Received: 9 June 2021 | Revised: 17 December 2021 | Accepted: 24 December 2021

DOI: 10.1111/cobi.13922

Conservation Biology

CONTRIBUTED PAPER

Motivating children's cooperation to conserve forests

Aleah Bowie[1] | **Wen Zhou**[1] | **Jingzhi Tan**[2] | **Philip White**[3] | **Tara Stoinski**[4] | **Yanjie Su**[5] | **Brian Hare**[1,6]

[1]Department of Evolutionary Anthropology, Duke University, Durham, North Carolina, USA

[2]Institute of Psychology, Leiden University, Leiden, The Netherlands

[3]Department of Statistics, Brigham Young University, Provo, Utah, USA

[4]Dian Fossey Gorilla Fund, Atlanta, Georgia, USA

[5]School of Psychological and Cognitive Sciences and Beijing Key Laboratory of Behavior and Mental Health, Peking University, Beijing, China

[6]Center for Cognitive Neuroscience, Duke University, Durham, North Carolina, USA

Correspondence
Wen Zhou, Department of Evolutionary Anthropology, Duke University, 108 Biological Sciences, Campus Box 90383, Durham, NC 27708, USA.
Email: wen.zhou@duke.edu

Article Impact Statement: Extrinsic motivation increases donations for forests among youth in the United States, China, and the Democratic Republic of the Congo.

Aleah Bowie and Wen Zhou contributed equally to this work and share first authorship.

Funding information
Duke University

Abstract

Forests are essential common-pool resources. Understanding children's and adolescents' motivations for conservation is critical to improving conservation education. In 2 experiments, we investigated 1086 school-aged children and adolescents (6–16 years old) from the United States, China, and the Democratic Republic of Congo. Testing participants in groups, we assessed their motivation for conservation based on collective-risk common-pool goods games in which they were threatened with losing their endowment unless the group donation exceeded a threshold needed to maintain the forest. Extrinsic motivations, rather than intrinsic, tended to lead to successful cooperation to maintain a forest. Certainty of losing individual payoffs significantly boosted successful cooperative conservation efforts across cultures (success rates were 90.63% and 74.19% in the 2 risk-extrinsic conditions, and 43.75% in the control condition). In U.S. participants, 2 extrinsic incentives, priming discussions of the value of forests and delay of payoffs as punishment, also increased success of cooperative conservation (success rates were 97.22% and 76.92% in the 2 extrinsic-incentive conditions, and 29.19% and 30.77% in the 2 control conditions). Conservation simulations, like those we used, may allow educators to encourage forest protection by leading groups to experience successful cooperation and the extrinsic incentives needed to motivate forest conservation.

KEYWORDS
common goods, child development, cooperation, culture, motivation

Resumen

Los bosques son recursos esenciales de la reserva común. Para mejorar la educación para la conservación, es muy importante entender qué motiva a los niños y adolescentes a conservar. Realizamos dos experimentos con 1086 niños y adolescentes en edad escolar (6-16 años) de China, la República Democrática del Congo y los Estados Unidos. Para los experimentos, juntamos a los participantes en grupos y valoramos sus motivos para conservar con base en juegos de bienes comunes y riesgos colectivos, en los cuales se les amenaza con la pérdida de su dotación del bien a menos que la donación grupal exceda el umbral necesario para mantener al bosque. Las motivaciones extrínsecas, y no las intrínsecas, fueron las que más derivaron en una cooperación exitosa para mantener al bosque. La certidumbre de perder los pagos individuales aumentó significativamente los esfuerzos cooperativos de conservación en las tres naciones (las tasas de éxito fueron de 90.63% y 74.19% en las dos condiciones de riesgo extrínseco y de 43.75% en la condición de control). En los participantes de los Estados Unidos, dos incentivos extrínsecos (las discusiones prioritarias sobre el valor de los bosques y el rezago de los pagos como castigo) también incrementaron el éxito de la conservación cooperativa (las tasas de éxito fueron de 97.22% y 76.92% en las dos condiciones de incentivos extrínsecos y de 29.19% y 30.77% en las dos condiciones de control). Las simulaciones de conservación, como las que usamos, pueden permitirle a los educadores promover la protección de los bosques al llevar a los grupos a experimentar la

cooperación exitosa y los incentivos extrínsecos necesarios para motivar la conservación de los bosques.

PALABRAS CLAVE
bienes comunes, cooperación, cultura, desarrollo infantil, motivación

摘要
森林是重要的公共资源。理解儿童和青少年参与保护的动机, 对于促进保护教育而言极为关键。在两个实验中, 我们测试了分别来自中国、刚果民主共和国和美国的1086名学龄儿童和青少年 (6-16岁) 。为了测量被试参与保护的动机, 被试以小组为单位参与了存在集体风险的公共物品博弈任务。在这项任务中, 如果小组为保护森林捐献的总额没有达到一定阈值, 小组中的每个人都将承受失去财产的风险。结果表明, 外部而非内部动机能够促使被试成功地通过合作保护森林。在不同文化下, 失去个人财产的风险都能显著地促进被试以保护为目标成功合作 (两种风险条件下的合作成功率分别为 90.63% 和 74.19%; 无风险的控制条件下成功率为 43.75%) 。在美国被试群体中, 两种外部刺激——关于森林价值的启动性讨论和作为惩罚的延迟回报, 都能促进以保护为目标的合作 (两种外部刺激条件下成功率分别为 97.22% 和 76.92%; 两个无外部刺激的控制条件下成功率分别为 29.19% 和 30.77%) 。利用本研究中使用的模拟保护情境, 教育者将能够促使群体体验到激励保护所需的外部刺激, 从而鼓励森林保护。

关键词: 公共物品, 儿童发展, 合作, 文化, 动机

INTRODUCTION

Forests are vital to human and planetary health. They are common-pool goods that require local and international cooperation to maintain (Van Vugt, 2009). Educating the public to support forest conservation through personal behavior and policy has been and remains a major focus of governments and conservationists (Adams & Plaugher, 2004; McBeath et al., 2014; Orr, 2004). Children and adolescents have long been regarded as a critical audience for this type of education (Davis, 1998; McBeath et al., 2014; Wilson, 1993). Positive exposure to wildlife and forests in zoos and parks has commonly been hypothesized to translate into positive environmental behavior in adulthood (Bowie et al., 2020; Zhang et al., 2019). However, it remains unclear what type of educational experiences might encourage proconservation behavior toward forests across diverse populations (Saylan & Blumstein, 2011).

The biophilia hypothesis suggests humans evolved intrinsic motivation to care for the natural world (Kellert, 1995; Wilson, 1984). It contends that universally across cultures, human selfish need to interact with life motivates humans to protect natural areas (Kahn, 1997). Early exposure to nature should nurture this intrinsic motivation and result in increased expression, whereas extrinsic rewards may dampen it (Ariely et al., 2009; Warneken & Tomasello, 2008).

In contrast, the anthrophilia hypothesis posits that humans evolved intrinsic motivation for prosocial behavior (i.e., beneficial but potentially selfishly motivated social acts, as opposed to antisocial interactions) (Eisenberg et al., 1983) toward kin ingroup members and strangers, but not more abstract social categories such as future generations or forests (e.g., Chapais, 2001; Hill & Hurtado, 2017; Warneken et al., 2007). Prosociality toward abstract social categories is a by-product and emergent property of plasticity in humanity's evolved motivation to help other humans. The anthrophilia hypothesis predicts that cross-cultural variability in proconservation behaviors toward forests is largely shaped by ecological and economic uncertainty (e.g., Boyd et al., 2010; Frankenhuis et al., 2016; Henrich et al., 2005). Experiences that incorporate extrinsic rewards and teach that there are links between material gain, reputation enhancement, or punishment and forest conservation are likely needed during childhood or adolescence to internalize the value of these shared resources (Ryan & Deci, 2000, 2020).

School-aged children and adolescents provide a strong test of these hypotheses. They are old enough to understand the concept of a common-pool good (children as young as 6 behave strategically in similar public goods games [e.g., Keil et al., 2017; Koomen & Herrmann, 2018; Yang et al., 2018]), but their motivations are not yet fully shaped by adult participation in economic markets. However, few experiments have examined the willingness of children or adolescents to help abstract, nonhuman entities, such as forests (Flanagan & Gallay, 2014; Koomen & Herrmann, 2018).

Adult motivation for conservation has been tested experimentally with a collective-risk common-pool goods game (Milinski et al., 2008). In this game, the group is threatened with losing their endowment unless individual donations exceed a threshold needed to maintain a common-pool good. In Western populations, the certainty of personal loss, reputational risk, and immediacy of the benefit the good delivers largely determine group success (Hauser et al., 2014; Jacquet et al., 2013; Milinski et al., 2008). What is needed to better understand the origin of these effects is a version of this game designed for cross-cultural use with children.

Cognitive preferences relating to certain decision-making are shaped by considerations of resources in environments (Bateson et al., 2014; Ellis et al., 2009). Frankenhuis et al. (2016) identified 2 ecological factors that influenced decision-making:

harshness, defined as the rates of mortality and morbidity caused by factors an individual cannot control, and unpredictability, defined as the change in mean variation in harshness over time. This framework provides a potential explanation for populational differences in decisions about resource distribution. Populations in highly uncertain environments tend to be more vigilant and more risk prone and have steeper temporal discounters than those in less uncertain environments (Ellis et al., 2009; Mittal & Griskevicius, 2014; Salali & Migliano, 2015).

We used the method developed by Milinski et al. (2008) to test school-aged children's and adolescents' cooperative motivations. Participants decided what portion of an endowment they wished to contribute to maintaining the conservation of a local forest. In 2 experiments, we varied the type and amount of motivation for donating and assessed participants' donation patterns to test the biophilia and anthrophilia hypothesis and to examine how children might be introduced to the concept of sustainability through cooperative forest management simulations.

METHODS

Experiment 1

We tested how risk of losing one's rewards influenced motivation for proenvironmental behavior toward a forest in school-aged participants from 3 different countries: United States, People's Republic of China, and Democratic Republic of the Congo (DRC). We hypothesized that children and adolescents from these countries provide a powerful test of our hypotheses because the countries vary on country-wide levels of forest coverage, types of forest exposure children receive, and resource uncertainty. Based on the percentage of land area covered by forest, DRC provides, on average, the highest potential for forest exposure (56.5%), followed by United States (33.9%) and China (22%) (World Bank, 2018). Although exposure to forest will vary greatly within countries, these data still help illuminate how dominant forests are in the ecology, economy, and culture of each country. Early positive exposure to forests can also be influenced by educational system. Among the 3 countries, the United States has the longest tradition of environmental education, and children have been involved in environmental programs for decades (e.g., school classes, park visits, camps [Carter & Simons, 2010; Meredith et al., 2000; Stapp et al., 1970]). More recently, China has followed suit (McBeath et al., 2014), whereas this type of experience is comparatively rare in DRC, where environmental education began to be integrated in school curricula in 2020 (Ngounou, 2020). Based on country-level statistics of life expectancy, health outcomes, and gross domestic product per capita (World Health Organization, 2019), DRC is comparatively more resource uncertain, and the United States is comparatively less resource uncertain; China is in between.

The biophilia hypothesis predicts cooperation will be strongest in response to thean level of nature exposure and will only be reduced by extrinsic motivators. Children in the United States (longest tradition of environmental education) and DRC (most forest) should be most likely to be intrinsically motivated to cooperate to protect forests. The anthrophilia hypothesis predicts cooperation will be strongest in response to high extrinsic rewards or punishments, regardless of forest exposure or education and will vary cross-culturally depending on the level of uncertainty characterizing a group's environment. That is, extrinsic incentive is predicted to have the largest effect in motivating children from DRC to cooperate and contribute to forest protection. The effect in China will be present but weaker. Children from the United States with the lowest level of resource uncertainty should be the least responsive to extrinsic incentive.

Participants ($n = 570$) were 6–16 years old. We decided on this sample size based on number of children and adolescents we had access to at each testing location.

Participants from the United States ($n = 198$; 81 females, 117 males; age range 6–11 years; mean age 8.04 years [SD 1.57]) were recruited from a summer camp at Zoo Atlanta in the suburban area of Atlanta, Georgia. Each camp was a week long, and 4- to 14-year-olds from across the Atlanta area could participate in the camp. Participants were mostly public-school attendees from middle-income families from the metropolitan Atlanta area, which is demographically diverse. However, in the context of the camp, it was not viewed as appropriate to collect information on individual participant's race or socioeconomic status. All participants took part in activities at camp that included viewing zoo animals, attending behind the scenes tours and demonstrations by zookeepers and educators, and making nature-related art projects. Participants were tested during the camp session in a space known as the Tree House, an approximately 10 × 10 m room above one of the small primate exhibits.

Chinese participants ($n = 216$; 108 females, 108 males; age range 6–14 years; mean age 9.60 years [SD 1.84]) were recruited from a primary school in a suburb of Beijing. All participants included were from a local primary school that served low- to middle-income populations. Participants were tested in a classroom.

Congolese participants ($n = 156$; 89 females, 66 males, 1 did not report gender; age range 6–16 years; mean age 11.75 years [SD 2.20]) were from local schools in and around Kinshasa, the capital city of the DRC. Two of the schools served primarily rural, low-income populations on the outskirts of Kinshasa, whereas the other 2 schools served primarily middle-income families from downtown Kinshasa. Children were tested at their school in a quiet room or outdoor area or in the education center at Lola ya Bonobo sanctuary. The mean age of the DRC participants was older than that for the other countries largely due to more variation in chronological age in each grade.

Data from an additional 96 participants were excluded from analyses based on a priori criteria (e.g., independent decision-making was interfered or essential data were not captured). Because subjects were tested in groups (see below), data for the entire group were excluded when the predefined exclusion criteria were met. Fifteen groups were excluded due to instruction from a teacher or conversations between participants during the experiments (3 from the United States; 4 from China; 8 from DRC). One group was excluded from the DRC sample due to lack of age information.

We used a between-subject design. Six age-matched peers played together and received tokens after an orientation from

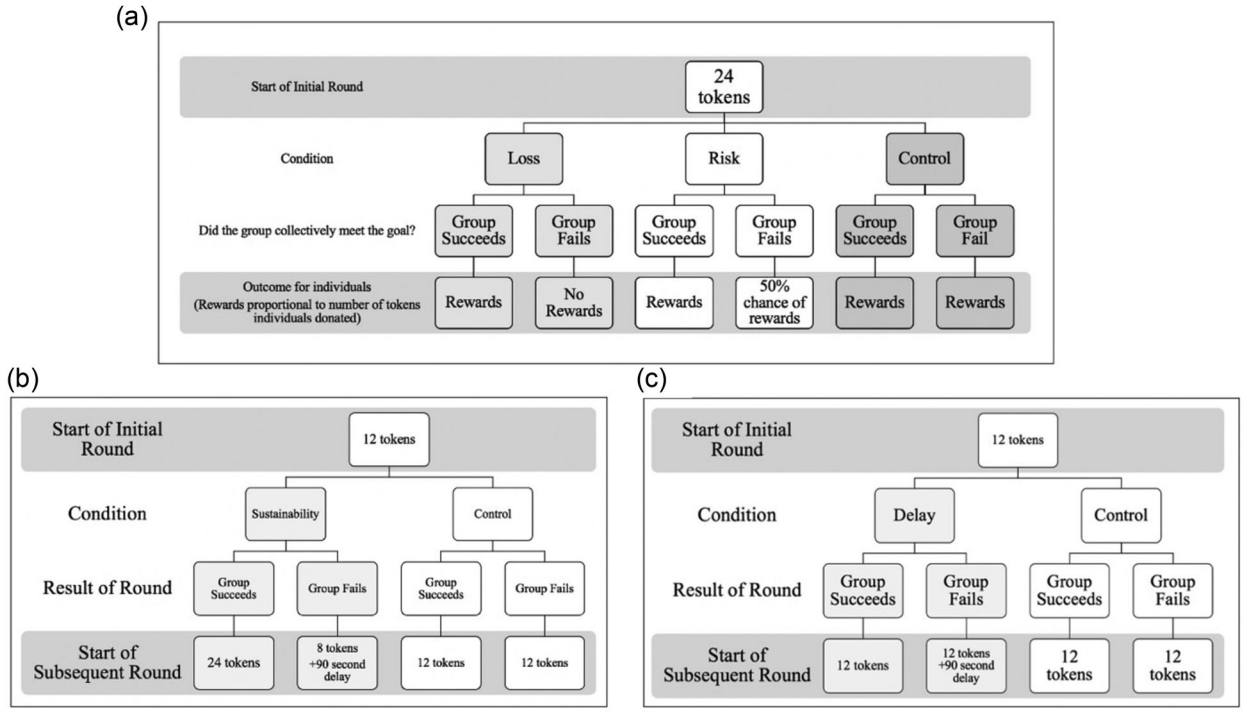

FIGURE 1 Outcomes of conditions in (a) Experiment 1 in which *group succeeds* indicates whether the group collectively gives enough to the collection bank to meet the goal (72 tokens) and *rewards* indicates individuals in the group can exchange their remaining tokens for rewards, (b) Experiment 2: sustainability condition and sustainability control, and (c) Experiment 2: delay condition and delay control. Success in a round for Experiment 2 required the group to collectively donate a minimum of 36 tokens

an experimenter (scripts in Appendix S1). Groups consisted of participants in the same classroom or camp group. Participants learned the goal of the game was for their group to meet a donation threshold required to keep a forest healthy. They were informed that they would anonymously decide to keep the tokens they received until the end and they would be allowed to exchange the tokens for prizes (i.e., toys or candies) or contribute any portion to local forest conservation. They were told they would have a set number of trials to reach the goal. The experimenter added tokens to Connect Four boards (Hasbro, United States) after each trial in a round to display the cumulative number of tokens given over the course of the trials (Appendix S1). The board allowed participants of all ages to visually understand how close they were to reaching the threshold.

After being oriented, each child was asked the same set of questions to confirm understanding of the task. Then participants were given 2 practice rounds before the test phase (Appendix S11). Each group was then assigned to 1 of 3 motivation conditions; age and sex were balanced across conditions (distribution of groups across conditions in Appendix S2). The 3 conditions, loss, risk, and control, differed only in the risk of forfeiting their earnings if the group failed to meet the donation threshold needed to care for the forest (Figure 1a; scripts in Appendix S11). In the loss condition, failure to meet the donation threshold resulted in all participants losing all their tokens earned in the game. In the risk condition, failure to meet the donation threshold resulted in a coin toss (50–50 chance of keeping or losing tokens earned in the game). In the control condition, participants kept the tokens they earned in the game regardless of whether their group met the donation threshold.

Before starting the game, participants received 24 tokens, learned the risk to their earnings if their group failed to meet the donation threshold, and were told they had 6 trials to succeed. They could donate 0, 2, or 4 tokens per trial and the donation threshold was 72 tokens per round (requiring 2 Connect Four boards to display). Success required an average donation of at least 2 tokens per trial per child (6 participants × 2 tokens × 6 trials). For each trial, each participant marked on a preprinted answer sheet whether they wanted to give 0, 2, or 4 tokens to the Forest Bank. After each trial, the experimenter took the sheets from all 6 individuals and recorded how many tokens each individual contributed on a data-collection sheet. The experimenter ensured all individuals handed in an answer sheet for each trial and ensured anonymity.

We analyzed the donation pattern at both group level and individual level to align with different inferential goals. We used binomial generalized linear regression model for group success to meet the donation threshold where we account for condition, country, and grade level (full results in Appendix S5). In the group analyses, which investigated the effects of country resource uncertainty on group donation pattern, we treated the group total number of tokens as the response variable. Because participants only chose to donate 0, 2, or 4 tokens each

trial, the donations were not continuous; thus, we used Poisson regression models with country, grade level, and condition as covariates (full results in Appendix S6). We analyzed individual donation patterns with a mixed-effects Poisson regression model with fixed effects for age, sex, country, threshold completion, and accumulated tokens per trial (full results in Appendix S7). We included random effects for individual and group to account for potential correlation between donations given by the same individual or the same group. We also calculated the donation pattern by age in each country from results of this model. In all the analyses, the loss and risk conditions were contrasted with the control. Participants from the United States and DRC were contrasted with participants from China. For all results, we included z-statistics, p-values, and 95% CIs on the effect size, which was log odd for the logistic models.

Experiment 2

We designed an age-appropriate game for children that simulates sustainable forest management in which extrinsic motivators encourage cooperation. Sustainability is often introduced through stories or individual responsibility (e.g., recycling, turning lights off, etc.) but is less often introduced through activities that require cooperation, assessment of cost–benefit tradeoffs, and opportunity costs associated with failed cooperation. We tested the biophilia and anthrophilia hypotheses by having participants play a game in which they experience the types of decisions involved in collective action needed to maintain a common-pool resource sustainably.

As in Experiment 1, children were given tokens, but it was emphasized that this endowment was a direct product of a nearby forest. In the main sustainability condition, participants could enhance the productivity of the forest and increase their endowment each round if they cooperated to meet a threshold of donations required to maintain the health of the forest. If the group failed to meet the threshold, the forest became less productive and they experienced a delay between rounds in receiving their endowment as the forest recovered more slowly from lack of care. Another group of participants experienced a delay condition that was highly similar to the sustainability condition except no sustainability framing was given and successful cooperation did not increase productivity. Participants in the 2 experimental conditions were compared with a paired control group. No incentives were provided to the control groups other than their intrinsic motivation to cooperate (see Figure 1b,c for illustration of design).

The biophilia hypothesis predicts children will succeed in the controls based on intrinsic motivation alone (and may be reduced by extrinsic motivators), whereas the anthrophilia hypothesis predicts cooperation will increase as extrinsic motivators increase the payoff of cooperation.

A naïve group of children ($n = 516$; 264 females, 252 males; mean age 8.07 years [SD 1.90]) from the same week-long summer camp at Zoo Atlanta participated in the experiment. All participants took part in camp activities described in Experiment 1. This group was chosen to directly test intrinsic levels of cooperation in participants taking part in an experiential environmental education program (i.e., in the control conditions) versus participants who in addition to camp activities also directly experienced extrinsic incentives for forest conservation (i.e., in the sustainability and delay condition). All testing took place in the same location as in Experiment 1.

Participants were distributed into age- and gender-matched groups with the same methods as in Experiment 1; age and gender were matched (see distribution of individuals and groups across conditions in Appendices S3 and S4; scripts for each condition in Appendices S12 and S13). Each group was assigned to 1 of 4 conditions: sustainability condition, sustainability control, delay condition, or delay control.

In the sustainability condition, right before participants ($n = 216$) began the game, participants were instructed to think about nearby forests and responded to 6 standardized questions designed to lead them to think about the value of forests and loss of everyday items they used as consequences of losing forests. It was then explained that in the game their donations would be used to help keep a forest healthy. During the discussion, they were told the tokens they would receive represented money made from selling lumber from the forest they were to manage; meeting the donation threshold (filling the collection bank with 36 tokens) increased forest productivity, whereas failing to meet the threshold reduced it; and success was 24 tokens for everyone in the next round, whereas failure reduced productivity of the forest to 8 tokens per player and required a 90-s waiting period between rounds while the forest recovered on its own (Figure 1b).

For the sustainability control, participants ($n = 144$) did not discuss forest conservation with an instructor and were told they received the same 12-token endowment after each round regardless of whether the group met the threshold. There was never a delay between rounds.

For the delay condition, participants ($n = 78$) did not discuss forest conservation with an instructor and were told failure to meet the donation threshold and fill the collection bank would result in a 90-s delay before the next round. Unlike the sustainability condition, they were told they would receive the same 12-token endowment regardless of success or failure at meeting the threshold (Figure 1c).

For the delay control, participants ($n = 78$) did not discuss forest conservation and were told they received the same 12-token endowment after each round regardless of whether the group met the threshold. There was never a delay between rounds.

There were 3 trials per round and 3 rounds total. Children could donate 0, 2, or 4 tokens per trial, and the donation threshold was 36 tokens per round. The procedure for each trial was the same as in Experiment 1.

As for Experiment 1, we analyzed the group success pattern with binomial generalized linear regression models and calculated the contrasts between conditions from the results (Appendix S8). We analyzed individual donation patterns with a mixed effects Poisson regression model with fixed effects for condition, age, gender, and accumulated tokens per trial (full results in Appendix S9). We calculated individual

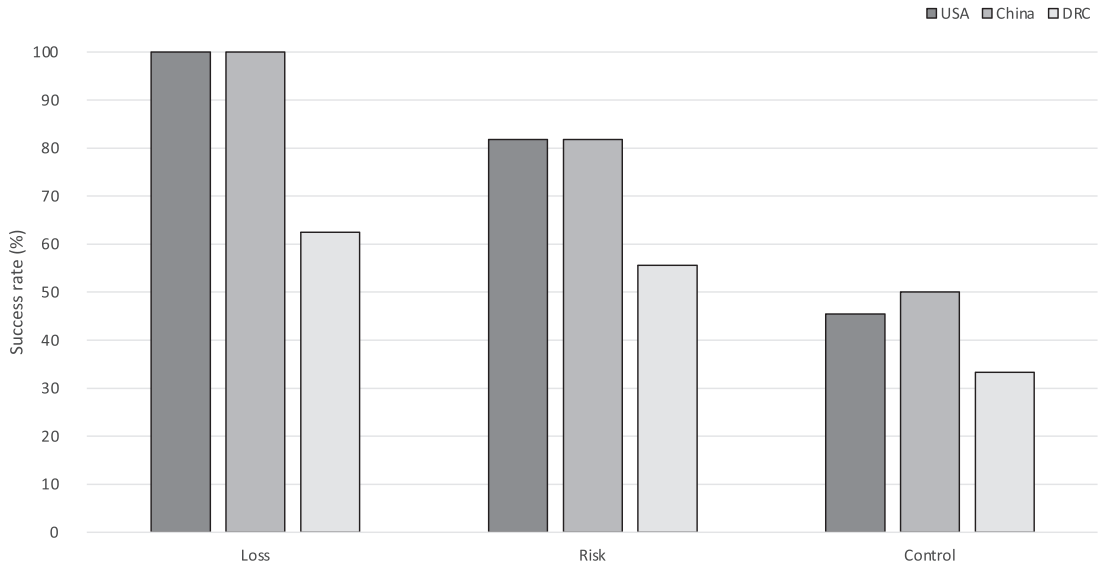

FIGURE 2 The cooperation success rate that group donation met the threshold (72 tokens) by condition and country in Experiment 1 (i.e., a 6-round common-goods game aiming to maintain a forest). Unless the group donation exceeds the threshold, participants are threatened with losing their endowment. Conditions differ only in the risk of forfeiting their earnings if the group fails to meet the donation threshold needed to care for the forest (Figure 1)

donation patterns by age from the results. In a separate Poisson regression model, we analyzed individual donation after the threshold was met and compared the patterns across conditions (Appendix S10).

Ethics approval for all studies was granted by Duke University Campus Institutional Review Board protocol 2017-1004 (United States and DRC) and protocol 2017-1054 (China).

RESULTS

Experiment 1

As the anthrophilia hypothesis predicted, results across conditions showed that extrinsic motivation led to the highest success rate in meeting the threshold (loss condition $z = 3.63, p < 0.001$, 95% CI: 1.40 to 4.46; risk condition $z = 2.61$, $p = 0.009$, 95% CI: 0.44 to 2.87) (Figure 2). Among the groups, 90.63% and 74.19% succeeded in loss and risk extrinsic conditions, respectively, and 43.75% of groups succeeded in the control condition. Countries' resource uncertainty was linked to success rates. Compared with the Chinese sample, groups from the DRC were less successful in meeting the threshold ($z = -2.34$, $p = 0.019$, 95% CI: −2.99 to −0.30). However, no significant difference was found between groups from China and the United States.

Groups across all 3 countries gave more in the loss ($z = 13.72$, $p < 0.001$, 95% CI: 0.34 to 0.46) and the risk conditions ($z = 8.57, p < 0.001$, 95% CI: 0.20 to 0.32) than in the control condition (Figure 3). Comparisons among countries were partially consistent with resource uncertainty driving lower donations. Groups from DRC donated significantly less compared with the Chinese groups ($z = -7.63, p < 0.001$, 95% CI: −0.39 to −0.17), but groups in the United States also gave less than Chinese groups ($z = -4.73, p < 0.001$, 95% CI: −0.18 to −0.07).

Across conditions, individual donations dropped significantly in trials after the donation threshold was met by participants from the United States ($z = -5.74, p < 0.001$, 95% CI: −1.34 to −0.62) and the DRC ($z = -2.12$, $p = 0.034$, 95% CI: −0.83 to −0.12), but not in China.

Results of the individual-level analysis showed that in the United States, older participants gave more tokens than younger participants ($z = 4.85, p < 0.0001$, 95% CI: 0.26 to 0.65). However, the Chinese and Congolese children and adolescents did not show increased donations as age increased, even though we sampled a larger age range in China and DRC.

Experiment 2

The results of Experiment 2 supported the anthrophilia hypothesis; both sustainability and delay groups had higher success rates in meeting the threshold than the control groups. Specifically, the success rates were 97.22% and 76.92% in the sustainability condition and the delay condition, respectively. In the sustainability control and the delay control, the success rates were 29.19% and 30.77%, respectively (Figure 4). Groups in the sustainability condition were far more likely to reach the donation threshold than groups in the sustainability control ($z = 5.58, p < 0$ .001, 95% CI: 2.42 to 5.00). Similarly, groups in the delay condition succeeded in reaching the donation threshold more than those in the delay control condition ($z = 2.44$, $p = 0.015$, 95% CI: 0.16 to 2.56). The sustainability condition yielded higher success rates than the delay condition ($z = 3.08$, $p = 0.002$, 95% CI: 0.76 to 3.41), whereas the controls did not differ from each other significantly.

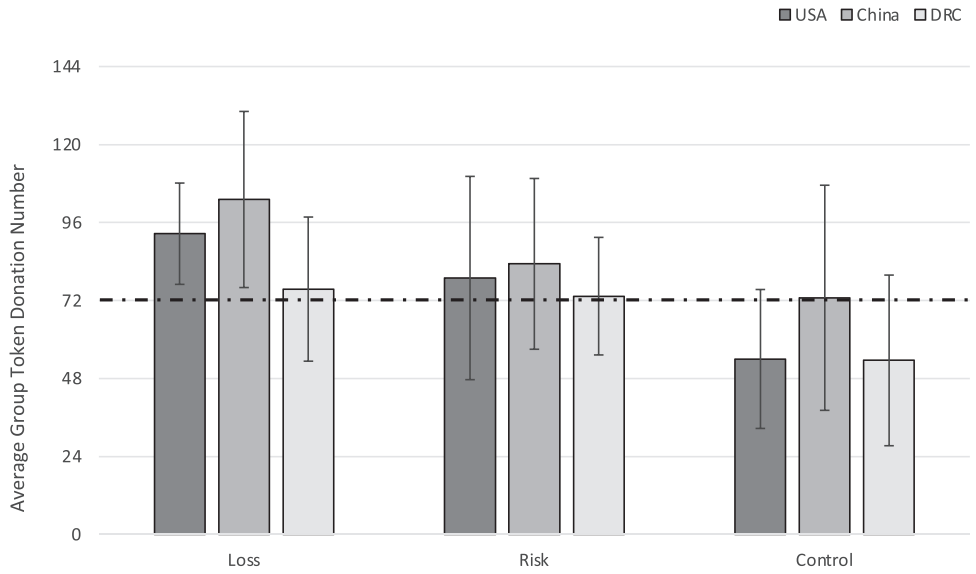

FIGURE 3 Average group token donations by condition and country in Experiment 1 (i.e., a 6-round common-goods game aiming to maintain a forest). Unless the group donation exceeds a threshold (72 tokens), participants are threatened with losing their endowment. Conditions differ only in the risk of forfeiting their earnings if the group fails to meet the donation threshold needed to care for the forest (Figure 1) (error bars, SD; horizontal dashed line, number of tokens [72] needed to reach conservation threshold)

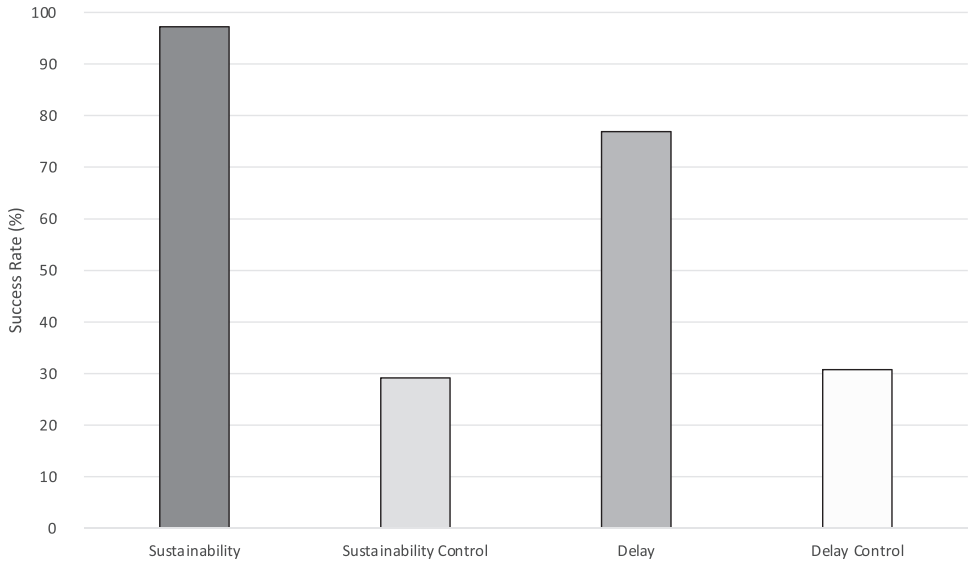

FIGURE 4 The cooperation success rate that group donations met the threshold (36 tokens) by condition in Experiment 2 (i.e., a 3-round common-goods game aiming to maintain a forest). In the sustainability condition and the control condition, unless the group donation exceeds the threshold, the forest has reduced productivity and participants experience a delay between rounds. In the sustainability condition, participants can enhance the productivity of the forest and increase their endowment each round if they cooperate to meet the threshold of donations required to maintain the forest. In the delay condition, the sustainability framing is not given, and successful cooperation does not increase productivity. In the 2 control conditions, no extrinsic incentive was provided

The individual analysis revealed the same pattern of results. Participants in the sustainability condition gave more tokens than those in sustainability control condition ($z = 7.47$, $p < 0.001$, 95% CI: 0.40 to 0.68), and individuals in the delay condition gave more tokens than those in delay control condition ($z = 4.28$, $p < 0.001$, 95% CI: 0.23 to 0.64). There was also a trend that participants in the sustainability condition donated more than the delay condition ($z = 1.71$, $p = 0.088$, 95% CI: −0.02 to 0.31). We did not find a significant difference between the 2 control groups.

After the group donation met the threshold, participants in the sustainability condition still donated more than the

sustainability control condition ($t = 3.57$, $p < 0.001$, 95% CI: 0.16 to 1.42). Similarly, participants in the delay condition donated more than the delay control condition after meeting the threshold ($t = 4.46$, $p < 0.001$, 95% CI: −0.01 to 1.06). We did not a see difference between the sustainability and control conditions or between the 2 controls after the threshold was met. Age did not affect individual donation in the sustainability or delay condition. However, in the control conditions, older children donated significantly more than younger children (sustainability control: $z = 2.21$, $p = 0.002$, 95% CI: 1.07 to 1.23; delay control: $z = 4.13$, $p = 0.002$, 95% CI: 1.00 to 1.10).

DISCUSSION

Overall, results of our experiments supported the anthrophilia hypothesis. In Experiment 1, across all 3 countries, children were most likely to successfully cooperate to support forest conservation when extrinsic motivation was highest. Once the threshold was met, there was little evidence of intrinsic conservation motives. Even children attending an environmental camp in the United States were unlikely to meet the donation threshold without rewards or punishment. Cultural differences and differences in population-level resource certainty likely also shaped donation preferences. Participants from the more resource-certain environment (United States) showed increased donation as age increased. This same relationship was not observed in the more resource-uncertain countries (China and DRC). In Experiment 2, we found that even minimal extrinsic motivation boosted cooperation—just the threat of minor time delay between rounds significantly increased success in reaching the threshold in children of all ages. We also found that simulating the costs and benefits of sustainable forest management led to the highest levels of cooperation observed. Children were most successful at working together when they personally experienced loss or gain as a result of their collective decisions around responsibly managing the forest that produced their endowment.

There was limited evidence in support of the biophilia hypothesis. Intrinsic motives were not strong enough to consistently drive cooperation across nationality or condition. Only a minority of groups succeeded when there was no personal consequence associated with group success or failure. Participants from the United States were attending a conservation camp, and the DRC was the most forested country. However, when failure resulted in loss of reward, children from these 2 countries curtailed donations as soon as their selfish rewards were secured. This suggests children understood how to maximize their individual payoff, but they were only motivated to give minimally when the common-pool good conflicted with their own interest. The exception to this pattern was the Chinese children; they donated even after the threshold was met. It may be they understood the rules of the donation games differently. However, all the children who participated from each country were required to pass the same comprehension check to assure they all understood the game. Chinese children's generosity seems more likely an expression of collectivist cultural norms (Ma et al., 2015; Wagner, 1995) or due to a higher sensitivity to experimenter demand effects (Kagitcibasi, 1997). It is also possible that the relative scarcity of forest resources in China increased the perceived value of forest and a readiness to participate in its protection (Zhang & Wen, 2008). Awareness campaigns may have also played a role in altering the beliefs about personal responsibility and willingness to take conservative action (Wray-Lake et al., 2010).

Together, these findings suggest that in addition to observing and learning about wildlife and wild places, children benefit from experiencing the decision-making process required to protect common-pool goods like a forest. Future research can better characterize the psychology underlying and developmental trajectory of this form of prosocial behavior directed at nonsocial agents. Infants develop different forms of prosocial helping, sharing, and comforting that rely on different types of social cognition and first appear at different time points (Dunfield, 2014). Similarly, the type of donation behavior seen here may rely on a specific set of social cognitive skills. Identifying the associated cognition and understanding its development could help target the time when playing these types of games might have the greatest impact on children. Further, because conservation challenges are centered globally and behavioral responses to interventions can be largely shaped by sociocultural factors (Nielsen et al., 2021), cross-cultural research is also badly needed, especially with children from developing countries with more resource uncertainty or different cultural norms than those tested here. For example, future research should replicate the sustainability condition from Experiment 2 with participants who are not in a conservation-related camp and are instead from countries that do not represent Western, educated, industrialized, rich, and democratic cultures (Tam & Milfont, 2020). Although the results from Experiment 1 suggest a range of children will respond similarly to the extrinsic motivators used in the sustainability condition of Experiment 2, this prediction needs to be tested. It will also be important to test whether participation in sustainability simulations translates to participants making proconservation decisions beyond the experimental context. Are participants in these simulations more willing to advocate for conservation initiatives or change their own behavior in real life? With such knowledge, a new tool will become available to be included in conservation education curriculum. Vital common-pool goods—including forests—might thus experience enhanced protection, and both people and wild places would benefit.

ACKNOWLEDGMENTS

We thank all the participants, the staff of Lola ya Bonobo, F. Minesi, C. André, and R. Belais for continuous support and B. Mwaki for data collection in the DRC. The Yongding Branch of Beijing No. 2 Experimental Primary School helped with data collection in China. We are also grateful for support from Zoo Atlanta from M. Kolar, S. Wiech, and Y. Robinson, D. Hontz, and Zoo Atlanta research assistances, A. Danner, F. Kidane, G. Ossello, J. Villegas, and K. Smith. We also thank 2 reviewers whose suggestions tremendously improved this article.

ORCID

Wen Zhou https://orcid.org/0000-0003-0679-0018

REFERENCES

Adams, M. B., & Plaugher, L. (2004). *Experimental forests and ranges of the USDA Forest Service* (Vol. 321). USDA Forest Service.

Ariely, D., Bracha, A., & Meier, S. (2009). Doing good or doing well? Image motivation and monetary incentives in behaving prosocially. *American Economic Review*, *99*(1), 544–555.

Bateson, P., Gluckman, P., & Hanson, M. (2014). The biology of developmental plasticity and the predictive adaptive response hypothesis. *The Journal of Physiology*, *592*(11), 2357–2368.

Belsky, J. (2008). War, trauma and children's development: Observations from a modern evolutionary perspective. *International Journal of Behavioral Development*, *32*(4), 260–271.

Bowie, A., Krupenye, C., Mbonzo, P., Minesi, F., & Hare, B. (2020). Implicit measures help demonstrate the value of conservation education in the Democratic Republic of the Congo. *Frontiers in Psychology*, *11*, 386.

Boyd, R., Gintis, H., & Bowles, S. (2010). Coordinated punishment of defectors sustains cooperation and can proliferate when rare. *Science*, *328*(5978), 617–620.

Carter, R. L., & Simmons, B. (2010). The history and philosophy of environmental education. In A. Bodzin, B. Shiner Klein, & S. Weaver (Eds.), *The inclusion of environmental education in science teacher education* (pp. 3–16). Springer.

Chapais, B. (2001). Primate nepotism: What is the explanatory value of kin selection? *International Journal of Primatology*, *22*(2), 203–229.

Davis, J. (1998). Young children, environmental education and the future. In N. Graves (Ed.), *Education and the environment* (pp. 141–155). World Education Fellowship.

Dunfield, K. A. (2014). A construct divided: Prosocial behavior as helping, sharing, and comforting subtypes. *Frontiers in Psychology*, *5*, 958.

Eisenberg, N., Lennon, R., & Roth, K. (1983). Prosocial development: A longitudinal study. *Developmental Psychology*, *19*(6), 846–855.

Ellis, B. J., Figueredo, A. J., Brumbach, B. H., & Schlomer, G. L. (2009). Fundamental dimensions of environmental risk. *Human Nature*, *20*(2), 204–268.

Engelmann, J. M., Herrmann, E., & Tomasello, M. (2018). Concern for group reputation increases prosociality in young children. *Psychological Science*, *29*(2), 181–190.

Eom, K., Kim, H. S., Sherman, D. K., & Ishii, K. (2016). Cultural variability in the link between environmental concern and support for environmental action. *Psychological Science*, *27*(10), 1331–1339.

Flanagan, C., & Gallay, E. (2014). Adolescents' theories of the commons. *Advances in Child Development and Behavior*, *46*, 33–55.

Frankenhuis, W. E., Panchanathan, K., & Nettle, D. (2016). Cognition in harsh and unpredictable environments. *Current Opinion in Psychology*, *7*, 76–80.

Hauser, O. P., Rand, D. G., Peysakhovich, A., & Nowak, M. A. (2014). Cooperating with the future. *Nature*, *511*(7508), 220–223.

Henrich, J., Boyd, R., Bowles, S., Camerer, C., Fehr, E., Gintis, H., McElreath, R., Alvard, M., Barr, A., & Ensminger, J. (2005). Economic man" in cross-cultural perspective: Behavioral experiments in 15 small-scale societies. *Behavioral and Brain Sciences*, *28*(6), 795–855.

Hill, K., & Hurtado, A. M. (2017). *Ache life history: The ecology and demography of a foraging people*. Routledge.

Jacquet, J., Hagel, K., Hauert, C., Marotzke, J., Röhl, T., & Milinski, M. (2013). Intra-and intergenerational discounting in the climate game. *Nature Climate Change*, *3*(12), 1025–1028.

Kağitçibaşi, Ç. (1997). Whither multiculturalism? *Applied Psychology: An International Review*, *46*(1), 44–49. https://doi.org/10.1080/026999497378494

Kahn, P. H., Jr. (1997). Developmental psychology and the biophilia hypothesis: Children's affiliation with nature. *Developmental Review*, *17*(1), 1–61.

Keil, J., Michel, A., Sticca, F., Leipold, K., Klein, A. M., Sierau, S., von Klitzing, K., & White, L. O. (2017). The Pizzagame: A virtual public goods game to assess cooperative behavior in children and adolescents. *Behavior Research Methods*, *49*(4), 1432–1443.

Kellert, S. R. (1995). *The biophilia hypothesis*. Island Press.

Koomen, R., & Herrmann, E. (2018). An investigation of children's strategies for overcoming the tragedy of the commons. *Nature Human Behaviour*, *2*(5), 348–355.

Ma, Q., Pei, G., & Jin, J. (2015). What makes you generous? The influence of rural and urban rearing on social discounting in China. *PLoS ONE*, *10*(7), e0133078.

McBeath, G. A., McBeath, J. H., Qing, T., & Yu, H. (2014). *Environmental education in China*. Edward Elgar Publishing.

Meredith, J., Cantrell, D., Conner, M., Evener, B., Hunn, D., & Spector, P. (2000). *Best practices for environmental education: Guidelines for success*. Environmental Education Council of Ohio.

Milinski, M., Sommerfeld, R. D., Krambeck, H.-J., Reed, F. A., & Marotzke, J. (2008). The collective-risk social dilemma and the prevention of simulated dangerous climate change. *Proceedings of the National Academy of Sciences*, *105*(7), 2291–2294.

Mittal, C., & Griskevicius, V. (2014). Sense of control under uncertainty depends on people's childhood environment: A life history theory approach. *Journal of Personality and Social Psychology*, *107*(4), 621–637.

Moore, C. (2009). Fairness in children's resource allocation depends on the recipient. *Psychological Science*, *20*(8), 944–948.

Ngounou, B. (2020). *DRC: Integrating environmental education into school curriculum*. https://www.afrik21.africa/en/drc-integrating-environmental-education-into-school-curriculum/

Nielsen, K. S., Marteau, T. M., Bauer, J. M., Bradbury, R. B., Broad, S., Burgess, G., Burgman, M., Byerly, H., Clayton, S., & Espelosin, D. (2021). Biodiversity conservation as a promising frontier for behavioural science. *Nature Human Behaviour*, *5*(5), 550–556.

Orr, D. W. (2004). *Earth in mind: On education, environment, and the human prospect*. Island Press.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, *25*(1), 54–67.

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary Educational Psychology*, *61*, 101860.

Salali, G. D., & Migliano, A. B. (2015). Future discounting in congo basin hunter-gatherers declines with socio-economic transitions. *PLoS ONE*, *10*(9), e0137806.

Saylan, C., & Blumstein, D. (2011). *The failure of environmental education (and how we can fix it)*. University of California Press.

Silk, J. B. (2002). Kin selection in primate groups. *International Journal of Primatology*, *23*(4), 849–875.

Silk, J. B. (2006). Practicing Hamilton's rule: Kin selection in primate groups. In P. M. Kappeler & C. P. van Schaik (Eds.), *Cooperation in primates and humans* (pp. 25–46). Springer.

Silk, J. B., & House, B. R. (2011). Evolutionary foundations of human prosocial sentiments. *Proceedings of the National Academy of Sciences*, *108*(Supplement 2), 10910–10917.

Singer, P. (1981). *The expanding circle*. Clarendon Press Oxford.

Stapp, W. B., Bennett, D., Bryan, W., & Fulton, J. (1970). The concept of environmental education. *The American Biology Teacher*, *32*(1), 14–15.

Tam, K.-P., & Milfont, T. L. (2020). Towards cross-cultural environmental psychology: A state-of-the-art review and recommendations. *Journal of Environmental Psychology*, *71*, 101474.

Van Vugt, M. (2009). Triumph of the commons. *New Scientist*, *203*(2722), 40–43.

Vogelsang, M., Jensen, K., Kirschner, S., Tennie, C., & Tomasello, M. (2014). Preschoolers are sensitive to free riding in a public goods game. *Frontiers in Psychology*, *5*, 729.

Wagner, J. A. I. (1995). Studies of individualism-collectivism: Effects on cooperation in groups. *Academy of Management Journal*, *38*(1), 152–173.

Warneken, F., Hare, B., Melis, A. P., Hanus, D., & Tomasello, M. (2007). Spontaneous altruism by chimpanzees and young children. *PLoS Biology*, *5*(7), e184.

Warneken, F., & Tomasello, M. (2008). Extrinsic rewards undermine altruistic tendencies in 20-month-olds. *Developmental Psychology*, *44*(6), 1785–1788.

World Health Organization. (2019). WHO's global health observatory. https://www.who.int/countries/

Wilson, E. O. (1984). *Biophilia*. Harvard University Press.

Wilson, R. A. (1993). The importance of environmental education at the early childhood level. *International Journal of Environmental Education and Information*, *12*(1), 15–24.

World Bank. (2018). *World Bank open data*. https://data.worldbank.org

Wray-Lake, L., Flanagan, C. A., & Osgood, D. W. (2010). Examining trends in adolescent environmental attitudes, beliefs, and behaviors across three decades. *Environment and behavior*, *42*(1), 61–85.

Yang, F., Choi, Y.-J., Misch, A., Yang, X., & Dunham, Y. (2018). In defense of the commons: Young children negatively evaluate and sanction free riders. *Psychological Science*, *29*(10), 1598–1611.

Zhang, K.-M., & Wen, Z.-G. (2008). Review and challenges of policies of environmental protection and sustainable development in China. *Journal of environmental management*, *88*(4), 1249–1261.

Zhang, W., Zhao, J., & Chen, J. (2019). Nature club programs promote adolescents' conservation behavior: A case study in China's biodiversity hotspot. *The Journal of Environmental Education*, *50*(3), 192–207.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Bowie, A., Zhou, W., Tan, J., White, P., Stoinski, T., Su, Y., & Hare, B. (2022). Motivating children's cooperation to conserve forests. *Conservation Biology*, e13922. https://doi.org/10.1111/cobi.13922