalism (Pizza & Kelemen, 2023).

3. Study 2

Study 1 revealed troubling patterns in U.S. urban adults from a sustainability perspective. In Study 2, we therefore explored whether similar patterns are present from early on in young U.S. urban children. As with Study 1, Study 2 was conducted as part of a larger project exploring various factors relevant to urban-dwellers attitudes to nature and environmental moral reasoning. However, the study had a slightly different design than the adult online study.

As elaborated further below, one key difference was that an experimenter led children through the study that was shorter, more attention-grabbing, and used more child-friendly language. A second key difference was that children received exposure to one of three short videos about the history of the Earth at the very beginning of the 30-min protocol. Depending on randomly assigned condition, these videos described the Earth in ways that framed it either as an object, an animal, or a person (see Materials and Procedures section). In all statistical analyses of children's data that are reported later, we therefore controlled for condition. Furthermore, since adults had a different study protocol, we do not formally compare children and adults in our results section. However, at the end of Study 2, we present some exploratory child–adult comparisons (with caveats) to offer some insight into similarities and differences between the two age groups that may suggest developmental differences.

3.1. Method

3.1.1. Participants

Participants were a diverse sample of 68 6- to 7-year-old children (M age = 6.49 years, SD = 0.5, 49% identified as girls) from the Greater Boston area. An additional child was tested, but the data were excluded due to equipment failure. Most children were tested in urban (31%) and suburban (54%) after-school programs with the remaining children representing a mix of urban and suburban children who were tested in our lab (15%). The urban after-school mainly served children from low to very low-income households from more densely populated neighborhoods, while the suburban after-school, like the lab, drew children from middle- to high-income households and areas with more single-family homes and open space (see Supplementary Materials for further demographic information on the sites). In terms of differences in nature exposure between each test site, the afterschool programs and our lab are in areas with proximity to green spaces including wetlands, a bay, and a prominent river. Furthermore, because the Greater Boston area has more tree coverage than many other U.S. urban areas (City of Boston, 2015; City of Newton, 2021), the differences between urban and suburban areas—as in other more verdant cities—are not consistently clean-cut (Short Gianotti, Getson, Hutyra, & Kittredge, 2016). Because of this, and for simplicity, we refer to the whole child sample as "urban."[4]

3.1.2. Materials and procedures

Study 2 data derive from a larger IRB-approved study preregistered at https://osf.io/gyk6e?view_only=5dbaf322eee845cbbf2f480064063e89, in which, as noted, children saw one of three different videos about the geo-history of the Earth at the outset: one describing the Earth as an inanimate object, one describing it as a living animal, and one describing it as a mentalistic person. The full interview had nine measures in total. As for Study 1, the specific measures and analyses for Study 2 focused only on those tasks that were designed to tap children's concepts of nature and their relationship to general environmental moral concern and biocentrism. These were preregistered at https://osf.io/upt72/?view_only=f401ae249e1e4a6a90e5521365ac79df. Note that some of the task and variable names have been modified for this paper to ease comprehension.

Children were individually interviewed in person using materials that largely paralleled Study 1 except for some minor changes. First, the introduction to the open-ended concept of nature task was simplified for children. They were asked "When you hear someone use the word 'nature,' what do you think they mean—what kinds of things do you think they are talking about?" The interviewer then waited until the children generated all the names that came to mind. Second, the four scenarios in the environmental moral reasoning task were read to children and were accompanied by pictures to support comprehension. Finally, to avoid fatigue effects, we shortened some measures. The ecological reasoning task was reduced to four trials, but, in contrast to adults, children were prompted to explain their answers, which were coded for any mention of ecological and/or taxonomic relations (see coding information in Supplementary Materials). The attribution of mind and life to the Earth questionnaire was shortened to 10 items: three about attribution of life, four about attribution

of mind, and three control items (see Supplementary Materials). To reduce potential experimenter error, the scenarios exploring environmental moral concern and the biocentric donation decision-making tasks were presented in one of two randomly assigned trial presentation orders. Note, while charitable giving by children might be uncommon in many countries, in the United States, it is an ecologically valid measure: Children are familiar with—and often encouraged to make—donations to private charitable entities. Furthermore, previous research has demonstrated the effectiveness of donation tasks in measuring children's moral behavior (e.g., Angerer, Glätzle-Rützler, Lergetporer, & Sutter, 2015; Body, Lau, & Josephidou, 2020; Ongley, Nola, & Malti, 2014). Finally, the exceptionalism questionnaire was not administered, as it has not been adapted for children. The demographic survey (including questions about exposure to nature) was also excluded due to time constraints. The open-ended concept of nature task and spontaneous biocentric justifications were coded as in Study 1. Intercoder reliability was high (Cohen's κ ranged from = .83 to .91, $ps < .001$, respectively).

3.2. Results

3.2.1. Human-inclusive concepts of nature and their predictors

3.2.1.1. Do urban U.S. children have a human-inclusive open-ended concept of nature? Children tended to mention at least two different kinds of natural entities when asked what kinds of things are part of nature (report of natural kinds $M = 2$, $SD = 0.93$), but they rarely spontaneously mentioned humans (10%). Most children mentioned plants (82%) and animals (68%), with fewer mentioning non-living natural things (40%). Of children that mentioned specific kinds of animals ($N = 23$, 34%), non-mammalian categories were mentioned most frequently (82%), with only half of the children ever mentioning mammals (47%). The named mammals were usually familiar urban or domestic animals (e.g., squirrels, rabbits, dogs, cats). Overall, 7% of children explicitly stated that nature is something untouched by humans.

3.2.1.2. Do urban U.S. children have a human-inclusive close-ended concept of nature? Although U.S. urban children tended to reflectively classify living and non-living natural entities as part of nature, only 34% of them were categorized as having a reflective human-inclusive concept of nature by placing both the adult and baby human items in the "part of nature" box. A human-inclusive concept was displayed more frequently in the closed-ended task than in the open-ended task, $\chi 2\ (1, N = 68) = 14.06$, $p < .001$. A significant repeated measures ANOVA with Greenhouse–Geisser correction ($\varepsilon = .68$), $F(2.72, 182.45) = 128.436$, $p < .001$, $\eta_p{}^2 = 0.66$, confirmed that children categorized humans ($M = 0.74$, $SD = 0.94$) as part of nature less frequently than plants ($M = 1.91$, $SD = 0.33$), animals ($M = 1.85$, $SD = 0.47$), and non-living natural things ($M = 1.65$, $SD = 0.62$), ($ps < .001$) but more than artifacts ($M = 0.1$, $SD = 0.39$; $p < .001$). All other natural kinds were categorized as part of nature to a similar extent, except that plants were included more than non-living natural things ($p = .002$).

3.2.1.3. Do ecological reasoning tendencies predict children's human-inclusive concepts of nature? A Wilcoxon signed-rank test revealed that children did not show a bias to make

ecological choices when asked which target entity was more likely to have the same disease as a base entity, Mdn = 2, $V = 973.5$, $p = .075$, $r = .22$. Nevertheless, their approach may have been more ecologically driven than the forced-choice data suggest. Specifically, children's spontaneous justifications of their choices revealed that they more frequently reasoned in ecological (Mdn = 3) than taxonomic terms (Mdn = 1; $V = 1291.5$, $p < .001$, $r = .84$).

Importantly, in contrast to expectation, children's ecological reasoning tendencies were not correlated with their tendencies to report a greater range of natural kind categories in the open-ended concept of nature task. Furthermore, higher ecological reasoning scores were not associated with a spontaneous or reflective human-inclusive concept of nature (all *p*s > .05).

3.2.1.4. Do attributions of mind and life to the earth relate to human-inclusive concepts of nature? As noted earlier, children were exposed to one of three videos about the history of the Earth (object, animal, person) before any other measures were administered. Before conducting any further analyses, we therefore checked whether this manipulation differentially induced attributions of mind or life to the Earth. A quantile regression on mind and life questionnaire scores revealed that children in the person condition had attributed mind to the Earth (Mdn = 4) more than children in the object condition (Mdn = 2; $b = 2$, $p = .013$). However, the animal condition did not differentially induce children to attribute life to the Earth ($p > .05$).

Although video condition affected children's performance on the mind and life questionnaire, surprisingly, regression analyses found that children's mind and life attribution scores did not predict either a spontaneous or reflective human-inclusive concept of nature (or report of a broader range of natural kinds in the open-ended task). Despite this, video conditions to induce attributions of mind (person condition) and life (animal condition) did have some effect on children's concept of nature. Logistic regressions revealed that children in the person condition ($b = 1.90$, $p = .012$, OR = 6.67, 95% C.I. = [1.68, 34.41]) and the animal condition ($b = 1.46$, $p = .05$, OR = 4.29, 95% C.I. = [1.06, 22.03]) were more likely to show a reflective human-inclusive nature concept than children in the object condition.

3.3. Environmental moral concern and biocentric moral reasoning and decision-making

3.3.1. Do human-inclusive concepts of nature predict environmental moral concern and biocentric reasoning?

On the four environmental harm scenarios, U.S. urban elementary school children showed reasonably marked levels of moral concern for the environment ($M = 2.19$, $SD = 0.55$). They also showed high levels of spontaneous biocentric reasoning in their justifications of their judgments ($M = 2.61$, $SD = 1.06$). Finally, on the close-ended task, they showed consistent responses by reflectively endorsing biocentric over anthropocentric justifications for why it was morally wrong to cause environmental harm ($M = 2.57$, $SD = 1.18$).

With respect to our central questions, however, neither children's spontaneous or reflective human-inclusive concept of nature scores, by themselves, predicted environmental moral concern. They also did not predict spontaneous or reflective biocentric reasoning (*p*s > .05; see correlation matrix in Supplementary Materials). This remained true when ecological reason-

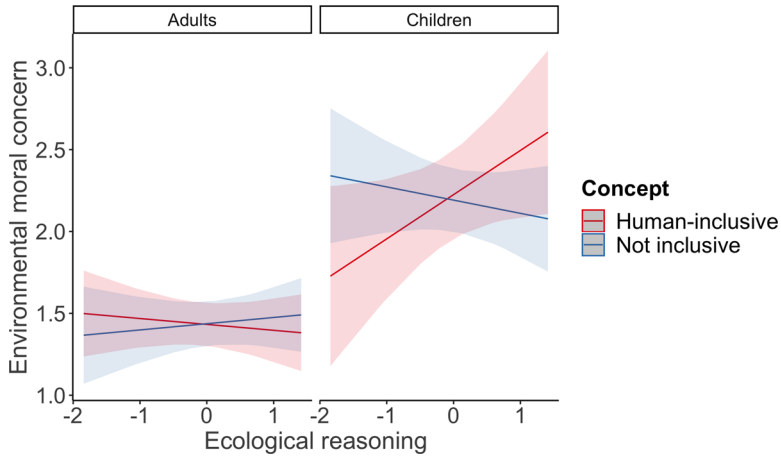

Fig. 1. Interaction effect of ecological reasoning and reflective human-inclusive concept of nature on environmental moral concern.

ing scores—a potential marker of informal nature expertise—were in the models. However, we also conducted exploratory analyses to test the effect of the interaction between these predictor variables on environmental moral concern and both spontaneous and reflective biocentric reasoning respectively. The analyses on environmental moral concern revealed that when it was included, the interaction between children's reflective human-inclusive concept and ecological reasoning scores ($b = 0.29$, $F(1, 64) = 6.23$, $p = .015$, $\eta_p^2 = 0.09$) was a significant positive predictor (see Fig. 1). The other models, with spontaneous and reflective biocentric reasoning as dependent variables, did not reveal any effects.

3.3.2. Do human-inclusive concepts of nature predict biocentric decision-making?

Most U.S. urban children preferred to donate money to conservation causes with biocentric ($M = 1.24$, $SD = 0.79$) rather than anthropocentric motivations. However, biocentric donation tendencies were not significantly predicted by children's spontaneous or reflective human-inclusive concepts of nature ($ps > .05$). Nevertheless, in a regression predicting biocentric donation from children's reflective human-inclusive nature concept and ecological reasoning scores, ecological reasoning ($b = 0.19$, $F(1, 65) = 6.39$, $p = .014$, $\eta_p^2 = 0.09$) was a significant predictor. No other effects were found ($p > .787$), and this remained true in a further model that included the interaction effect.

3.3.3. Exploratory comparisons between children and adults

The adult and child samples of our two studies are not necessarily comparable. While children lived in the Greater Boston area, with many coming from middle- to high-income households, our self-identified urban adults were living across the United States, and we did not collect data about their socioeconomic status. Furthermore, each sample was exposed to a slightly different study protocol. It is impossible to rule out potential effects of these non-developmental differences on any effects detected in child–adult comparisons. Despite all

those important caveats, we did conduct a limited number of exploratory analyses to compare the two samples and identify any patterns that might guide future developmental research.

These analyses found that U.S. urban children and adults did not differ in their spontaneous inclusion of humans as part of nature (*p*s > .05). However, urban children were less likely to show a reflective human-inclusive concept of nature, $\chi 2\ (1, N = 257) = 6.15, p = .01$.

With regard to moral reasoning, children showed higher levels of environmental moral concern than adults (Child Mdn = 2.25 vs. Adult Mdn 1.25, Wilcoxon = 2579.5, $p < .001$, $r = .46$). Using ecological reasoning standardized scores, we therefore conducted an exploratory analysis on both children and adults to see whether the significantly predictive interaction between reflective human-inclusive nature concept and ecological reasoning was an effect that was specific to children. A three-way interaction, ($b = 0.42$, $F(1, 249) = 4.70$, $p = .031$, $\eta_p{}^2 = 0.02$), confirmed that it was. An age group effect also confirmed the findings that children had higher environmental moral concern than adults ($b = 0.75$, $F(1, 249) = 40.15$, $p < .001$, $\eta_p{}^2 = 0.14$). See Supplementary Materials for biocentric reasoning comparisons between children and adults.

3.4. Discussion

Study 2 revealed that U.S. urban children do not generally have a human-inclusive concept of nature. Indeed, patterns suggested that they were less likely than U.S. urban adults to include humans as part of nature, even in a more reflective closed-ended task with lower verbal demands. Being experimentally induced to attribute mind or life to the Earth increased children's reflective tendency to include humans in nature. This is potentially because it facilitated children's recognition of commonalities between humans and the familiar species that they spontaneously named as representing "nature" (Epley et al., 2007; Bang & Marin, 2015). However, no other variables were predictive of children's human-inclusive nature concepts.

In terms of moral reasoning about the environment, young urban children's environmental moral concern and their spontaneous and reflective biocentrism were notable, especially when compared to low levels in urban adults (see Supplementary Materials). Furthermore, exploratory regression analyses revealed an interesting interaction effect: Children who had a human-inclusive concept of nature and greater ecological reasoning tendencies showed heightened moral concern about unsustainable, environmentally damaging practices. Additionally, greater tendencies to engage in ecological reasoning were also predictive of biocentric decision-making about donations to conservation causes.

Taken together, these findings suggest that the most promising sustainability interventions with urban U.S. children are likely to be those that target children's basic awareness that humans are part of nature via an emphasis on ecological interconnectedness. Specifically, despite the challenges of teaching about the causal complexity of ecosystems to young children (Grotzer & Solis, 2015), children are deeply interested in—and biased to attend to—functional relationships (Kelemen, 2012), and when leveraged, this interest has been found to enhance insect conservation concern (Kelemen et al., 2023). Formal and informal learning programs that help young children understand humans' shared history and reciprocal functional interconnectedness with other components of local or, potentially, global

ecosystems (Cuzzolino, Grotzer, Tutwiler, & Torres, 2019; Grotzer & Solis, 2023; Kelemen et al., 2023; U.S. Global Change Research Program, 2009) therefore seem fruitful ways to enhance environmental moral concern and biocentrism—attitudes that predict sustainable behaviors in adults. Starting this kind of targeted ecological-functional teaching in the elementary school years—in combination with early education on the evolutionary mechanisms underlying common ancestry (Kelemen, 2019; Ronfard, Brown, Doncaster, & Kelemen, 2021)—might also have the benefit of helping to inhibit the development of human exceptionalism. This would be significant given the results in Study 1 that indicated that exceptionalism plays a distinctive role in adults' low levels of pro-environmentalism.

4. General discussion

Building a more sustainable society requires individuals to be concerned about environmental welfare and willing to act to mitigate environmental crises. In the present two studies, we explored the degree to which U.S. urban adults and children show basic tendencies to categorize humans as part of nature, the cognitive predictors of any human-inclusive concepts, and the role that such human-inclusive concepts might play in predicting environmental moral concern, generally, and biocentric reasoning, more specifically.

Across two studies, we found that neither U.S. urban adults nor children generally tend to construe humans as part of nature. In both groups, humans were seen as separated from other living and non-living natural entities, existing outside of (and in the case of adults, also above) the natural world that they impact and deplete. Tendencies to attribute life to the Earth enhanced U.S. urban adults' spontaneous and children's reflective tendencies to be human-inclusive. However, among adults, the basic tendency to categorize humans as part of nature never predicted general environmental moral concern or biocentrism. In contrast, one factor distinctively detracted from both of these sustainability-relevant variables: human exceptionalism.

The cluster of ideas that characterizes humans as biologically unique and superior—not just separate—consistently negatively predicted adults' human-inclusive concepts of nature and biocentric tendencies. In a context in which urban adults' general environmental moral concern and spontaneous biocentric reasoning tendencies were already low, these patterns give reasons for concern. Indeed, urban adults' level of exposure to nature—via direct experience or media—was the only consistently countervailing variable in the mix, highlighting that sheer exposure is likely to be a crucial factor in interventions that debunk the elements of exceptionalist belief and enhance environmental moral concern and biocentrism.

Our abilities to make systematic comparisons between the U.S. urban adults in Study 1 and the early elementary school children in Study 2 are limited given that children engaged in a different, more circumscribed study protocol and might have demographically differed from the adult online sample in other unknown ways. Nevertheless, an overall assessment is that, compared to U.S. urban adults, patterns in U.S. urban children were different and, arguably, more hopeful. Despite generally lacking human-inclusive concepts of nature, consistent with prior research from our lab (Kelemen et al., 2023), elementary school children displayed

more marked general environmental and conservationist concern than adults. They also saw greater intrinsic value in nature as reflected in their tendencies to be biocentric across multiple measures (see also Pizza & Posada, 2020; Ruckert, 2016; Wilks, Caviola, Kahane, & Bloom, 2021). Finally, while the basic tendency to include humans as part of nature was not relevant to adults' moral reasoning, it did predict children's: In interaction with heightened sensitivities to ecological relationships, children with human-inclusive concepts expressed greater moral concern about environmental harm with ecological reasoners also displaying more biocentric decision-making.

The reasons for these patterns of potential developmental difference are unclear. However, one possibility is that even though U.S. urban adults displayed greater ecological reasoning tendencies on our forced-choice measure—echoing Coley's (2012) original developmental findings with this task—the adults were simply more exceptionalist in outlook (Arias-Maldonado, 2015; Kim et al., 2023; Xu & Coley, 2022). That is, the negative effects of exceptionalism may have outweighed other cognitive variables that might have positively predicted environmental concern. Further research should explore this possibility directly since we did not measure exceptionalism in children and therefore do not know how it would have impacted their results if it had been included as a predictor variable.

4.1. Implications of this research for efforts to achieve sustainability

The implications of specific results for sustainability interventions targeted at adults versus children have already been discussed at earlier points. Nevertheless, we end by revisiting some general ideas. As noted earlier, among U.S. urban adults, exposure to nature was not only predictive of a spontaneous human-inclusive nature concept but—most relevant to sustainability—environmental moral concern and biocentrism. These results align with a growing number of results suggesting that fostering familiarity and connection to nature through personally meaningful immersive nature experience and media promote conservationist attitudes. Physically and economically accessible social and educational programs that safely facilitate these immersive experiences outside and inside of urban areas (e.g., local nature preserves, waterways) are therefore increasingly urgent given the attenuation of exposure to diverse natural environments via the global forces of urbanization (e.g., DeVille et al., 2021; Martin et al., 2020). Having said this, further research is needed to fully understand the mechanisms by which direct informal nature exposure versus media-based nature exposure positively influences adults' pro-environmentalist moral attitudes, and how each of these different forms of exposure might act on the subcomponents of human exceptionalism. Nature media incorporating direct moral testimony against exceptionalism might be the most efficient route to shaping attitudes given prior research on the effectiveness of testimony as a moralization mechanism (e.g., Rottman, Young, & Kelemen, 2017).

In terms of fostering environmental concern in communities, our findings support prior research (Bang & Marin, 2015; Betz & Coley, 2022; Kim et al., 2023) that emphasizes the importance of promoting a basic view of humans as part of nature from childhood. In addition, our research identifies a potential tool for promoting human-inclusive nature concepts in young children. Specifically, our findings suggest that inducing young children to attribute

mind or life to living things and ecosystems, such as the Earth, could help them identify commonalities and perceive all living things as part of a greater group that deserves to be conserved. Of course, this agency-oriented approach should be considered cautiously given that it is inaccurate from a scientific perspective and thus might have unintended effects for scientific learning more broadly, for example, about biological mechanisms like evolution (e.g., Kelemen, 2012) or about the distal or indirect cause–effect relationships of ecosystems (Cuzzolino et al., 2019; Grotzer & Solis, 2023). Nevertheless, preliminary results in other research suggest that inducing attributions of life to the Earth via narratives fosters children's general learning about Earth's ecosystems and that this, in turn, has beneficial consequences for environmental moral concern (Pizza & Kelemen, 2021; see also Williams, Whitmarsh, & Mac Giolla Chríost, 2021).

Our results with children also provide evidence that increasing ecological understanding from early in development is likely to improve sustainability attitudes in the longer term. Specifically, interventions designed to foster recognition of local and more global ecosystem functional interdependencies might be helpful as suggested by prior research (Grotzer & Solis, 2023; Kim et al., 2023). Furthermore, such interventions should be implemented early in education to prevent human exceptionalist beliefs from taking hold. These education interventions and communication strategies would benefit by framing humans in terms of their biological commonalities with, rather than their differences from, other species, for example, via teaching of evolutionary mechanisms (Ronfard et al., 2021). They should also highlight humans' role in reciprocal causal influences on the sustainable future of our Earth (Grotzer & Solis, 2023). Such interventions may hold promise for transforming westerners' exceptionalist views of human uniqueness (Medin & Bang, 2014) and ensure that individuals' concern about the environment, and motivation to engage in sustainability practices, does not deplete over development or time.

4.2. Limitations and future directions

Some limitations of these studies should be acknowledged and addressed in future research. First, the results that we obtained in this study were deliberately focused on a small slice of one nation's population (U.S. urban-dwellers), and further research therefore needs to explore how generalizable these findings are to other populations. This is especially important given previous literature demonstrating that children and adults from U.S.-based rural and Indigenous communities tend to be more aware of ecological relations, show greater psychological closeness to nature, and are eager to consider and align with non-human animal perspectives. These are all factors that are likely to be relevant to the current patterns of results (Bang & Marin, 2015; Medin & Bang, 2014; Unsworth et al., 2012; Washinawatok et al., 2017).

Second, we did not collect information about socioeconomic status—or exposure to nature—in our child sample, and the sample size did not allow us to conduct analyses by level of income or kind of background. Further research should explore the effect of those variables on conceptualizations of nature and conservation, especially given the disproportionate impact of the environmental crisis on lower-socioeconomic communities (e.g., Evans & Kantrowitz, 2002).

Third, as has been elaborated, the methods used in the child and adult studies were not entirely the same, and reported child–adult differences should be interpreted cautiously. Additional longitudinal research is necessary to confirm whether these differences result from developmental or experiential differences between the samples or a combination of both.

Finally, although these studies detected significant factors that impact environmental moral concern and biocentrism (e.g., exposure to nature), experimental research is needed in the future to confirm the direction of causality in these relationships.

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Data availability statement

The data that support the results of this study are available from the corresponding author upon reasonable request.

Open Research Badges

This article has earned Open Materials badge. Data are available at https://osf.io/atwzj?view_only=dbb06843eb7241759acb558088beb32f.

Notes

1 In psychology, the term "anthropocentric" is often broadly applied to a range of different tasks and strategies, including: (a) folk biology categorization and reasoning tasks where humans are privileged over other kinds of animals as a basis for making trait inferences or in drawing analogies (e.g., Arenson & Coley, 2018; Herrman et al., 2010, 2012; Ross, Medin, Coley, & Atran, 2003; see also Carey, 1985a; Hatano & Inagaki, 1994); (b) situations where human agents' viewpoints and physical perspectives are privileged over those of other non-human agents (e.g., Bang et al., 2007; Medin et al., 2014); and (c) studies probing environmental moral reasoning, which find that across various child and adult samples, considerations of human welfare are privileged as a basis for rendering and justifying moral judgments from early in development (e.g., Kahn, 1999; Kahn & Lourenço, 2002; also Byrne et al., 2010). All of these cases involve some kind of cognitive anchoring to our own familiar and salient human species, but in this paper, we

adopt the term "anthropocentric moral reasoning" to make clear that we are narrowly referring to anthropocentrism in a moral reasoning context alone. Anthropocentric moral reasoning involves prioritizing human needs and welfare, often at the expense of other natural entities, and contrasts with "biocentric moral reasoning"—our focal construct (also known as "eco-centrism"), which reflects intrinsic valuing of all natural kinds.

2 To clarify, it is logically possible for anthropocentric moral reasoning to be human-focused
(e.g., due to in-group biases, familiarity, and salience effects) and to reflect assumptions that humans are different (e.g., culturally or biologically distinct) without also incorporating explicit assumptions that humans are biologically or culturally superior to other living things or that they have disproportionate influence over natural entities or natural outcomes. However, human exceptionalism as a construct and as a specific subtype of anthropocentric reasoning does include explicit ideas of superiority and outsized influence often, presumably, because it builds upon and elaborates assumptions of intrinsic, biological distinctiveness (e.g., Betz & Coley, 2022, exceptionalism scale).

3 The spontaneous human-inclusive concept of nature score was not included in the model because only 12% of participants had that dichotomized concept (this was similar in Study 2). Furthermore, exploratory analyses that included it found that the variable was not significant and revealed the same main results. The same applies to all subsequent models that we report.

4 A priori, we did not plan to explore whether low-income urban children differed from suburban middle- to high-income children on our measures. However, we did conduct post hoc exploratory analyses to examine any potential differences. These revealed no differences between the low-income urban versus middle- to high-income suburban child samples on any dependent variable, except for the donation score. On the biocentric donation score, children in the lower income context trended toward a lower tendency to endorse biocentric financial donations. Further research in a larger study focused on differences between urban versus suburban samples is required before drawing conclusions as to whether this particular pattern reflects a robust difference between socioeconomic groups.

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