ENVIRONMENTAL ENGAGEMENT AND CULTURAL VALUE: GLOBAL PERSPECTIVES FOR PROTECTING THE NATURAL WORLD

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ENVIRONMENTAL ENGAGEMENT AND CULTURAL VALUE: GLOBAL PERSPECTIVES FOR PROTECTING THE NATURAL WORLD

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This image is designed by Yuan Wang

Environmental issues are a rapidly growing focal point in today's global discussion. These issues are becoming increasingly pertinent due to the potentially devastating outcomes of human environmental carelessness. As a species, humans now have realized the need for worldwide environmental engagement. This engagement is intended to heighten awareness about environmental problems, build knowledge in education, and change human behaviors to improve sustainability. Synthesizing the literature on cultural dimensions (e.g., attitudes, beliefs, values) that undergird positive views of environmental issues and engagement of sustainability practices would significantly contribute to the development of effective approaches to fostering sustainable environmental practices. Through the identification of commonalities across cultures and sensitivity to cultural differences we can begin to work toward a global consensus on viable solutions this critical issue.

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Table of Contents

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EDITORIAL
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Editorial: Environmental Engagement and Cultural Value: Global Perspectives for Protecting the Natural World

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Keywords: culture, environmental behavior, value, cross-culture, environmental belief, environmental engagement

Editorial on the Research Topic

Environmental Engagement and Cultural Value: Global Perspectives for Protecting the Natural World

Environmental issues have become a focal point in today's global discussion. As a species, humans have now realized the need for environmental engagement. This engagement is intended to heighten awareness about environmental problems, build knowledge through education about the impact of human behaviors on nature, and change human behaviors to increase sustainability. In particular, globalization and migration have led to a growing need to understand environmental engagement across nations and cultures. The way members of a society relate to the environment seems to be culturally patterned, which means that environmental engagement may differ from one culture to another; however, very little research has examined cultural factors in pro-environmental engagement. Motivations, levels of intensity, and forms of pro-environmental behavior can differ dramatically across cultures, contexts of economic development, political systems, and geographic regions (Gifford and Nilsson, 2014; Eom et al., 2016). This special topic in *Frontiers in Psychology* provides researchers with global and diverse perspectives on their theoretical, empirical, and methodological approaches to understand the human-environment interaction in environmental psychology today. The special issue includes four topics: (1) values, norms, and diversity; (2) emotional connectedness with nature; (3) environmental commons, biodiversity, and education; and (4) public perception of local environmental issues.

VALUES, NORMS, AND DIVERSITY

Xiang et al. investigated cultural orientations (individualistic-collectivistic differences) and the role of perceived intractability to individual climate action in a sample of Chinese college students. Through three studies, the authors found a negative association and impact of perceived intractability to act to reduce climate change. Individuals with more individualistic orientations had a greater likelihood for climate change inaction compared to individuals with collectivistic orientations. The authors suggested that policymakers should encourage the public to believe their individual actions are necessary for a collective effort to fight against climate change.

Zhao et al. conducted three studies to explore the relationship between awe, social dominance orientation, and ecological behavior in a sample of Chinese college students. The authors found that the trait tendency of experiencing awe partially enhanced individuals' ecological behaviors because awe reduced their views of human dominance over nature.

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Medina et al. postulated that the existing literature presented a conflicting representation of ethnic groups' concerns toward the environment. The authors argued that one possible solution is to investigate both individual and in-group social norms among ethnic minorities' environmental actions. The authors advocated for a holistic approach that evaluates social, cultural, economic, and political influences as well as uses a mixed-method methodology on future research directions.

NATURE RELATEDNESS AND EMOTIONAL CONNECTEDNESS WITH NATURE

Marczak and Sorokowski investigated the relationship between emotional connectedness with nature and modernization in the Meru people of Kenya. The authors found that people in this Indigenous non-Western society have overall positive feelings toward nature (generally supporting the biophilia hypothesis). However, levels of modernization in the sample influenced participants' emotional bonds with nature. Participants with a traditional lifestyle (e.g., remote villages in the bush) showed less emotional affinity toward the natural environment than town-dwellers and participants who live near a market town. Furthermore, the authors suggested that individuals in modern societies who only spend time outdoors occasionally might be more inclined to perceive nature in a positive way. In contrast, inhabitants in Meru bush might not feel as connected to nature because they face extremely harsh living conditions every day.

Dornhoff et al. compared nature relatedness (e.g., cognitive, affective, and experiential connection with nature) of high school students from Ecuador and Germany. The authors found Ecuadorian youth rated higher in relatedness to nature and environmental concern. This cultural difference was reflected in country-specific differences in the structure of environmental concern. Time spent in nature and self-transcendent values positively predicted nature relatedness and environmental concern in both samples.

ENVIRONMENTAL COMMONS, BIODIVERSITY, AND EDUCATION

Flanagan et al. identified qualitative themes in the narratives produced by a group of 4th−12th graders in a place-based stewardship education project. The authors focused on two themes of the environmental commons: (1) natural resources and systems on which life depends; and (2) collective actions to protect a community's resources. Specific elements such as awareness of nature, ecological balance, interdependence, environmental identity, generativity, human impact, teamwork, and collective efficacy were discussed in the program.

Fiebelkorn and Menzel explored German and Costa Rican science teachers' estimations of the global distribution of biodiversity and perceptions of the threat to plant species. The authors found that the teachers in both countries recognized Brazil as the country with the highest and most threatened biodiversity, and both groups expressed "spatial optimism" and "overestimation bias." In addition, the authors found that German teachers had a global perspective of biodiversity loss, while Costa Ricans had a local view.

PUBLIC PERCEPTION OF LOCAL ENVIRONMENTAL ISSUES

Doran et al. investigated Norwegian and German mental representations in the categorization of different energy transition pathways. The authors found that people from both countries, using card sorting methods, categorized the energy transition components as a multifaceted issue at the individual level (e.g., avoid long flights and cycling), at the societal/political level (taxes and urban development), and at the technological level (e.g., electric cars and solar panels). Cultural differences were observed in the individual level of mental representations.

Böhm et al. further explored Norwegian and German perceptions of energy transition pathways among individual, social/political, and technological levels. The authors employed affective image analysis based on free associations to investigate the affective reaction regarding the issues of energy transition pathways. Participants from both countries showed a similar view of mental images among the three levels.

CONCLUSION

Although much progress has been made in understanding value, attitude, motivation, awareness, and behavioral changes resulting from the environmental movement, research on non-WEIRD cultures are underrepresented in the field. This special topic not only assembles cutting edge empirical cultural/cross-cultural research in various topics, but also offers an overview of potential methods and applications of cultural issues in environmental psychology.

AUTHOR CONTRIBUTIONS

FJ drafted the manuscript. TK provided feedbacks.

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BRIEF RESEARCH REPORT
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Emotional Connectedness to Nature Is Meaningfully Related to Modernization. Evidence From the Meru of Kenya

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The aim of this study was to investigate an affective relationship with the natural environment in a non-western society and to determine its links with modernization. Emotional connectedness to nature, a significant predictor of nature-protective behavior, was assessed in a sample of 99 members of the Meru people of Kenya, recruited in places supposedly varying regarding their level of modernization: small market towns, farming villages, and a remote pastoralist settlement in the bush. The participants answered questions concerning their level of emotional affinity toward the natural environment and their lifestyle. The results show that feelings toward the natural environment in the studied population were, in general, positive. Such findings support the universality of the Biophilia hypothesis and are promising in the light of extant literature on the links between connectedness to nature and concern for the natural environment. Surprisingly we also found that a more traditional lifestyle was negatively related to emotional connectedness to nature. These findings suggest that contact with nature under conditions of direct dependence on the natural environment may have a different influence on people's feelings toward nature than in the west. Contrary to the common view, we conclude that the impact of modernization on non-western people's affective relationship with nature might have been unduly demonized.

Keywords: emotional connectedness to nature, modernization, non-western societies, indigenous environmentalism, human relationship with nature, Biophilia hypothesis

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INTRODUCTION

Since the industrial revolution, human pressure on the natural world has been growing, leading to global environmental degradation. It was suggested that the ecological crisis is inherently connected with western science, industrial capitalism and culture based on the biblical teachings that humans are to dominate nature (Gottlieb, 1996). Following this line of thought, it is treated as a sort of common knowledge that across the world non-western non-industrialized people live in greater harmony with the natural environment than people in industrialized societies (e.g., Gadgil et al., 1993). From dozens of publications on the subject, we took a closer look at some examples.

For instance, the people of Garhwal Himalaya in India have conserved their sacred sites for many centuries, paying a great deal of attention to the protection of biodiversity in the region (Anthwal et al., 2010). Integrated knowledge about their environments and beliefs that see nature as powerful and sacred are believed to have enabled various groups of Canadian First Nations to

live in balance with their local environments for thousands of years (Turner et al., 2000), whereas the Tibetan Baima's strong adherence to their traditional beliefs was recognized to play a key-role in biodiversity conservation and management of natural resources in their region (Luo et al., 2009).

There exists extensive evidence, however, suggesting that traditional societies might not necessarily be engaged in nature protection (e.g., Hames, 2007). The insignificant negative impact that some non-industrialized societies have had on their natural environments may stem from their small populations, lack of technology which would enable mass-degradation of nature and the absence of external markets which would put further pressure on natural resources (LeBlanc and Register, 2004).

Whether non-industrialized societies deliberately care for balance with the natural environment or not, the topic of the close relationship with nature among these people remains prevalent in western discourses (Berkes, 2018). Such a special bond with nature is in line with the much discussed Biophilia hypothesis which states that humans have an innate need and propensity to affiliate with the natural world, and for this reason they are prone to express pro-environmental concern (Kellert and Wilson, 1995). Indeed, an affective bond with nature was shown to be a significant predictor of nature-protective behavior (e.g., Hinds and Sparks, 2008; Geng et al., 2015).

Evidence from various industrialized societies suggests that, overall, people have positive feelings toward the natural world (see **Table 1**). To the best of our knowledge, no studies have yet examined in a quantitative way people's emotional relationship with nature outside the WEIRD populations (western, educated, industrialized, rich, and democratic, in the terminology of Henrich et al., 2010). Such an investigation could test the universality of the Biophilia hypothesis. Moreover, if the studied society is, to varying degrees, affected by modernization, its examination directly answers the question of the impact of western culture on people's feelings toward the natural environment. Additionally, it can shed light on the potential willingness of people to engage in nature protection.

For these reasons, we conducted a study in a sample of the Meru, an indigenous East African population who vary in terms of modernization. In accordance with the Biophilia hypothesis, we predicted that people in the studied population will overall have positive feelings toward nature. Our second hypothesis was that modernization will be associated with a decrease in emotional connectedness to nature.

MATERIALS AND METHODS

Participants

The present study was conducted among the Meru people, the indigenous inhabitants of central Kenya. We analyzed data obtained from 99 participants: 49 women aged between 16 and 92 years (M = 40.82, SD = 20.6) and 50 men aged between 15 and 85 (M = 37.62, SD = 17.47). The Meru are mostly agriculturalists practicing terrace agriculture. Although there exist numerous places where people follow traditional lifestyle either as small-scale farmers or semi-nomadic herders much like their ancestors, the market towns of the Meru County are influenced to a large extent by western economy and culture (Thomas, 1995).

The selection of the sample was intentional and aimed to reflect the differences in the level of modernization of the subjects. We surveyed inhabitants of a semi-nomadic remote settlement in the bush (n = 31), residents of villages up to 60 min ride away from the towns (n = 34), and town-dwellers (n = 34). People in the settlement in the bush were pastoralists with little access to modern media or the market economy. People in the second group were mostly farmers who partially participated in the market economy and had some access to modern media (especially to cell phones and radio). The town-dwellers functioned entirely in the market economy, and had access to modern media, basic healthcare and schooling. It is worth noting, however, that half of the participants attended only a few years of school and many received no formal schooling at all.

Procedure

The potential participants were invited to take part in a research project about people's feelings toward the natural environment. They were told that the researchers would ask 14 questions about the way the respondent feels about nature and a few more questions about their age and habits. All participants provided informed consent before study inclusion and were instructed they could quit the procedure at any time. The consent was oral due to high levels of illiteracy in the region. The study complied

TABLE 1 | Mean connectedness to nature in selected populations measured with the Connectedness to Nature Scale (Mayer and Frantz, 2004) on a five point Likert scale.

Sample and country (study)	*n*	*M*	*SD*
Inhabitants of Vienna and its vicinity, Austria (Cervinka et al., 2012)	547	3.55	0.7
High school students in Tuscany, Italy (Di Fabio and Bucci, 2016)	144	4.57	0.79
Farmers, Australia (Gosling and Williams, 2010)	141	3.9	0.66
Secondary school students, Singapore (Leong et al., 2014)	138	3.61	0.52
Portuguese adults in the metropolitan area of Lisbon, Portugal (Loureiro and Veloso, 2014)	282	3.42	0.66
Students and general inhabitants of Madrid, Spain (Olivos et al., 2011)	247	3.43	0.44
Park visitors in Bogota, Colombia (Scopelliti et al., 2016)	300	3.69	0.5
Adults, Great Britain (Swami et al., 2016)	380	3.9	0.59
Adults, United States (Zhang et al., 2014)	1108	3.59	0.83
University students, United States (Zhang et al., 2014)	151	4.54	0.88

with the Declaration of Helsinki. We also obtained the approval of the Institutional Ethics Committee of the relevant university. Furthermore, the study protocol and consent procedure received approval from the head of the local Meru community.

The study was conducted in the Meru language in cooperation with an interpreter from the Meru community. The participants were recruited through opportunistic sampling in the areas mentioned above. Approximately 10% refused to participate.

We assessed participants' level of modernization based on questions about their place of residence. Additionally, we asked about frequency of visits to the market towns in the past 3 months, years of schooling and TV exposure per week which are common measures of modernization among aboriginal populations (Godoy et al., 2005; Cheung and Kwan, 2009; Sorokowski et al., 2014).

To assess emotional connectedness to nature, we used a questionnaire based on the Connectedness to Nature Scale (CNS, Mayer and Frantz, 2004). The original scale is a popular tool to assess subjects' perception of feeling emotionally connected to the natural world and is considered to be a good predictor of pro-environmental behavior (Mayer and Frantz, 2004). Fourteen original questions from CNS were discussed with four representatives of the Meru, two women and two men, and developed so that they were comprehensible to an average member of the community. We made every effort to make the questions sound intelligible and we illustrated them with particular instances (see the **Supplementary Material**). Next, the questions were translated into Meru (using the back-translation procedure). The subjects answered the questions on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

RESULTS

The following statistics were performed in R Studio Version 3.2.4. The value of Cronbach's coefficient alpha of the Meru connectedness to nature scale was initially 0.58, therefore we decided to remove the items that presented the weakest correlations. After removing four items (items: 4, 6, 11, 14, see the **Supplementary Material**), the value of Cronbach's coefficient alpha was rendered acceptable for a scale of this length (0.69). In order to check the construct validity of the connectedness to nature scale adapted for the Meru sample, we performed Confirmatory Factor Analysis (CFA). The model was confirmed a single factor model. We obtained good fit indices (χ^2 (29) = 36.65, RMSEA = 0.05, SRMR = 0.11, CFI = 0.95). The mean score for each studied variable, as well as correlations between the corrected Meru connectedness to nature scores, and the indicators of modernization, along with the intercorrelations between indicators of modernization, are shown in **Table 2**.

To test the hypothesis that people in the studied population have, in general, positive feelings toward nature, we performed a Wilcoxon rank sum test between the mean level of connectedness to nature in our sample and the baseline level of three which indicates moderate endorsement of nature. There was a statistically significant difference between the mean score in our sample and the baseline level (W = 3800, $p < 0.001$).

To approximate whether our sample differs from the western populations reviewed in the introduction, we ran a Wilcoxon rank sum test between the mean level of connectedness to nature in our sample and the averaged connectedness to nature score from the reviewed studies. This time, we observed no significant difference between the means (W = 660, $p = 0.08$).

To verify whether the place of residence of the participants was associated with their emotional connectedness to nature we conducted one-way ANOVA with participants' place of residence as the grouping variable and their emotional connectedness to nature score as the dependent variable. There was a significant effect of place of residence on the level of connectedness to nature, $F(2,97) = 8.68$, $p < 0.001$, $\omega^2 = 0.13$. Tukey's *post hoc* tests revealed significant differences in connectedness to nature between towns and both the remote settlement and villages (towns-remote settlement: $p < 0.001$, $d = 1.06$ towns-villages: $p = 0.015$, $d = 0.77$). These differences are presented graphically in **Figure 1**.

Multiple regression analysis with additional indicators of modernization (frequency of visits to the market towns in the past 3 months, years of schooling and TV exposure per week) was used to test if the indicators of modernization predicted participants' connectedness to nature. Only visits to the market towns had significant effect on connectedness to nature (B = 0.003, SE B = 0.002, β = 0.3, $p < 0.05$; $F(3,95) = 5.31$, $p < 0.001$, $R^2 = 0.14$, adjusted $R^2 = 0.12$, $SE = 0.49$). In the final regression model, we included the above indicators of modernization as independent variables and sex and age as covariates. This model shown that both visits to the market towns and sex were significant predictors of connectedness to nature [$F(5,93) = 5.26$, $p < 0.001$,

TABLE 2 | Correlations between connectedness to nature score and indicators of modernization, and mean scores for each variable.

	1	2	3	4
1. Connectedness to nature	–			
2. Visits in the town	0.36***	–		
3. TV exposure	0.28**	0.54***		
4. Years of schooling	0.19*	0.46***	0.52***	–
5. Place of residence	0.38***	0.6***	0.52***	0.51***
Mean (SD)	4.05 (0.53)	47.17 (40.42)	3.09 (3.29)	7.54 (5.12)

*Signif. codes: ***$p < 0.001$; **$p < 0.01$; and *$p < 0.05$.*

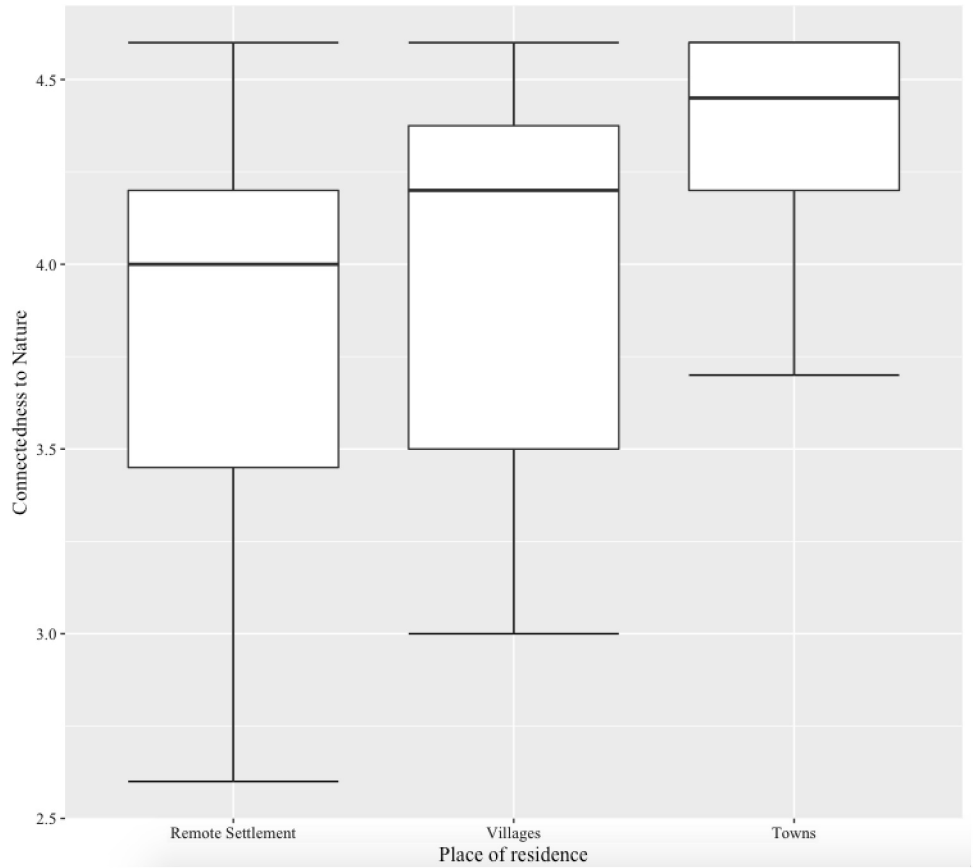

FIGURE 1 | Graphical representation of analysis of variance (ANOVA) with participants' place of residence (independent variable) and emotional connectedness to nature score (dependent variable).

$R^2 = 0.22$, adjusted $R^2 = 0.18$, $SE = 0.48$]. The results of further examination of the individual predictors are presented in **Table 3**. Including place of residence in the model made other variables become statistically non-significant, which empirically supports the conclusion that place of residence encapsulates the relevant aspects of modernization at stake in connectedness to nature.

TABLE 3 | Results of the multiple regression with indicators of modernization, sex and age as predictors and connectedness to nature as the dependent variable.

	B	*SE B*	β	*p*
Constant	3.87	0.22		<0.001
Visits to the market towns	0.004	0.001	0.27	<0.05
Years of schooling	0.01	0.01	0.11	0.38
TV exposure	0.03	0.02	0.2	0.1
Sex	−0.24	0.1	−0.23	<0.05
Age	0.01	0.003	0.19	0.07

DISCUSSION

The current study sought to examine the emotional bond with nature in a non-western society and its links with the influence of modernization in a sample of the Meru, an indigenous East African population who vary regarding their lifestyle. We hypothesized that the Meru will overall have positive feelings toward nature. Moreover, we predicted that an increase in modernization will be associated with a decrease in their emotional connectedness to nature.

In line with the first hypothesis, the feelings toward the natural environment in the studied population were, in general, positive. Such results are in favor of the Biophilia hypothesis which states that humans have a universal innate affinity with the natural world (Kellert and Wilson, 1995). What is more, when compared to the studies presented in the introduction, the endorsement for nature in the Meru was not much different from the feelings toward nature measured with CNS in industrialized populations. It must be noted, however, that we used a modified version of CNS, thus such a comparison should be treated with caution. At the same time, there exist over a dozen measures of people's subjective relationship with nature (Capaldi et al., 2014). These measures are often used interchangeably in the extant literature, since they are all highly correlated with each other and with other relevant constructs (i.e., personality, environmental attitudes) in a similar way (Tam, 2013). Therefore, despite using a different

scale, to state that the studied population show similar feelings toward nature as other studied populations is justified.

These findings are promising in the context of links between affinity with nature and pro-environmental behavior which were observed in industrialized populations (Schultz, 2001; Mayer and Frantz, 2004; Schultz and Tabanico, 2007; Nisbet et al., 2009; Gosling and Williams, 2010; Geng et al., 2015). It remains obscure, however, whether such links exist in non-western populations. Further research should focus on linking connectedness to nature to non-western people's pro-environmental behavior.

Contrary to the second hypothesis, we found that indicators of modernization such as place of residence and frequency of visits to the market towns were positively correlated with emotional connectedness to nature. One explanation for our findings might be associated with a different degree of dependence on the natural environment in the studied population. Far from the towns the contact with nature is inevitable as more traditional people live off their land as horticulturists and pastoralists. Interestingly, findings from western societies indicate that spending time in nature is related to increased affinity toward the natural environment (Mayer and Frantz, 2004; Mayer et al., 2008; Collado et al., 2013; Navarro et al., 2017). However, time spent outdoors in these studies was limited to recreational activities among safe and particularly attractive elements of the natural world, and often associated with free time whereas the contact with nature among the Meru inhabiting remote villages and the pastoralist settlement was constant, and related to, among other things, danger posed by wild animals, experiencing heat and water shortages in the dry season and torrential rains during monsoon time. Perhaps the liberation from direct dependence on nature allows people to appreciate its qualities more.

Another point to consider is that individuals who only occasionally spend time outdoors might be biased to perceive and remember nature's mostly positive sides. Town-dwellers might associate nature with time off, visiting relatives in the countryside and various gratifications stemming from it as well as with neat images from wallpapers, rather than the harsh realm of snakes and scorpions, water and firewood shortages as well as extreme weather conditions which are experienced daily by the herders. A similar connection between the contextual influences in the natural environment (seasonal and meteorological changes) and feelings toward nature was found in an American sample (Duffy and Verges, 2010). In this sense, nature viewed in a more abstract way might foster cognitive errors that turn people's feelings in favor of the environment. Future studies should focus on the links between environmental conditions and an affective relationship with nature.

Our study has several limitations. First, the concept of connectedness to nature might not be culturally universal. Nature and humans' place in it outside the Western world might be perceived in different categories than in the West (Van den Born et al., 2001; Sulemana et al., 2016). The assessment of affective bond with the environment might be therefore laden with an artifact associated with an attempt of studying people from a different culture through the lens of notions constructed in the Western culture. More qualitative ethnographic information would allow for better understanding of Meru's meanings of relationship with nature.

Another point to consider as limitation of the present study, is the reliance on an exogenous institutional review board's approval. Although relying on the institutional review board of researchers' home university seems to be customary in research in traditional societies published in peer-reviewed journals (e.g., Purzycki et al., 2016), it contributes to the problem of bias in accountability that plagues the field of social scientific research regarding populations that have little institutional representation in the academy. As much as obtaining the approval from an ethical review board of the Meru would be the most reliable, it was not possible because such body did not exist. However, in order to ensure that the study protocol was suitably anchored in the cultural context of the Meru, we consulted a number of representatives of the Meru about the form and content of the study.

Due to resource constraints, the Connectedness to Nature Scale was not fully validated for use with the Meru. However, in order to ensure maximum validity, the items were first formulated in the most understandable way in cooperation with four Meru representatives, and consequently translated from English using the back-translation procedure. Moreover, CFA results suggest that the scale used can be considered psychometrically valid. Additionally, as noted by Riley et al. (2017), the external validity of scales developed in one population often overlaps when these measures are used in other populations. Nevertheless, our results should be interpreted carefully.

This research examined the links between modernization and emotional affinity toward nature based on a sample of one ethnic origin – the Meru people of Kenya. In order to determine the relationship between modernization and the impact of western culture on people's feelings toward the natural environment, more research in traditional populations is needed.

CONCLUSION

Our findings provide rare quantitative data on the affective relationship with the natural environment in a non-western society. Whereas overall positive feelings toward nature in the studied population are promising regarding people's potential willingness to engage in pro-environmental behavior, the positive links between modernization and connectedness to nature which we found suggest that, at least in the studied group, the influence of modernization on non-western people's emotional bond with the environment might have been unduly demonized. We hope that this paper will bring more attention to people's psychological relationship with the natural environment outside the WEIRD world.

DATA AVAILABILITY

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

AUTHOR CONTRIBUTIONS

MM and PS conceived and designed the study, analyzed the data, and wrote the manuscript. MM collected the data.

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SUPPLEMENTARY MATERIAL

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Laypeople's Affective Images of Energy Transition Pathways

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This paper explores the public perception of energy transition pathways, that is, individual behaviors, political strategies, and technologies that aim to foster a shift toward a low-carbon and sustainable society. We employed affective image analysis, a structured method based on free associations to explore positive and negative connotations and affective meanings. Affective image analysis allows to tap into affective meanings and to compare these meanings across individuals, groups, and cultures. Data were collected among university students in Norway (n = 106) and Germany (n = 125). A total of 25 energy transition pathway components were presented to the participants who generated one free association to each component by indicating the first that came to mind when thinking of the component. Participants evaluated their associations by indicating whether they considered each association to be positive, negative, or neutral. These associations were coded by two research assistants, which resulted in 2650 coded responses in the Norwegian sample and 2846 coded responses in the German sample. Results for the two samples are remarkably similar. The most frequent type of association is a general evaluation of the component, for example concerning its valence or its importance. The second most frequent types of association are requirements needed to implement the component (e.g., national policies) and consequences of the component (e.g., personal or environmental consequences). Individual behaviors (e.g., walking) elicited thoughts about consequences and requirements, but also about the prevalence of such behaviors. Associations in response to technologies (e.g., carbon capture and storage) mainly referred to some descriptive aspect of the technology. Evaluations of the free responses were predominantly positive, but some components also elicited negative associations, especially nuclear power. The free associations that people generate suggest that they have vague and unspecific knowledge about energy transition pathways, that they process them in an automatic and intuitive rather than deliberative manner, and that they have clear affective evaluations of the presented components.

Keywords: energy transition, climate change, mental representation, affective imaging, free associations, Norway, Germany

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INTRODUCTION

Energy transition commonly refers to "a change in the state of an energy system as opposed to a change in an individual energy technology or fuel source" (Grubler et al., 2016, p. 18). This may involve a heterogeneous multitude of potential changes including international agreements, national policies and regulations, industrial production and technological development, as well as changes to individual lifestyles, amongst others. Although the successful transition toward low-carbon and sustainable societies requires concerted changes at different levels, many aspects of this transition imply some sort of involvement of the public. Examples include public acceptance of policies, regulations, and technologies, as well as voting decisions. Public engagement with carbon reduction depends in part on the meanings that people ascribe to energy in everyday life (Whitmarsh et al., 2011).

This paper investigates the public perception of energy transition pathways, with a focus on subjective mental representations in the form of connotative meanings and affective images. These meanings and images have been shown to play an important part in shaping public perceptions and responses to societal risk issues such as climate change (Leiserowitz and Smith, 2017). The next section introduces the core concepts addressed throughout this paper covering energy transition pathways, mental models, and affective images. We will then present an exploratory study that investigated public perceptions of energy transition by eliciting free associations to various key terms related to the subject obtained from university students in two countries. Results of the study indicate which connotative meanings and affective images laypeople in these two samples ascribe to energy transition. Conclusions are drawn concerning the public understanding of this topic and likely implications for policy support and behavioral change toward a low-carbon society.

THEORETICAL BACKGROUND

Energy Transition Pathways

Energy transition is a multifaceted concept that involves a variety of dimensions (Böhm et al., in press). One apparent dimension concerns the level of social aggregation at which a change takes place, ranging from individuals (e.g., energy saving at home or at work, purchasing of energy efficient appliances, avoiding car rides) to local and national governments (e.g., regulations such as green taxes) and international bodies (e.g., Paris agreement). Another possible dimension touches upon the distinction between supply-oriented (changes in energy production, e.g., renewable energy sources) and demand-oriented (changes in energy consumption, e.g., transportation modes) measures to transform energy systems. These various dimensions and levels rarely work in isolation, as can be illustrated by looking at renewable energies. Not only are energy sources from wind and solar embedded in a societal context of infrastructures and policies, but this context also has an impact on public support (Perlaviciute and Steg, 2014).

A large body of research exists in environmental psychology on topics that have some relevance to energy, yet little research has taken a comprehensive look at the many facets of energy transition. One existing research field deals with specific individual energy sources, for example perception and acceptance of nuclear power (for reviews, see Perlaviciute and Steg, 2014; Steg et al., 2015). Another existing research field tries to explain specific behaviors of individuals such as energy saving (e.g., turning down the heating, turning off the lights) or reduction in car driving (e.g., using public transport, car sharing) (for a review, see Steg and Vlek, 2009). In sum, these fields tend to focus on specific, often isolated, aspects of energy transition.

We argue that if the aim is to study subjective mental representations of energy transition, a broad range of potential actions and changes need to be taken into account (see also Böhm et al., in press). Henceforth, we will use the term *energy transition pathway* if we mean a combination of steps that are taken with the aim of reducing carbon emissions and improving the sustainability of energy use and production. An individual step such as a specific behavior, policy, or technology will be referred to as an *energy transition pathway component*.

Mental Models

It is widely agreed that people's subjective mental representations, or mental models, shape risk perceptions and play an important role in guiding behavior (Böhm and Pfister, 2001; Bostrom, 2017). Mental models comprise people's knowledge about, and associations with, a phenomenon including causal inferences. They provide the basis for understanding a given event or situation; they also allow people to mentally simulate the future and to infer what will happen next (Bostrom, 2017). Mental models about a situation may include behavioral options, potential consequences of different behaviors, relevant actors and events, but also associations such as mental images, sounds, and smells. They can furthermore vary with respect to elaboration and range from full-fledged and detailed to vague and fragmentary representations (Böhm and Pfister, 2001).

An expanding literature suggests that mental models can guide individual behavior and policy support, for instance in response to climate change (e.g., Böhm and Pfister, 2001, 2017; Bostrom et al., 2012). Bostrom et al. (2012) demonstrated that people supported different climate policies depending on which factors they saw as the main causes of climate change. Engineering technologies were most supported by people who held a mechanistic model and considered natural events (e.g., volcano eruptions) the main cause of climate change. People who attributed climate change to carbon dioxide supported policies that specifically target carbon emissions (e.g., taxes on fossil fuels, carbon market), people with more vague conceptions about climate change supported unspecific green policies (e.g., funding research), and generally, people tended to support those policies they considered most effective in tackling the problem. Whilst several other studies have investigated mental models about climate change (e.g., Reynolds et al., 2010; for overviews, see Böhm and Pfister, 2001; Böhm, 2008; Bostrom, 2017), less is known about laypeople's mental models about energy systems and their perceptions of different pathways to

energy transition specifically. For example, which strategies does the public consider in the transition toward a low-carbon energy system, and what consequences do they anticipate, for example, for the economy, the environment, or society?

Mental models are not always detailed and elaborate, which may depend on how much a person knows and has thought about the issue in question. For global problems such as climate change, it has been found that people generally lack detailed conceptual understandings of the phenomenon (Leiserowitz and Smith, 2017). Given that energy transition is closely related to climate change (and that it is a new, similarly global and complex issue), people's understanding of energy transition may also not be very elaborate. For this exploratory study, we therefore concluded that the public perception of energy transition may be better studied on the level of mental images rather than as detailed mental models with explicit, for example causal, judgments. One way of tapping into mental images is the elicitation of free associations, which allows studying the content of people's minds without forcing them to express their thoughts in full language (cf. Leiserowitz and Smith, 2017).

Smith and Joffe (2013) analyzed free associations to climate change (they use the term global warming) from a social representations theory perspective, a theoretical approach that can explain the origin of mental images. These authors showed how strongly the socio-cultural context shapes people's representations of global risk issues such as climate change. They argue that when trying to build a mental representation of an unfamiliar issue, people assimilate the new information to familiar structures, using symbols, icons, and metaphors that circulate in their socio-cultural context. In this respect, visual images are particularly important elements of the socio-cultural context because of their concreteness, ability to convey emotions and their status as expressive carriers of meaning in common sense thinking.

The assumption is that new information is encoded based on some familiar concept ('anchoring', Smith and Joffe, 2013). For climate change, it has been shown that laypeople often understand this phenomenon on the basis of their pre-existing mental models about ozone depletion, air pollution, or weather (Bostrom, 2017). A concrete representation of a new phenomenon is then created by transforming the familiar model through incorporating tangible images, concepts, and symbols ('objectification,' Smith and Joffe, 2013). For climate change, these may include images of melting ice, polar bears, flooding, smoking chimneys, or car exhaust pipes (see below). Smith and Joffe (2013) found that social representations of climate change were structured according to antinomic dyads, namely, self versus other, natural versus unnatural, and certainty versus uncertainty.

Smith and Joffe (2013) point out that the free associations revealed as part of their study mirrored the images that the British press used to depict climate change visually. Climate change, and presumably energy transition, are socially mediated phenomena in the sense that few aspects of it are personally experienced (Weber and Stern, 2011). An interesting question is thus whether traditional versus social media and new technologies assume different roles in shaping subjective mental representations. Comparisons of the themes and frames that are used in the coverage of the COP 21 summit in Paris (Painter et al., 2018) or coverage of the IPCC Fifth Assessment report (O'Neill et al., 2015) show that traditional print and online and social media are more similar than one might expect. An analysis of climate change debates on Twitter (Williams et al., 2015) showed that these discourses take place in part in homogenous attitudinal echo chambers constituting segregated and polarized camps of activists and skeptics, but also in mixed-attitude communities in which activists and skeptics interact. Exchanges between like-minded individuals tend to carry positive sentiment whereas messages in mixed-attitude communities are likely to express negative sentiment. These results indicate that social media have a strong potential to shape people's associative mental images and to portray affect-laden meanings; as opposed to other forms of new technologies that seem likely to help build up an elaborate cognitively focused mental model (e.g., smart meter web portals, Mack and Tampe-Mai, 2016).

Affective Images

It is increasingly recognized that information processing, risk perception, and decision-making are influenced by affect and emotions (Pfister and Böhm, 2008; Lerner et al., 2015). Dual systems theories see affect as being based on fast and intuitive, as opposed to analytic, processing (Epstein, 1994). Affective reactions often occur instantaneously and automatically and thus allow individuals to respond rapidly to their surroundings (Zajonc, 1980; Pfister and Böhm, 2008). Affect generally refers to an overall good or bad, positive or negative evaluation of an object, event, situation, idea, person, or other entity (e.g., Slovic et al., 2004). Leiserowitz and others (Leiserowitz, 2006; Lorenzoni et al., 2006; Leiserowitz and Smith, 2017) introduced the term 'affective images' to refer to mental images to which affective evaluations have become attached. Mental images include both perceptual and symbolic representations, that is, the whole range of sights, sounds, smells, ideas, words, symbols, or numbers. Affective images are all sorts of representations that carry affective meaning, with affective states becoming attached to mental images by learning and experience.

When it comes to research exploring public views on climate change, affective images have been linked with both risk perceptions and policy preferences. Smith and Leiserowitz (2012) tracked affective image associations to the term global warming among the American public over time in the period from 2002 to 2010. They identified significant trends; for example, 'naysayer' but also disaster images increased, while ice-melting images decreased. There was an overall trend to evaluate these associations negatively, with 'naysayer' images being among the strongest predictors of risk perception. These results document that affective images not only form a core element of people's mental representations related to climate change but also shape people's evaluations and, ultimately, their behaviors and policy preferences. Other research has shown that affect seems to be an integral part of social representations of climate change and energy-related topics (Fischer et al., 2012).

Truelove (2012) proposes a dual-process model of energy support, in which affective images and evaluations interact with cognitive evaluations in determining support for energy sources.

Truelove's study reports affective images for four energy sources: coal, nuclear power, natural gas, and wind. It also documented how each energy source is associated with specific mental images (e.g., coal with mining, nuclear power with Chernobyl and cooling towers, natural gas with fires and pipes, wind with wind mills/turbines). Consistent patterns of relationships emerged among image evaluations, emotions, and beliefs about each of the energy sources such that coal and nuclear energy were viewed most negatively, natural gas was viewed more positively than coal and nuclear energy but less positively than wind power, with wind power considered the most favorable energy source. Affective image evaluations, emotions, and cognitive beliefs each explained levels of support for the energy sources.

Truelove's (2012) study is an important pioneering piece of work in the study of affective images concerning energy transition. It is restricted in that it considered only four types of energy sources, and as a result, the complex multifaceted nature of energy transition seems somewhat underrepresented. As the study measured a variety of concepts in addition to affective images, such as emotions, cognitive beliefs, and policy support, it included a broad range of psychological variables for few transition components. Our approach is complementary in the sense that we aim to explore laypeople's mental representation of the broad landscape of potential energy transition pathways. Specifically, we will include a broad range of energy transition pathway components but only one psychological measure of the mental representation, namely, affective images.

Affective images stem from personal experiences on the one hand, and social discourses and media reporting on the other (Smith and Joffe, 2013; Leiserowitz and Smith, 2017). It is because of this that social representations are likely to be shaped to some extent by socio-cultural contexts. Affective images are a highly sensitive measure of the public discourse about a topic, which makes it well suited to identify interpretative communities that differ in their conceptualizations of an issue (Fischer et al., 2012; Leiserowitz and Smith, 2017). This is exemplified by research on naysayers versus alarmists, two communities that interpret climate change through different lenses (Leiserowitz and Smith, 2017). Such communities are prone to engage in motivated reasoning, for example by seeking out information that confirms their views, and reinforcing each other in their interpretations; a process which may be amplified by social media (Williams et al., 2015).

RESEARCH AIMS

Our approach in studying public perceptions of energy transition extends prior research in several respects. First, in accordance with Böhm et al. (in press), this study conceptualizes energy transition as a multifaceted construct that comprises steps at different levels ranging from individual actions to policies, infrastructure, technologies, and international agreements. Rather than presenting respondents with a relatively small selection of energy transition pathway components, such as different energy sources, a comprehensive range of potential components is considered. As there is still little research on laypeople's perceptions of energy transition in this broad sense, an exploratory approach is employed to tap into the mental representation of these components in the form of affective images (elicited through free associations and affective judgments) rather than studying specific beliefs or judgments (e.g., ascriptions of causes and consequences, attitudinal judgments).

Second, this study extends the existing literature by providing a comparison between two different cultural contexts, Norway and Germany, which differ in interesting ways with respect to their socio-political contexts and histories concerning energy systems (Arnold et al., 2016). For example, oil and hydroelectric power play important roles in Norway, the former as a source of employment and economic development and the latter as an energy source. The economic importance of fossil fuels in Norway blends with national identity and is in conflict with a general pro-environmental and climate-friendly national self-image. Germany is politically committed to the transition toward renewable energy ("Energiewende"), but has a long tradition of using coal as an energy source. Coal extraction is not only an economically important factor but also forms regional identities. Public engagement with energy in Germany is strongly shaped by opposition toward nuclear energy and high levels of environmental awareness. One further aim of our study is to map which content people mentally associate with various energy transition pathways in these two cultural contexts, and which affective evaluation they attach to these associations. Even though affective images can provide a rich source of tapping into and comparing meanings across individuals, groups, and cultures, studies addressing cultural context in affective imaging remain scarce (but see Lorenzoni et al., 2006).

METHODS

We collected data in a Norwegian and a German sample. We employed affective image analysis (see below) in both samples, a structured method to explore connotative and affective meanings. Affective image analysis uses free associations and evaluations of these associations. We will compare these two elements of affective image analysis across the two samples.

Participants

Norwegian participants (n = 106; 81 women, 25 men; M_{age} = 23.7, SD_{age} = 3.67, age range: 19–39) were students at the University of Bergen in Norway. They were recruited via student Facebook groups associated with the Faculty of Psychology. Most participants (n = 102) were enrolled in a psychology program (predominantly clinical psychology or work and organizational psychology); the remaining four participants came from biology, law, social economics, and theater science, respectively. A majority (n = 63) indicated that they had heard the term energy transition before participating in the study, while the remaining 43 participants responded that this was not the case.

German participants (n = 125; 88 women, 24 men, 1 recorded non-binary, 12 did not respond to the gender question; M_{age} = 22.0, SD_{age} = 3.32, age range: 18–35, 15 did not report

their age) were students at the Leuphana University of Lüneburg in Germany. They were recruited in psychology lectures. Most (n = 72) studied psychology, 35 marketing and management, 2 a combination of environmental sciences and psychology, and 1 other (individual studies); 15 did not indicate their study program. All indicated that they had heard the term energy transition before participating in the study.

Participants from both countries were informed about the topic and aims of the study, the anonymity of their answers, and the right to withdraw at any time from their participation. Consent of the participants was obtained by virtue of survey completion.

Materials

Energy Transition Pathway Components

The main stimulus material consisted of 25 terms that describe actions that can be taken as part of a strategy toward sustainable ways of producing and using energy. We aimed to select a set of components that would cover a broad range of possible actions and include those that are relevant in the public's mind as well as from a scientific and political perspective. We based the selection on four sources: (a) general desk research on the issue of energy transition, (b) desk research of the psychological and social science literature to identify environmental behaviors and policy options used in previous studies, (c) pilot interviews with students from the same target population as the participants in the current study, and (d) interviews with experts from the climate and political sciences. The components correspond in part to those used by Böhm et al. (in press). They comprise actions on three broad levels: individual actions (e.g., using public transportation), political actions (e.g., international agreements), and technologies (e.g., carbon capture and storage). They also included two types of action that are distinguished in the environmental psychology literature (e.g., Gardner and Stern, 2008), namely curtailment (e.g., energy saving) and efficiency (e.g., energy efficient household articles). A complete list of the 25 components is given in **Table 1**.

TABLE 1 | The 25 energy transition pathway components used in this study.

Label	Energy transition pathway component
appliances	Energy efficient home appliances (e.g., light bulbs)
ccs	Carbon capture and storage
compensate	Climate compensation (e.g., when buying flights)
e.cars	Electric cars
educ	Environmental education (e.g., in school, at work)
engage	Political engagement
flights	Avoid long flights
houses	Energy efficient houses (e.g., geothermal heating)
hydro	Hydropower
int.agree	International agreements (e.g., on carbon emissions)
int.trade	International trade with carbon offsets
it	Information technologies (e.g., monitor home energy use)
nuclear	Nuclear power
pub.trans	Public transportation
regulate	Regulations (e.g., laws to reduce sales of fossil fuel cars)
saving	Energy saving (e.g., turn down heating)
science	Science
sharing	Sharing economy (e.g., carpooling)
solar	Solar panels
subsidy	Subsidies (e.g., for renewable energy)
tax	Taxes (e.g., on carbon intensive goods and services)
urban	Urban planning (e.g., car free zones)
vegetar	Vegetarian food
walking	Walking and cycling
wind	Wind farms

Measures

We followed a method described by Leiserowitz and colleagues (Leiserowitz, 2006; Lorenzoni et al., 2006; Leiserowitz and Smith, 2017) as affective image analysis (see also Pfister et al., 2000, for an application to the public perception of genetic engineering). The basic idea is to tap into people's mental images and affective connotations concerning some issue by having them first generate one or more free associations to the issue in question and then asking them to evaluate the affective valence of their own free associations. The content of the free association gives an indication of the mental images that people associate with the issue; the evaluation of the free associations reflects their affective connotations on a dimension of positive to negative valence. Mental images and their affective evaluation constitute the two elements of affective images (Leiserowitz and Smith, 2017).

Free associations

For each energy transition pathway component, participants were asked to briefly describe the first thought that came to their minds with respect to this component. They were instructed to answer spontaneously and swiftly but without rushing. They gave their responses in writing in a free text field in the questionnaire.

Evaluation of free associations

After having completed the free association task, participants were requested to go through their free associations again and to indicate for each whether they considered it something positive, or negative, or neutral (neither positive nor negative). Responses were coded as +1, −1, or 0, respectively.

Background variables

At the end of the questionnaire, participants were asked whether they had heard the term energy transition before participating in the study (yes/no). They were also asked to indicate their age, gender, and study program.

Coding of Free Associations

The free associations were content analyzed (Bos and Tarnai, 1999) in order to capture the content of the mental images. We developed a coding scheme in a bottom-up manner in the following steps: first, four individuals (two of the authors, plus two research assistants from the same target population as the respondents, i.e., university students) looked at the responses independently and came up with a proposal for categories. These four proposals were then merged by discussion and developed into a common coherent category system. We described this category system in writing, giving for each category a definition

and examples. The resulting coding scheme consists of five superordinate categories, each being divided in subcategories; the complete list of categories is given in **Table 2**. The complete coding scheme including coding instructions and examples of responses for each category is provided in the **Supplementary Material**. The five superordinate categories are: (a) requirements (i.e., the response indicates that the component will not work in isolation but requires some additional action; subcategories refer to requirements at the level of international politics, national politics, or individual life styles), (b) consequences (i.e., the response refers to potential positive or negative consequences of the component; subcategories refer to consequences for individuals, society, or the environment), (c) evaluation (i.e., the respondent expresses an evaluation of the component, for example concerning its feasibility or importance), (d) prevalence (i.e., the response refers to the prevalence of the component, indicating how widespread, or rare, it is; for example indicating that the component applies only to certain people), and (e) remnant categories (e.g., mere descriptions of the component, when the response stated some descriptive aspect of the component such as that electric cars are electric).

The responses differ quite strongly in specificity. For example, some people said something like "that's important" or "that's good"; or, with respect to responses falling in the category of requirements, some participants said something like "won't work on its own" very generally; while others were more specific and said something like "important to have binding agreements that include sanctions if they are broken." In order to capture such differences in specificity, the coding scheme contains categories at three levels of specificity (see **Table 2**). Responses were coded at the most specific category possible. Superordinate categories were used when the response did not give more specific information to assign it to a subcategory (in **Table 2** listed as codes labeled as *no specification*) or if something specific was said that did not match any of the available subcategories.

In both samples, two university students coded the free associations. These were Norwegian native speakers for the Norwegian data and German native speakers for the German data. First, the two coders coded the responses independently. They were then asked to go through the responses on which they had disagreed and discuss whether they could solve the disagreement.

The Norwegian sample generated 2650 free associations. In their independent coding, coders agreed in 69.3% of these responses, Cohen's Kappa = 0.674, $p < 0.001$, considering all three levels of the coding scheme. At Level 1, the two coders agreed in 80.3% of the responses, Kappa = 0.712, $p < 0.001$. After having discussed their disagreements, coders assigned a mutual code to all of the 2650 responses.

The German sample generated 2946 free associations. Intercoder-agreement was lower in the German than in the Norwegian sample. In their initial independent coding, the two coders agreed in 47.0% of the responses, Cohen's Kappa = 0.446, $p < 0.001$, considering all three levels of the coding scheme. At Level 1, agreement was 71.4%, Kappa = 0.61, $p < 0.001$. After discussing disagreements, the coders assigned a mutual code to 2846 of the responses.

Procedure

In Norway, data collection was done in a computer lab. Each participant was seated at an individual computer that was shielded by partitioning walls at the sides and at the front. Computer lab sessions were run in groups of 16 to 29 participants. All materials were presented and data collected via a computer-based survey (programmed in an online tool called Explorable[1]). The data reported in this paper were collected at the beginning of a larger survey; the entire lab sessions lasted on average 45 min. For the entire survey, participants received a gift voucher worth NOK 200.00 (ca. EUR 21.00) as an incentive for participating.

In Germany, data were collected by means of a paper-and-pencil questionnaire that was distributed at the end of lectures. The questionnaire consisted only of the free association and evaluation tasks (plus the background variables). Participants needed on average 20 min to fill in the questionnaire; they received a chocolate bar and a ballpoint pen as an incentive for their participation.

Participants were informed that the study dealt with the question of how people think and feel about various steps that can be taken as part of energy transition, which was defined as long-term changes in energy systems that aim at fostering a more sustainable society. The energy transition pathway components were then presented, each followed by an open text field on the computer screen (Norway) or a blank space on the paper questionnaire (Germany) for participants to fill in their free associations. Each participant received the components in one of two random orders. After participants had filled in their free associations, they were asked to evaluate them. In the computer-based procedure in Norway, participants were presented with their own free associations that they had entered before. In the paper-and-pencil based procedure in Germany, participants were asked to turn back in their questionnaire to evaluate their free associations. At the end of the questionnaire, participants had the opportunity to leave comments. Upon having completed the questionnaire, participants were thanked and received their incentive.

RESULTS

We will first focus on the content of the free associations and report the distributions of the free associations across the categories of the coding scheme. We then report the results concerning participants' evaluations of their free associations. All statistical analyses were done using the R statistical environment (R Core Team, 2018).

Free Associations

Aggregated Distribution of Free Associations

Table 2 lists for each category of the coding scheme what percentage of the free associations falls into that category, aggregated across all energy transition pathway components. The two distributions for the Norwegian and German data are remarkably similar. By far the most frequent type of free

[1]https://explorable.com/

TABLE 2 | Distribution of the free associations across the categories of the coding scheme, aggregated across all energy transition pathway components, for Norwegian and German sample (percent).

	Codes			Category	Percentages Norway			Percentages Germany		
Label	**Level 1**	**Level 2**	**Level 3**		**Level 1**	**Level 2**	**Level 3**	**Level 1**	**Level 2**	**Level 3**
R1	**1**			**Requirements**	**15.66**			**15.50**		
R1.0		10		*No specification*		0			0.91	
R1.1		11		Requirement on international level		1.32			1.30	
R1.1.0			110	*No specification*			0.11			0.25
R1.1.1			111	Need for international agreements			0.72			0.53
R1.1.2			112	Need for monitoring targets			0.49			0.53
R1.2		12		Requirement on the level of national policies		9.51			9.77	
R1.2.0			120	*No specification*			0.75			1.86
R1.2.1			121	Regulation via incentives			2.19			2.57
R1.2.2			122	Regulation via punishments			0.79			0.88
R1.2.3			123	Need for facilitation (available infrastructure)			3.66			2.64
R1.2.4			124	Need to increase knowledge (fund research)			2.11			1.83
R1.3		13		Requirement on the level of the citizens within a society		4.83			3.51	
R1.3.0			130	*No specification*			0.04			0.07
R1.3.1			131	Need to change behavior/lifestyles			1.28			1.41
R1.3.2			132	Need to change attitudes/values			0.26			0.18
R1.3.3			133	Need for collective action			2.00			0.84
R1.3.4			134	Need to increase awareness			1.25			1.02
R2	**2**			**Consequences**	**14.26**			**13.00**		
R2.0		20		*No specification*		0			1.09	
R2.1		21		Personal consequences		6.45			6.11	
R2.1.0			210	*No specification*			0.11			0.70
R2.1.1			211	Personal time resources			0.30			0.18
R2.1.2			212	Personal financial resources			2.49			2.35
R2.1.3			213	Personal comfort			1.47			1.37
R2.1.4			214	Personal social interactions			0.11			0.14
R2.1.5			215	Personal health effects			1.43			1.16
R2.1.6			216	Personal freedom			0.53			0.21
R2.2		22		Societal consequences		1.02			0.81	
R2.2.0			220	*No specification*			0.04			0.21
R2.2.1			221	Social risks			0.08			0.07
R2.2.2			222	Social justice			0.91			0.53
R2.3		23		Environmental consequences		6.79			4.99	
R2.3.0			230	*No specification*			3.55			0.25
R2.3.1			231	Environmental pollution			0.83			1.51
R2.3.2			232	Environmental preservation			1.32			2.85
R2.3.3			233	Environmental aesthetics			1.09			0.39
R3	**3**			**Evaluation**	**48.98**			**49.23**		
R3.0		30		*No specification*		0.60			1.62	
R3.1		31		Evaluation concerning feasibility		3.36			4.85	
R3.2		32		Evaluation concerning effectiveness		5.36			2.11	
R3.3		33		Evaluation concerning importance		10.83			13.63	
R3.3.0			330	*No specification*			8.72			11.52
R3.3.1			331	Importance for the present			0.30			0.25
R3.3.2			332	Importance for the future			1.81			1.86
R3.4		34		Expression of skepticism		4.00			7.77	
R3.4.0			340	*No specification*			1.92			5.87
R3.4.1			341	Skepticism toward underlying intentions			1.55			1.83
R3.4.2			342	Skepticism toward the scientific bases			0.53			0.07
R3.5		35		Expression of affective valence		16.98			9.28	

(Continued)

TABLE 2 | Continued

Codes			Category	Percentages Norway			Percentages Germany		
Label	**Level 1**	**Level 2**	**Level 3**		**Level 1**	**Level 2**	**Level 3**	**Level 1**	**Level 2**	**Level 3**
R3.5.0			350	*No specification*			0.19			
R3.5.1			351	Positive affect			14.08			6.99
R3.5.2			352	Negative affect			2.72			2.28
R3.6		36		Expression of conflicting aspects		7.85			9.98	
R3.6.0			360	*No specification*			0.15			1.16
R3.6.1			361	Conflict between different impacts			7.66			8.75
R3.6.2			362	Conflict between different generations			0.04			0.07
R4	**4**			**Prevalence**	**2.38**			**8.57**		
R4.0		40		*No specification*		0.60			4.32	
R4.1		41		Prevalence with respect to personal actions		1.17			3.65	
R4.1.0			410	*No specification*			0.19			0.46
R4.1.1			411	Respondent is already doing it			0.75			2.39
R4.1.2			412	Respondent lacks motivation			0.23			0.81
R4.2		42		Prevalence among certain social groups		0.60			0.60	
R4.2.0			420	*No specification*			0.19			0.25
R4.2.1			421	Prevalence among certain subcultures			0.19			0.28
R4.2.2			422	Prevalence among demographic groups			0.23			0.07
R5.0				**Remnant Categories**	**18.72**			**13.70**		
R5.1		51		Mere description		11.02			10.01	
R5.2		52		Non-codeable response		2.68			2.28	
R5.3		53		Don't know response		5.02			1.41	
				Sum	**100**	**100**	**71.36**	**100**	**100**	**71.40**

Percentages are based on n = 2650 responses in Norway and n = 2846 responses in Germany. Level 1 categories are in bold face. Subcategories add up to the next higher superordinate category.

association, accounting for slightly less than 50% in both samples (48.98% in Norway and 49.23% in Germany), is a general evaluation of the energy transition pathway component in response to which the free association was generated. The most frequent subcategories are an evaluation of the component's importance (e.g., "that would matter a lot"; 10.83 and 13.63% for Norway and Germany, respectively) and an expression of affective valence (e.g., "that's a good thing"; 16.98%, 9.28%), followed by an expression of conflicting aspects, especially conflicting impacts (e.g., "good for the environment, but expensive"; 7.66%, 8.75%).

The second most frequent categories, by a notable margin, are requirements and consequences, accounting for 13.00–15.66% of the free associations. Requirement means that the participant expressed some requirement needed to make a component work. These requirements often referred to national policies (e.g., necessary regulation or infrastructure; 9.51%, 9.77%) or, less often, to something required of the citizens in a society (e.g., lifestyle changes; 4.83%, 3.51%). Consequences means that the free association referred to a consequence of the energy transition pathway component, most often to personal consequences such as financial costs (6.45%, 6.11%) or to environmental consequences (6.79%, 4.99%).

The least frequent type of association referred to the prevalence of a component (2.38%, 8.57%). The remnant category comprises associations where the respondent either merely rephrased the component (the most frequent remnant category; 11.02%, 10.01), or responses that fit none of the categories (2.68%, 2.28%) or don't know responses (5.02%, 1.41%).

Free Associations to Individual Energy Transition Pathway Components

In order to explore which types of free associations were generated with respect to which energy transition pathway component, we will consider only Level 1 codes from the coding scheme; the frequencies of the subcategories get too low when broken down across individual components. **Tables 3**, **4** show the percentage distributions of Level 1 code categories across components for the Norwegian and the German sample, respectively.

Again, the two samples show a very similar pattern; this is indicated numerically by a high correlation between the Norwegian and the German frequencies across the cells of the cross-tabulation of Level 1 codes with energy transition pathway components (i.e., across the cells of **Tables 3**, **4**), $r = 0.86$, $p < 0.001$.

The relationship between type of free association, as captured by Level 1 codes, and energy transition pathway components was explored by means of a correspondence analysis (Greenacre, 1984, 1993), which is depicted in **Figure 1**. Norwegian and German data were analyzed in a common analysis. The correspondence analysis provides a graphical representation of the association between Level 1 codes and

TABLE 3 | Distribution of Level 1 codes for all energy transition pathway components, Norwegian data (percent).

Energy transition pathway component	Level 1 codes				
	Requirements	**Consequences**	**Evaluation**	**Prevalence**	**Remnant**
appliances	0.72	0.72	2.26	0.04	0.26
ccs	0.15	0.11	1.32	0.00	2.42
compensate	0.19	0.45	1.92	0.00	1.43
e.cars	0.34	1.09	1.55	0.15	0.87
educ	1.36	0.04	2.15	0.04	0.42
engage	0.60	0.04	2.57	0.26	0.53
flights	0.68	0.60	2.42	0.11	0.19
houses	0.60	0.38	1.89	0.23	0.91
hydro	0.45	0.75	1.25	0.11	1.43
int.agree	1.09	0.15	2.23	0.00	0.53
int.trade	0.34	0.60	2.19	0.00	0.87
it	1.28	0.19	1.70	0.00	0.83
nuclear	0.11	0.53	2.45	0.00	0.91
pub.trans	1.66	0.79	1.17	0.19	0.19
regulate	0.49	0.38	2.26	0.04	0.83
saving	0.91	1.02	1.28	0.26	0.53
science	0.38	0.11	2.57	0.00	0.94
sharing	0.60	0.60	2.19	0.08	0.53
solar	0.45	0.42	1.96	0.15	1.02
subsidy	0.42	0.15	2.49	0.00	0.94
tax	0.68	0.45	2.34	0.08	0.45
urban	0.60	0.72	2.23	0.08	0.38
vegetar	0.75	1.06	1.66	0.23	0.30
walking	0.60	1.96	1.02	0.23	0.19
wind	0.19	0.94	1.92	0.11	0.83
Sum	**15.66**	**14.26**	**48.98**	**2.38**	**18.72**

*Percentages are based on n = 2650 responses. Abbreviations of energy transition pathway components are explained in **Table 1**.*

components. We selected the two-dimensional configuration for interpretation, yielding a cumulative principal inertia = 62.95% (see **Figure 1**). The distances among the components in this plot reflect how similar their distributions are across the Level 1 codes; components that are located close to each other have elicited a similar pattern of free associations. Likewise, the distances among Level 1 codes reflect resemblance of their distributions across components; Level 1 codes that are located close to each other have been generated in similar patterns in response to the energy transition pathway components.

The corresponding Level 1 codes for the Norwegian and the German sample are located in close proximity to each other. Thus, the energy transition pathway components generated similar patterns of free associations in the two samples; as was already indicated by the high correlation between the two samples concerning Level 1 code frequencies across components. In order to interpret which types of free associations were generated for which energy transition pathway components, imagine for each component a line that connects the component with the origin of the coordinate system. The projection of a Level 1 code onto this imagined line indicates how closely this type of free association relates to the component.

Evaluation is located close to the origin, which indicates that evaluations are not specific for any particular component; they are generated frequently across all components. Evaluations are the most typical free association overall. Components in the lower left quadrant, especially walking, generated associations concerning consequences and prevalence. The remnant category is most closely associated with carbon capture and storage and also with carbon compensation; especially in Norway also with hydropower. Public transportation, environmental education, and international agreements elicit associations that reflect that people see them as needing further requirements, particularly in the Norwegian sample. Energy efficient houses is the energy transition pathway component that is most closely at the origin of the configuration, which indicates that it is the component whose pattern of free associations is most similar to the average pattern across all components. This could imply that energy efficient houses are the most prototypical energy transition pathway component in laypeople's minds.

The horizontal dimension as a whole separates individual action on the left side (e.g., walking, vegetarian food, energy saving, public transport) from political-societal actions (in the upper half; e.g., science, subsidies, regulation) and technologies

TABLE 4 | Distribution of Level 1 codes for all energy transition pathway components, German data (percent).

Energy transition pathway component	Level 1 codes				
	Requirements	**Consequences**	**Evaluation**	**Prevalence**	**Remnant**
appliances	0.98	0.60	1.76	0.53	0.35
ccs	0.25	0.25	0.49	0.04	0.70
compensate	0.53	0.49	1.51	0.25	0.88
e.cars	0.42	0.60	2.35	0.35	0.67
educ	0.63	0.07	2.28	0.88	0.49
engage	0.63	0.39	1.83	0.88	0.32
flights	0.14	0.70	2.71	0.49	0.28
houses	0.56	0.74	2.04	0.35	0.46
hydro	0.35	0.53	2.00	0.25	0.74
int.agree	0.91	0.04	2.28	0.04	0.60
int.trade	0.35	0.25	1.86	0.00	0.49
it	0.35	0.56	2.35	0.18	0.63
nuclear	1.23	0.28	2.18	0.00	0.67
pub.trans	1.58	0.77	1.19	0.28	0.46
regulate	0.70	0.32	2.32	0.07	0.74
saving	1.02	0.46	1.37	0.95	0.56
science	0.70	0.25	1.79	0.11	1.23
sharing	0.39	0.91	2.11	0.67	0.32
solar	0.63	0.42	1.62	0.56	0.95
subsidy	0.63	0.25	2.35	0.14	0.42
tax	0.53	0.49	2.46	0.00	0.35
urban	0.49	0.49	2.57	0.11	0.46
vegetar	0.42	0.98	2.14	0.60	0.18
walking	0.60	1.44	1.41	0.77	0.18
wind	0.46	0.74	2.25	0.11	0.60
Sum	**15.50**	**13.00**	**49.23**	**8.57**	**13.70**

*Percentages are based on n = 2846 responses. Abbreviations of energy transition pathway components are explained in **Table 1**.*

(in the lower half; e.g., CCS, nuclear-, solar-, hydropower) on the right. Individual actions are associated with prevalence, consequences, and requirements (especially Norway); political-societal actions and technologies elicited primarily descriptive associations (the predominant remnant category) and also more evaluations than average (in Norway).

Evaluation of Free Associations

Participants' evaluations of their own free associations as either positive, neutral, or negative are summarized in **Table 5**. Concerning the sample sizes, note that the Norwegian sample has no missing values; all participants provided a free association to each and every energy transition pathway component, and also evaluated each and every of their free associations. In the German sample, in contrast, there are missing values in both the free associations and their evaluations. We assume that this difference was brought about by the different data collection methodologies, computer-based versus paper-and-pencil questionnaire, that were applied in the two samples.

A graphical depiction of the average evaluations of the free associations for each energy transition pathway component is shown in **Figure 2**. The plot illustrates that the Norwegian and German mean evaluations across the components are highly correlated, $r = 0.85$, $p < 0.001$. Nuclear power, carbon capture and storage, avoid long flights, and international trade with carbon offsets are the components that elicited the most negatively evaluated free associations in both samples. Free associations to climate compensation such as buying carbon offsets for flight tickets, to international agreements, and to taxes generated slightly positively evaluated free associations in both countries. Looking at the top four components with the most positively evaluated free associations in each sample, we find that *educ*, *walking*, *science*, and *hydro* are the top components for the Norwegian sample, and that *walking*, *sharing*, *saving*, and *appliances* are the top components for the German sample. Whereas Norwegians seem to have favorable associations toward general political strategies (*educ*, *science*) and, maybe not surprisingly given its prevalence in the country, the use of hydropower, Germans are more favorable toward individual activities such as participation in the sharing economy (e.g., car pooling) or saving energy (e.g., turning down the heating).

If the free associations for a component are evaluated equally in both samples, the component lies on the diagonal. This is the case only for a few of the components. There is a general tendency of Norwegian participants to evaluate their free associations to the components more positively than German participants

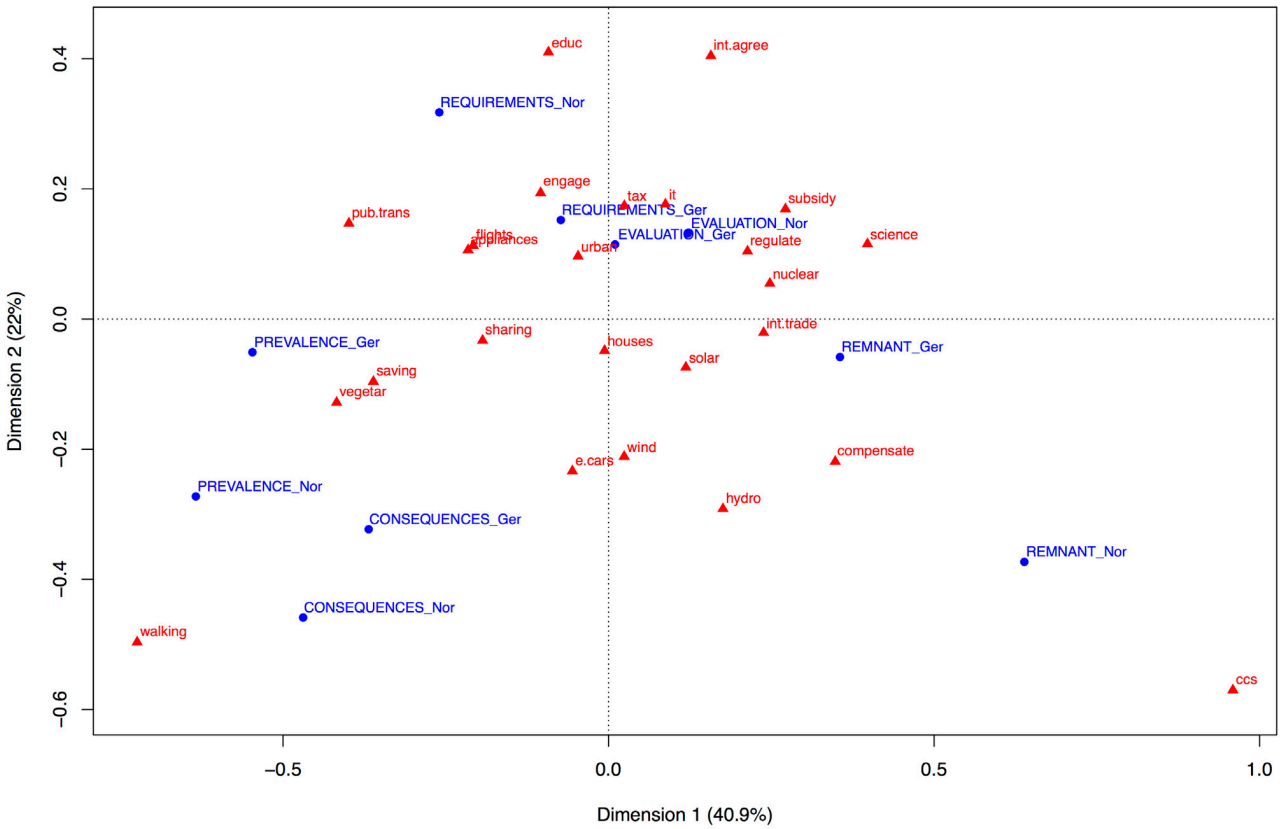

FIGURE 1 | Correspondence analysis plot of Level 1 code categories cross-tabulated with energy transition pathway components; common analysis of Norwegian and German data. Energy transition pathway components are labeled in lower-case letters and red font. Level 1 codes are labeled in blue font and upper-case letters; labels of Level 1 codes for the Norwegian sample end on "_Nor", those for the German sample on "_Ger". See **Table 1** for labels of the energy transition pathway components.

do. Exceptions are climate compensations, sharing economy, and energy saving, whose free associations are more positively evaluated in the German than in the Norwegian sample.

DISCUSSION

This study explored which mental images and affective evaluations laypeople associate with various energy transition pathway components, as have been described in the beginning of this paper. A remarkable result is the similarity between Norwegian and German participants despite differences in the socio-political contexts and traditions concerning energy. Considering studies showing that social representations are at least partly shaped by the socio-cultural context (Smith and Joffe, 2013) and that affective images are learned from experience (Leiserowitz, 2006; Lorenzoni et al., 2006), we expected that the energy transition pathway components presented would be associated with divergent affective images in the two study samples. This turned out to not be the case; the overall distributions of the free associations across the categories of our coding scheme were virtually identical. Both samples also associated very similar patterns of mental images with the different energy transition pathway components, as illustrated in the correspondence analysis. The fact that average evaluations of the free associations for the individual components were highly correlated provides further grounds to establish that the mental representation of the energy transition pathway components were very similar among Norwegian and German participants.

We drew quite homogeneous samples; namely, university students at both locations. While this homogeneity facilitates comparisons, it may have minimized variation in social and educational backgrounds. Some of the differences that exist between Norway and Germany concerning these countries' socio-political energy contexts are presumably experienced more intensely in other socio-economic and professional groups than university students. A recent study showed, for instance, that employees in the Norwegian oil and gas industry tend to show less support for policies that restrict the production of fossil fuels than the larger population (Tvinnereim and Ivarsflaten, 2016). It cannot be ruled out that the choice of samples may have precluded larger variations in affective images to show up; still, the consistency of the results across samples is suggestive and raises confidence that the results are not merely random but may be descriptive of the underlying, albeit homogeneous, population of university students.

TABLE 5 | Average evaluation of free associations per energy transition pathway component.

	Norwegian sample					German sample				
Energy transition pathway component	***n***	***M***	***SD***	**95%CI lower limit**	**95%CI upper limit**	***n***	***M***	***SD***	**95%CI lower limit**	**95%CI upper limit**
appliances	106	0.75	0.49	0.66	0.85	110	0.75	0.53	0.66	0.85
ccs	106	−0.04	0.60	−0.15	0.08	54	−0.67	0.48	−0.79	−0.54
compensate	106	0.01	0.79	−0.14	0.16	102	0.15	0.84	−0.02	0.31
e.cars	106	0.70	0.59	0.59	0.81	114	0.35	0.81	0.20	0.50
educ	106	0.84	0.46	0.75	0.93	114	0.59	0.76	0.45	0.73
engage	106	0.55	0.66	0.42	0.67	62	0.29	0.88	0.07	0.51
flights	106	−0.23	0.78	−0.38	−0.08	78	−0.35	0.83	−0.53	−0.16
houses	106	0.66	0.57	0.55	0.77	112	0.64	0.67	0.52	0.77
hydro	106	0.82	0.43	0.74	0.90	57	0.30	0.78	0.10	0.50
int.agree	106	0.35	0.77	0.20	0.50	69	−0.16	0.87	−0.36	0.05
int.trade	106	0.02	0.85	−0.14	0.18	94	−0.56	0.60	−0.68	−0.44
it	106	0.59	0.57	0.49	0.70	108	0.40	0.77	0.25	0.54
nuclear	106	−0.54	0.71	−0.67	−0.40	113	−0.58	0.75	−0.71	−0.44
pub.trans	106	0.54	0.76	0.39	0.68	114	0.54	0.73	0.41	0.68
regulate	106	0.54	0.72	0.40	0.67	109	0.24	0.87	0.08	0.40
saving	106	0.52	0.75	0.38	0.66	114	0.77	0.53	0.67	0.87
science	106	0.83	0.42	0.75	0.91	109	0.72	0.49	0.62	0.81
sharing	106	0.56	0.60	0.44	0.67	114	0.82	0.50	0.73	0.92
solar	106	0.70	0.57	0.59	0.81	59	0.56	0.73	0.37	0.74
subsidy	106	0.75	0.47	0.66	0.85	103	0.60	0.72	0.46	0.74
tax	106	0.27	0.75	0.13	0.42	66	0.05	0.85	−0.16	0.25
urban	106	0.62	0.62	0.50	0.74	63	0.29	0.81	0.09	0.49
vegetar	106	0.54	0.71	0.40	0.67	114	0.55	0.67	0.43	0.67
walking	106	0.83	0.49	0.74	0.92	114	0.83	0.48	0.75	0.92
wind	106	0.70	0.57	0.59	0.81	64	0.45	0.85	0.24	0.66

Abbreviations of energy transition pathway components are explained in ***Table 1****.*

The most frequent type of free association was a general evaluation of the energy transition pathway component in response to which the association was generated. This most often referred to the level of importance assigned to each component, or to an affective evaluation of the component as something good or bad. Less often did the participants express that the component entails conflicting aspects, positive and negative, mostly referring to conflicting good and bad impacts. Other (less frequent) evaluations concerned the feasibility or effectiveness of the component or expressed some skepticism, for example concerning the trustworthiness of involved actors as well as their intentions. At a large interval from these evaluations, the second most frequent types of association are requirements needed to make a component work (usually some requirement at the level of national policies or individual actions), and consequences, typically personal consequences affecting finances or comfort or environmental consequences. About equally frequent as requirements and consequences were mere descriptions of the component or some aspect of it.

Rather than mentioning any detail that would hint at an elaborate mental representation of the components, the free associations generated by the participants suggest that knowledge about the presented pathway components is rather vague and unspecific. This matches prior studies indicating that people often hold a general pollution model according to which anything that pollutes the environment is also bad for the climate (Bord et al., 1998). People then tend to apply a corresponding good environmental practice heuristic assuming that all actions that are good for the environment will also help mitigate climate change (Read et al., 1994). Our results suggest that energy transition is processed on a similarly general and unspecific level.

Nevertheless, people express clear evaluations of the components as good or bad, important or unimportant, effective or ineffective. One might assume that strong evaluations are based on knowledge; that people become more opposed or supportive of an issue, the more they know about it. The positive relationship between knowledge and polarization that has been found in the climate change literature supports this assumption (Kahan et al., 2012; Guber, 2013), though it has been argued that communicating scientific facts can neutralize polarization (van der Linden et al., 2017). What our results seem to indicate, however, is that relatively strong evaluations are triggered in the absence of a correspondingly strong knowledge base. A similar disconnect between knowledge and evaluation has been documented for the public perception of genetic engineering (Pfister et al., 2000). In terms of dual systems theories (e.g., Kahneman, 2011), energy transition pathways seem to be processed in an automatic and intuitive rather

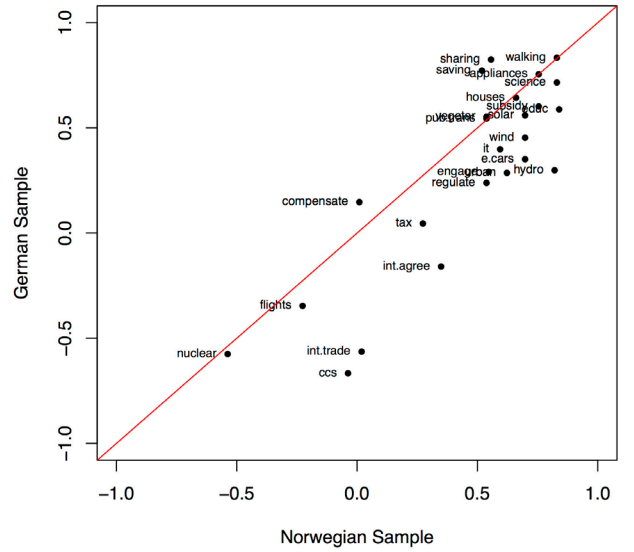

FIGURE 2 | Scatterplot of participants' evaluations of their own free associations, averaged across participants for each energy transition pathway component. Means for the Norwegian sample are plotted along the horizontal axis, those of the German sample along the vertical axis. See **Table 1** for labels of the energy transition pathway components.

than a deliberative manner. That requirements are among the most frequent associations suggests that people hold a systemic view of energy transition, where one action is not sufficient, but the conjunction of many elements is required to bring about positive effects. If attempting to characterize the overall mental model of energy transition that emerges from our data, there appears to be a vague and intuitive understanding of a systemic interaction of many components, with the most relevant consequences being those for individual citizens and the environment. Similar results were found in an international qualitative study on social representations of climate and energy (Fischer et al., 2012), which found across five European countries the people see such issues not as isolated phenomena but contextualize them in a broader general framework of energy-related issues.

When considering which types of association are generated in response to which energy transition pathway components, there seems to be a divide between individual actions, on one side, and socio-political actions and technologies, on the other side. This may indicate that people recognize the collective nature of energy transition, in addition to seeing individual behaviors as embedded in the societal context. It seems that with respect to individual actions people are most preoccupied with whether or not other people will join in and adopt the behavior (prevalence), what the personal consequences of the behavior are, whether the behavior is effective (environmental consequences), and that individual behavior depends on contextual conditions (requirements), such as the availability of public transport or other infrastructures. These three types of action seem to reflect a fundamental distinction in laypeople's thinking about energy transition (for similar findings, see Böhm et al., in press).

By far the most negatively evaluated energy transition pathway component was nuclear power, whereas renewables such as solar-, wind-, and hydropower were located at the positive pole of evaluation. This resembles the pattern reported in another study that employed an affective image analysis with an explicit focus on energy sources (Truelove, 2012). Other large-scale survey research has also found that nuclear power tends to be evaluated more negatively than renewable energy sources (Steentjes et al., 2017), even though support for nuclear power as a climate mitigation strategy can show large variation across countries (Doran et al., 2018). One reason for why renewables are evaluated rather positively could be that people associate these energy sources with the future (Fischer et al., 2012). Also very positively evaluated were associations to individual actions such as walking and cycling, policies such as subsidies and regulation, and science. These are again options that have been found to be positively regarded by the public in more comprehensive survey research (e.g., Bostrom et al., 2012). While we did not measure support for these components, other studies found a positive relationship between affective images and behavioral measures such as policy support (Leiserowitz, 2006; Smith and Leiserowitz, 2012; Truelove, 2012) and thus suggest that the positively evaluated components would also be likely to be supported.

An obvious limitation of this study concerns the small samples. Both samples were convenience samples, drawn from accessible pools of university students that cannot serve for drawing inferences regarding the wider public in each of the two countries. Although we do not claim to provide an international comparison, the results are very similar across the two countries, which suggests some stability. We therefore hope that our results have heuristic value and can guide future research in the study of the mental representation of energy transition pathways. We believe that the contents of the free associations as identified in our coding scheme give a good reflection of people's concerns with respect to different energy transition pathways. We also believe that the cognitive structure of the components that emerged from the patterns of free associations connected to them and from the affective evaluation of these associations are worthy of further exploration in systematic survey and experimental research. The labor intense coding of the free associations precluded the use of larger samples in the present study. However, the emergence of new computer-based automated linguistic analysis techniques, such as structural topic models, may open up new avenues for collecting and analyzing free responses in large-scale surveys (see e.g., Tvinnereim and Fløttum, 2015).

ETHICS STATEMENT

This empirical study complied with the Norwegian Social Science Data Services (NSD) privacy regulations and the ethical principles of research by the National Committee for Research Ethics in the Social Sciences and the Humanities (NESH). Formal approval from NSD was

not sought, as the collected data material was anonymous, see www.nsd.uib.no/ personvernombud/en/notify/index.html.

DATA AVAILABILITY

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

AUTHOR CONTRIBUTIONS

GB and RD contributed conception and design of the study. GB and H-RP performed the statistical analyses. GB wrote the first draft of the manuscript. GB, RD, and H-RP wrote sections of the manuscript. All authors contributed to manuscript revision, read and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2018.01904/full#supplementary-material

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Relation Between Awe and Environmentalism: The Role of Social Dominance Orientation

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The present study attempts to explore the effect of awe on environmentalism and the mediating role of social dominance orientation in generating this effect. In Study 1, a series of questionnaires were used to investigate the correlation among trait awe, social dominance orientation, and ecological behavior. Results demonstrated that, while trait awe was positively correlated with ecological behavior, it was partially mediated by social dominance orientation. In follow-up studies, two priming experiments were conducted to test the causal relationship and the psychological mechanisms between awe and environmentalism. Results revealed that inductions of awe (relative to various control states) decreased participants' social dominance orientation, which in turn partially enhanced their willingness to make personal sacrifices for the environment (Study 2), and intentions to engage in pro-environmental behavior (Study 3). This study not only corroborates the critical role of awe in promoting environmentalism, but also highlights the importance of social dominance orientation in explaining why awe increases environmentalism. Implications and future directions were also discussed.

Keywords: awe, self-transcendent emotion, social dominance orientation, environmentalism, environmental engagement

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INTRODUCTION

Environmental deterioration is one of the most troubling problems of humanity. Various environmental problems, such as air pollution, water shortage, land degradation, global warming and biodiversity decline, pose severe threats to humankind's sustainable development. Many of these problems are due to human behavior (Vlek and Steg, 2007; Steg and Vlek, 2009). Therefore, changing people's environmentally harmful behavior and exploring methods to encourage increased engagement in activities that protect the environment have become vital tasks.

Psychological science helps solve current environmental problems by identifying the main drivers and barriers of environmental protection behaviors (e.g., Onwezen et al., 2013; Gifford, 2014; De Leeuw et al., 2015; Zelenski et al., 2015). For example, recent studies have shown that self-conscious emotions (e.g., pride, guilt) are important factors that can potentially influence environmental behaviors (Ferguson and Branscombe, 2010; Harth et al., 2013; Onwezen et al., 2013; Bissing-Olson et al., 2016). However, the role that awe, an important self-transcendent emotion, plays in environmental behavior change is unclear. A Chinese saying states that "keep awe in mind,

and you will stay out of improper behavior." Awe dissuades people from focusing on immediate self-interests and encourages them to consider the welfare of others and that of the broader external environment (Rudd et al., 2012; Piff et al., 2015; Prade and Saroglou, 2016; Bai et al., 2017). A growing body of evidence suggests that awe considerably influences the promotion of prosocial behaviors (Rudd et al., 2012; Piff et al., 2015; Prade and Saroglou, 2016). We therefore posit that this relationship may be extended to environmentalism.

Environmentalism is widely defined as concern for the environment and support for environment-friendly behaviors, intentions, and attitudes (Milfont et al., 2013). Many researchers have discussed environmentalism as a multifaceted construct (Jia et al., 2015; Milfont et al., 2017; Stanley et al., 2017). For example, Milfont et al. (2017) proposed to study environmentalism by investigating environmental citizenship actions, pro-environmental behaviors, and donations to environmental organizations. Jia et al. (2015) measured environmentalism through environmental involvement, environmental identity, and environmental attitudes. In the present study, we utilized three indicators, namely, ecological behavior, environmental sacrifice, and pro-environmental intention, to assess the multifaceted construct of environmentalism. Research has indicated that environmentalists possess a propensity to act pro-socially (Kaiser and Byrka, 2011). Thus, the purpose of this study is to elucidate the effect of awe on environmentalism. In other words, the current study aims to determine whether awe influences environmentalism and the possible psychological mechanism that underlies this relationship.

Awe and Environmentalism

Awe is an emotion that arises when people encounter something so strikingly vast that it defies their current knowledge structures and provokes a need to update their mental schemas (Keltner and Haidt, 2003). Awe involves positively valenced feelings, such as wonder, amazement, appreciation, and admiration (Keltner and Haidt, 2003; Piff et al., 2015). Although awe experiences are tinged with fear, awe is typically considered a positive prosocial emotion (Gordon et al., 2016; Stellar et al., 2017). Various stimuli, such as natural wonders, beautiful art, extraordinary human accomplishments, intellectual epiphany, and religious experiences, can evoke the intense emotional response of awe (Keltner and Haidt, 2003; Shiota et al., 2007; Saroglou et al., 2008).

Awe is referred to a self-transcendent emotion, and it reflects self-transcendence values, encourages individuals to transcend their momentary desires, diminishes the emphasis on the individual self and self-interest, and shifts the attention of individuals toward the needs and concerns of others (Piff et al., 2015; Stellar et al., 2017, 2018). Research has indicated that self-transcendent emotions are other-oriented and work as powerful proximal determinants of prosocial action (Stellar et al., 2017). Ample evidence suggests that positive awe experiences in daily life and in the laboratory enhance the welfare of others and motivate people to engage in various forms of prosocial behaviors (Rudd et al., 2012; Piff et al., 2015; Prade and Saroglou, 2016). For example, in Rudd et al. (2012) study, participants who experienced awe were more willing to volunteer their time to help others compared with those who did not experience awe. Piff et al. (2015) conducted a series of studies and discovered that dispositional tendencies to experience awe were positively associated with increased generosity in an economic game, and experimentally inducing awe makes participants endorse ethical decision-making and helping behaviors and results in numerous prosocial values. In addition, some evidence shows that awe effectively reduces antisocial behaviors, such as aggressiveness (Yang et al., 2016). The subjective experience of awe is consistent with the notion of self-transcendence (Shiota et al., 2014). Prior research has demonstrated that the endorsement of self-transcendence values encourages people to engage in pro-environmental behaviors (Cheung et al., 2014; Jia et al., 2017). Therefore, given the preceding discussion and the generally prosocial nature of environmentalism, awe is expected to be positively related with environmentalism.

The Mediating Role of Social Dominance Orientation

The reason a positive relationship may exist between awe and environmentalism remains unclear. In this study, we focus on the role of social dominance orientation in explaining the relationship between awe and environmentalism. Specifically, we suggest that awe may encourage people to engage in pro-environmental actions because it can reduce their dominance over nature.

The belief that humans can dominate over nature is at the heart of current environmental problems (Milfont et al., 2013, 2017). Human dominance over nature is conceptually related to social dominance theory, which focuses on individuals' attitudes about hierarchical and unequal relations between groups in society (Pratto et al., 1994; Sidanius and Pratto, 1999). Social dominance orientation is the core individual-level variable in social dominance theory, which reflects individuals' preference for group-based hierarchy and inequality (Pratto et al., 1994). Individuals with high social dominance orientation are concerned with group or interpersonal dominance rather than general or individual equality (Pratto et al., 1994; Son Hing et al., 2007). Research has shown that social dominance orientation is closely related to various group-based attitudes and behaviors (Sidanius et al., 1994; Kteily et al., 2011, 2012). For example, social dominance orientation can reduce generosity in allocating resources to outgroups (Sidanius et al., 1994) and increase prejudice and discrimination against ethnic and racial outgroups (Kteily et al., 2011).

Although the focus of social dominance orientation is on a generalized orientation toward unequal and dominant/subordinate relations between humans, previous research has indicated that the theoretical scope of social dominance theory can be extended to understand person–environment relations (Milfont et al., 2013, 2017; Milfont and Sibley, 2014; Panno et al., 2017; Carrus et al., 2018). That is, the preference for hierarchy and inequality in the social world can translate into the preference for hierarchy in the natural world, with humans hierarchically dominating over nature (Milfont et al., 2017). Existing literature has demonstrated that

social dominance orientation is inimical to pro-environmental attitudes and behaviors (Milfont and Duckitt, 2010; Milfont et al., 2013; Panno et al., 2017; Stanley et al., 2017). Individuals with high social dominance orientation show less concern about environmental issues (Milfont et al., 2013), are less supportive of environmental policies (Pratto et al., 1994) and more supportive of environmental inequality (Jackson et al., 2013), prioritize business gains over environmental protection, and exploit the environment in unsustainable ways (Son Hing et al., 2007). The need to maintain and enforce group-based hierarchical social structures causes them to dominate over the environment (Milfont and Sibley, 2014). In summary, social dominance orientation is negatively associated with environmentalism.

We now discuss the relationship between awe and social dominance orientation. In our view, several reasons support the notion that awe may be negatively associated with social dominance orientation. Evidence shows that social dominance orientation is positively related to self-enhancement values, which concern the enrichment of the self through the obtainment of achievement, power, and pleasure, and negatively related to self-transcendence values, which transcend the focus on the self and prioritize the welfare of the society, the maintenance of peace, justness, and protection of nature (Duriez and van Hiel, 2002). Conversely, awe, a self-transcendent positive emotion, is negatively related with self-enhancement values (Boer and Fischer, 2013). Thus, a consistent pattern emerges in which self-enhancement values have opposite associations with awe and social dominance orientation.

Research has also shown that awe can increase humility and decrease entitlement (Piff et al., 2015; Stellar et al., 2018). People exposed to awe-inducing stimuli are likely to feel a sense of self-diminishment, insignificance, and smallness (Shiota et al., 2007; Van Cappellen and Saroglou, 2012; Piff et al., 2015; Bai et al., 2017; Stellar et al., 2018). Conversely, individuals high in social dominance orientation often attach more value to superiority and dominance than to egalitarianism, feel superior and exhibit less concern for others (Lippa and Arad, 1999; Duckitt, 2001; Son Hing et al., 2007; Ho et al., 2015). A final piece of evidence supporting the notion that awe and social dominance orientation can be negatively related originates from research on pro-sociality. As previously mentioned, awe has been proven to increase ethical decision making, generosity, helpfulness, and prosocial values (Piff et al., 2015; Prade and Saroglou, 2016). Social dominance orientation operates in the opposite direction. Research has demonstrated that social dominance orientation causes people to make unethical decisions and exploit others for self-interest gains (Son Hing et al., 2007; Milfont et al., 2013). Accordingly, we propose that awe is negatively associated with social dominance orientation, and individuals with high levels of awe are more likely to exhibit low levels of social dominance orientation.

Overall, based on this hypothesized relationship between awe and social dominance orientation, and together with prior research showing that social dominance orientation is negatively associated with environmentalism, we assume that social dominance orientation may play a mediating role in the relationship between awe and environmentalism.

Overview of the Current Study

On the basis of the aforementioned arguments and evidence, we established the following hypotheses:

Hypothesis 1: Awe is positively associated with environmentalism; and
Hypothesis 2: Social dominance orientation mediates the relationship between awe and environmentalism.

We conducted three sub-studies in China to test Hypotheses 1 and 2. Different environmentalism measures were considered to provide a powerful test for the two hypotheses. In Study 1, questionnaires were used to determine whether trait tendencies to experience awe predict ecological behavior and to examine whether social dominance orientation is a potential mediator between them. In follow-up studies, different priming experiments, including narrative recall (Study 2) and watching compelling video clips (Study 3), were conducted to further determine whether participants' experience of awe increases their willingness to sacrifice for the environment (Study 2) and intentions to engage in pro-environmental behavior (Study 3) by reducing their social dominance orientation.

STUDY 1 CORRELATIONAL RESEARCH

Study 1 has two objectives. First, we explored whether trait awe is positively correlated with ecological behavior. Second, we tested whether social dominance orientation can mediate the effect of trait awe on ecological behavior.

Methods

Participants

A total of approximately 600 Chinese adults were initially recruited from various organizations in China in a variety of industries including education, health care, business management, and information technology. Of the 556 participants who finally completed the questionnaires, 27 records were excluded from the analysis because of quality control checks (e.g., the same response was given across most of the survey), and the valid sample comprised 529 Chinese adults (304 female and 225 male; M_{age} = 29.55 years, SD = 8.89 years; age range: 18–56 years). Participants varied considerably in terms of education levels (11.90% with high school education or less, 18.90% with a college degree, 53.70% with a bachelor degree, and 15.50% with a post-graduate degree).

Procedure

All participants signed an informed consent form prior to the study, and then they were asked to fill out a series of self-report questionnaires within 25 min. Several questionnaires were translated from English to Chinese and back-translated for accuracy. After they completed the questionnaires, the participants were required to provide demographic information. Upon completion, they were thanked and debriefed. All procedures were reviewed and approved by the ethics board of Shanghai Normal University.

Measures

Trait awe

The dispositional positive emotion scale is widely used to assess trait awe (Shiota et al., 2006). In the current study, the Chinese version of the trait awe inventory was used to assess participants' trait awe (Zhao et al., 2018, unpublished). This inventory consisted of 21 items rated on five-point Likert scale (1 = *strongly disagree*, 5 = *strongly agree*). One sample item is "I feel wonder almost every day." Higher scores reflected that individual has a higher level of trait awe. The Cronbach's α was 0.86.

Social dominance orientation

Social dominance orientation was measured using the eight-item version of the social dominance orientation scale (Ho et al., 2015). One sample item is "Some groups of people are simply inferior to other groups." Each item was answered on a seven-point Likert scale (1 = *strongly disagree*, 7 = *strongly agree*), with higher scores indicating higher levels of social dominance orientation. The Cronbach's α was 0.75.

Ecological behavior

The eight-item version of the ecological behavior scale was adopted to evaluate the frequency with which participants engaged in each of eight specific environmental activities, such as "looked for ways to reuse things" within the last year (Milfont and Duckitt, 2004). Items were rated on a five-point Likert scale (1 = *never*, 5 = *very often*), with higher scores reflecting more ecological behaviors. The Cronbach's α was 0.81.

Control variables

We included gender, age, education, and social desirability as control variables that potentially influenced environmentalism (Dunlap et al., 2000; Zelezny et al., 2000; Kollmuss and Agyeman, 2002; Milfont and Duckitt, 2010), in order to isolate the independent effects of awe, social dominance orientation on environmentalism in the following analyses.

Social desirability was assessed using the shortened social desirability scale. Six items were randomly sampled from the original social desirability scale (Schuessler et al., 1978). One sample item is "I find that I can help others in many ways." Participants rated each item on a 6-point Likert scale (1 = *strongly disagree*, 6 = *strongly agree*), and higher scores represented a higher level of social desirability. The Cronbach's α was 0.72.

Results

Preliminary Analyses

Table 1 presents the means, standard deviations and correlations of all variables. In keeping with Hypothesis 1, trait awe is negatively related with social dominance orientation ($r = -0.38$, $p < 0.001$), and positively associated with ecological behavior ($r = 0.41$, $p < 0.001$). Additionally, social dominance orientation is negatively related to ecological behavior ($r = -0.41$, $p < 0.001$).

The Effect of Awe on Ecological Behavior

We examined Hypothesis 1 that awe positively predicts ecological behavior. The control variables were inputted, followed by trait awe, into a hierarchical regression analysis. The results showed that trait awe ($\beta = 0.40$, $SE = 0.04$, $F(5,523) = 23.30$, $p < 0.001$, 95% CI [0.32, 0.48]) is positively related to ecological behavior. Thus, Hypothesis 1 is supported.

Mediation via Social Dominance Orientation

We tested whether social dominance orientation mediates the effect of trait awe on ecological behavior. Model 4 of Hayes' PROCESS ($N = 5000$) was utilized (Hayes, 2013). As illustrated in **Figure 1**, after adjusting for the control variables, the results lend credence to Hypothesis 3 that the link between trait awe and ecological behavior is mediated by social dominance orientation ($\beta_{indirect} = 0.11$, $SE = 0.02$, $F(6,522) = 29.84$, $p < 0.001$, 95% CI [0.08, 0.15]). Hypothesis 2 is thus verified.

Discussion

These results support Hypotheses 1 and 2, suggesting that individuals' trait tendencies to experience awe affect their social dominance orientation, which in turn partially mediates the effects of trait awe on ecological behavior. However, the correlational nature of Study 1 constrains the interpretability. Therefore, in Studies 2 to 3, we experimentally manipulated awe to test its causal effects on environmentalism and examine the mediation model proposed in Hypothesis 2.

STUDY 2 CAUSAL RESEARCH

Study 2 was also has two objectives. First, this study examined the causal relationship between awe and environmental sacrifice and determined whether feeling awe, relative to feeling happiness,

TABLE 1 | Descriptive statistics and correlations between measured variables.

Variables	*M*	*SD*	1	2	3	4	5	6	7
(1) Gender	0.57	0.50	1						
(2) Age	29.55	8.89	0.06	1					
(3) Education	1.73	0.87	−0.03	0.08	1				
(4) Social desirability	3.99	0.69	0.15***	0.09*	0.08	1			
(5) Trait awe	3.93	0.43	0.04	0.04	0.10*	0.10*	1		
(6) Social dominance orientation	3.04	0.94	−0.08	−0.04	−0.05	−0.08	−0.38***	1	
(7) Ecological behavior	3.43	0.67	0.08	0.01	0.11*	0.09*	0.41***	-0.41***	1

*Gender was dummy coded as 0 = male and 1 = female. Education was coded as 0 = high school education or less, 1 = college degree, 2 = bachelor degree and 3 = post-graduate degree. *p < 0.05; ***p < 0.001.*

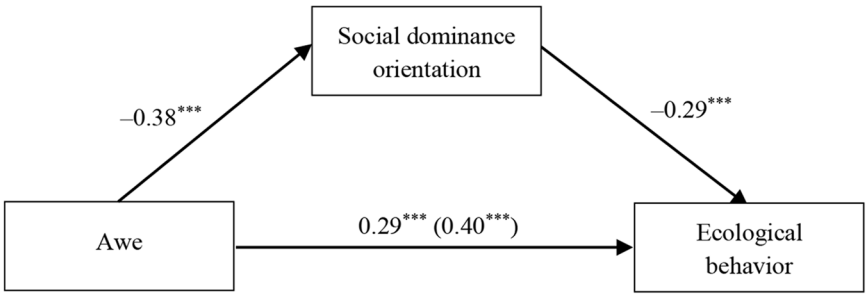

FIGURE 1 | Mediation model for Study 1. ***$p < 0.001$.

increases participants' willingness to make personal sacrifices for the environment. Second, we attempted to replicate the mediation effect of social dominance orientation on the relationship between awe and environmentalism. We selected happiness as the comparison emotion because both emotions are positive and can broaden individuals' perspective (Fredrickson, 2001), but they differ in whether perceptual vastness and need for accommodation are experienced or not (Shiota et al., 2007). Moreover, happiness has been used as a positive emotion with which to contrast the effects of awe in previous research (Rudd et al., 2012; Jiang et al., 2018).

Methods

Participants

There were 179 Chinese adults were recruited via Qualtrics to complete an online survey in exchange for monetary compensation. The final valid sample comprised 168 participants (M_{age} = 23.57 years, SD = 4.67 years; 115 female and 53 male), and 11 participants were excluded from the analysis for failing to complete the manipulation correctly (i.e., wrote something unrelated to experiencing the corresponding emotion). Participants varied considerably in terms of education levels (0.60% with high school education or less, 13.70% with a college degree, 70.20% with a bachelor degree, and 15.50% with a post-graduate degree).

Procedure

All participants were required to sign an informed consent form prior to the study, and all procedures were ensured approval by the ethics board. This study includes four parts. First, a between-subject design was adopted, and participants were randomly assigned to one of three narrative recall conditions, namely, awe condition (N = 57), happiness condition (N = 55), and neutral condition (N = 56). In each condition, participants were asked to recall and describe a narrative regarding a personal experience that is an elicitor of the corresponding emotion. This method has been proven to be a well-validated priming technique to induce specific emotions (Piff et al., 2015). The specific instructions were as follows (adopted from Piff et al., 2015; Bai et al., 2017).

Awe condition

When experiencing awe, people usually feel like they are in the presence of something so great that their current understanding of the world, their surroundings, or themselves is challenged in some way. Please think about a particular time, fairly recently, when you encountered a natural scene that made you feel awe. This might have been a glorious sunset, a magnificent landscape, or any other time you were in a natural setting that you felt was amazing.

Happiness condition

When experiencing happiness, people usually feel delighted by something that satisfies their inner needs and desires. Please think about a particular time, fairly recently, when you felt happy. This might have been attending a birthday party, joining a happy family party, having a nice time with friends, or any other time you encountered something that made you feel happy.

Neutral condition

Please take a few minutes to think about something you did fairly recently. This might have been riding a bike, studying for a test, or any other thing that happened during your day.

All participants in each condition were asked to write at least eight sentences (at least 100 words) describing their experiences: what happened, when it happened, who was involved, what they saw, and the accompanying emotions and thoughts. In a post-study review of the written sentences, all participants were ensured to follow the instructions.

Second, participants were required to report their current emotion states and the accompanying sense of self-diminishment.

Third, to reduce participants' potential demand characteristics, they were asked to complete unrelated items pertaining to their attitudes about sport and entertainment news consisting of a filler task.

Lastly, participants completed measures of social dominance orientation, environmental sacrifice, and demographic information in sequence. Upon completion, they were thanked and debriefed.

Measures

Current emotion state

Participants reported the degree to which they currently felt each of seven emotions using single items (1 = *not at all*, 7 = *extremely*): anger, disgust, sadness, fear, pride, happiness, and awe (Piff et al., 2015).

Social dominance orientation

Six items were used in this study to access participants' social dominance orientation. The short four-item version of the social dominance orientation scale was adopted to evaluate participants' social dominance orientation in a general sense (Pratto et al., 2013). One sample item is "Group equality should be our ideal." Additionally, two items about human dominance over nature were also adopted in our specific setting (Milfont and Duckitt, 2010). One sample item is "Human beings were created or evolved to dominate the rest of nature." Each item was rated on a seven-point Likert scale (1 = *strongly disagree*, 7 = *strongly agree*), with higher scores indicating higher levels of social dominance orientation. The Cronbach's α was 0.73.

Environmental Sacrifice

Two environmental sacrifice items were used to assess the willingness of participants to make self-sacrifices for environmental protection. The items were "are you willing to make sacrifices to your standard of living (e.g., accept higher prices, drive less, and conserve energy) to protect the natural environment?" and "are you willing to change your daily routine to protect the environment?" (Liu and Sibley, 2012). Participants rated these items on a seven-point Likert scale (1 = *definitely no*, 7 = *definitely yes*). The Cronbach's α was 0.81.

Control variables

In addition to gender, age, and education, we also included self-diminishment as control variable that potentially influenced the relationship between awe and pro-sociality (Piff et al., 2015), so as to clarify the mediating role of social dominance orientation in the relationship between awe and environmentalism in the following analyses.

Self-diminishment was measured with one item (i.e., I feel small or insignificant) taken from Piff et al. (2015). Participants rated this item on a seven-point Likert scale (1 = *strongly disagree*, 7 = *strongly agree*), and higher scores represented a higher level of self-diminishment.

Results

Manipulation Check

We conducted a multivariate analysis of variance to access the effectiveness of emotion priming manipulation. The results demonstrated that the three groups varied in terms of awe, $F(2,165) = 64.69$, $p < 0.001$, $\eta_p^2 = 0.44$, and happiness, $F(2,165) = 51.15$, $p < 0.001$, $\eta_p^2 = 0.38$. Participants in the awe condition ($M = 5.26$, $SD = 1.04$) reported higher levels of awe than those in the happiness ($M = 3.29$, $SD = 1.29$) and neutral conditions ($M = 3.04$, $SD = 1.08$; awe vs. happiness: 95% CI for mean difference [1.55, 2.40], $p < 0.001$; awe vs. neutral: 95% CI for mean difference [1.80, 2.65], $p < 0.001$), whereas participants in the happiness condition ($M = 5.27$, $SD = 1.21$) reported higher levels of happiness than those in the awe ($M = 3.40$, $SD = 0.92$) and neutral conditions ($M = 3.09$, $SD = 1.49$; happiness vs. awe: 95% CI for mean difference [1.41, 2.33], $p < 0.001$; happiness vs. neutral: 95% CI for mean difference [1.72, 2.64], $p < 0.001$). No differences were observed in anger, disgust, sadness, fear, or pride across the conditions ($ps > 0.14$, $\eta_p^2 < 0.023$). These results suggests that our manipulation of the target emotions was successful.

The Effect of Awe on Environmental Sacrifice

A one-way analysis of variance (ANOVA) demonstrated that a significant difference in environmental sacrifice across the three conditions, $F(2,165) = 16.56$, $p < 0.001$, $\eta_p^2 = 0.17$. *Post hoc* analysis revealed that participants in the awe condition ($M = 5.65$, $SD = 0.96$) reported higher levels of environmental sacrifice than those in the happiness ($M = 5.01$, $SD = 0.85$) and neutral conditions ($M = 4.74$, $SD = 0.76$; awe vs. happiness: 95% CI for mean difference [0.32, 0.96], $p < 0.001$; awe vs. neutral: 95% CI for mean difference [0.59, 1.23], $p < 0.001$); the difference between happiness and neutral conditions was not significant (95% CI for mean difference [−0.06, 0.59], $p = 0.10$). As expected, feeling awe increased participants' willingness to make self-sacrifices for the environment, but feeling happiness did not. Therefore, Hypothesis 1 is supported.

The Effect of Awe on Social Dominance Orientation

A one-way ANOVA showed that there was a significant main effect for emotion manipulations on social dominance orientation, $F(2,165) = 9.07$, $p < 0.001$, $\eta_p^2 = 0.10$. *Post hoc* analysis revealed that participants in the awe condition ($M = 2.86$, $SD = 0.58$) reported lower levels of social dominance orientation than those in the happiness ($M = 3.33$, $SD = 0.87$) and neutral conditions ($M = 3.45$, $SD = 0.86$; awe vs. happiness: 95% CI for mean difference [−0.76, −0.18], $p < 0.01$; awe vs. neutral: 95% CI for mean difference [−0.88, −0.30], $p < 0.001$); the difference between happiness and neutral conditions was not significant (95% CI for mean difference [−0.40, 0.18], $p = 0.45$). Also as expected, feeling awe reduced participants' social dominance orientation.

Mediation via Social Dominance Orientation

As reported above, the awe condition led to significant increments in environmental sacrifice and decrements in social dominance orientation. Social dominance orientation was negatively related to environmental sacrifice, $r = -0.46$, $p < 0.001$. Therefore, a mediation analysis was conducted to test whether the awe induction increased participants' willingness to sacrifice for the environment through reduced social dominance orientation. Model 4 of Hayes' PROCESS ($N = 5000$) was also employed (Hayes, 2013). As illustrated in **Figure 2**, after controlling for gender, age, education, and self-diminishment, the positive association between awe and environmental sacrifice is reduced significantly when social dominance orientation is included in the model. Bootstrapping results indicate that the link between awe and environmental sacrifice is mediated by social dominance orientation ($\beta_{indirect} = 0.11$, $SE = 0.04$, $F(6,161) = 10.15$, $p < 0.001$, 95% CI [0.05, 0.20]). Thus, Hypothesis 2 is verified. These findings are similar to those of Study 1.

Discussion

Study 2 provided the first experimental piece of evidence for the prediction that awe is positively associated with environmental

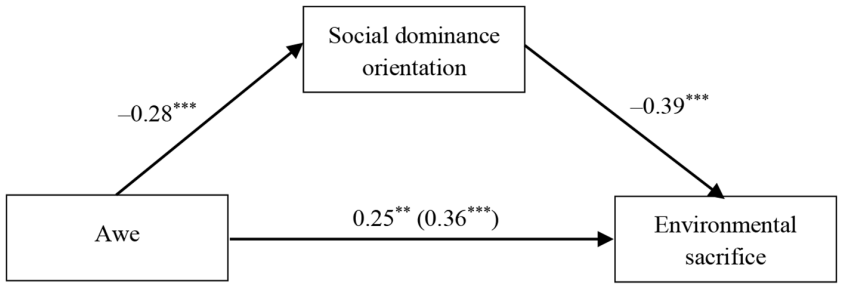

FIGURE 2 | Mediation model for Study 2. $^{**}p < 0.01$; $^{***}p < 0.001$.

sacrifice. Recalling a time when participants experienced awe, relative to a happiness or a neutral condition, decreased their social dominance orientation, which in turn increased their willingness to make self-sacrifices for the environment. The findings of Study 2 are similar to those of Study 1.

However, several limitations exist. First, Study 2 depended on participants' retrospective self-reports, which may reflect their memories of the events but not the awe experience itself (Piff et al., 2015), and this may have influenced their subsequent attitudes. Therefore, Study 3 was designed to broaden and expand upon our previous mediational results by using more tightly controlled experiments in the laboratory. Second, previous research has indicated that nature exposure may influence people's environmental behaviors (Zelenski et al., 2015). However, our manipulation of awe in Study 2 primarily focused on the nature elicitor, which may corrupt the specificity effect of awe to a certain extent. Meanwhile, other elicitors of awe aside from nature were also present (Keltner and Haidt, 2003). The idea that the awe experienced in non-nature environments can also increase environmentalism remains unexamined. In light of these concerns, Study 3 was conducted to further clarify the independent effect of awe on environmentalism and ascertain whether nonnature-based awe (e.g., social elicitors) triggers environmentalism or not.

STUDY 3 CAUSAL RESEARCH

In Study 3, awe was induced by exposing participants to awe-inspiring video clips. In addition to a nature-based awe condition (i.e., appreciation of extraordinary nature scenes), we chose mundane nature (e.g., grass) as a comparison condition to help us rule out the possibility that the effect of awe on environmentalism is reducible to mere nature exposure. Mundane natural environments are probably among the most familiar types of nature for people (Joye and Bolderdijk, 2015). Moreover, we verified the generalizability of our findings by incorporating an awe experience induced by social elicitors (i.e., wonder at childbirth). The fourth video was neutral and acted as the control. These conditions allowed us to further test whether awe increases environmentalism and determine whether social dominance orientation mediates the effect of awe on environmentalism.

Methods

Participants

Participants were 187 from a public university in Shanghai, China. The final valid sample comprised 174 students (M_{age} = 21.71 years, SD = 2.32 years; 105 female and 69 male), and 13 participants were excluded from the analysis: seven for failing to complete the questionnaires (i.e., substantial missing data), and six for failing to complete the manipulation correctly (i.e., wrote something unrelated to the corresponding video). Participants varied considerably in terms of majors, such as law, sociology, psychology, and management.

Procedure

All participants were required to sign a written informed consent form prior to the study, and all procedures were ensured approval by the ethics board. This study includes four parts. First, participants were seated in front of computers in private cubicles, asked to put on headphones, and were randomly assigned to one of four video clip conditions: social awe condition (n = 44), natural awe condition (n = 45), mundane nature condition (n = 43), and neutral condition (n = 42). The video clips have been validated in previous research (Saroglou et al., 2008; Piff et al., 2015; Davis, 2016).

Social awe condition

A 5-min childbirth video clip depicting the image of the fetus on a sonogram and the birth of the baby in a maternity hospital, followed by the mother holding her infant in the first minutes after childbirth.

Natural awe condition

A 5-min nature video clip from the BBC's Planet Earth series, composed primarily of mountains, waterfalls, oceans, forests, deserts, space, and canyons, accompanied by uplifting music.

Mundane nature condition

A 5-min nature video clip depicting the grass swaying in the wind, accompanied by nature sounds (crickets chirping).

Neutral condition

A 5-min neutral video clip depicting an individual introducing each stage of beer brewing.

After watching the corresponding video, participants were required to write at least five sentences describing the video content and summarizing its gist. They were then asked if there

was anything else the video would like to tell us. The description not only can help to enhance the priming effect, but also can be used to check whether participants carefully watched the experiment video or not.

Second, participants were asked to complete the questions on current emotion states and the sense of self-diminishment used in Study 2 to check the specific states induced by the video clips.

Third, participants completed a distracting task to minimize potential demand characteristics. They were requested to search for 10 hidden neutral words in grids of letters (Prade and Saroglou, 2016).

Lastly, participants completed measures of social dominance orientation, pro-environmental intention, and demographic information in sequence. Upon completion, they were thanked and debriefed.

Measures

Current emotion state

Participants' current emotion state was assessed using the seven feeling single items as in Study 2 (Piff et al., 2015).

Social dominance orientation

Social dominance orientation was assessed as in Study 2. The Cronbach's α was 0.74.

Pro-environmental intention

Pro-environmental intention was assessed by asking how likely it is that participants would buy organic local food, buy less non-essential stuff, buy fewer new things, recycle things, and eat fewer meat meals in the future (Fielding and Head, 2012). All items were rated on a seven-point Likert scale (1 = *very unlikely*, 7 = *very likely*), with higher scores indicating higher levels of pro-environmental intention. The Cronbach's α was 0.79.

Self-diminishment

Self-diminishment was assessed as in Study 2.

Results

Manipulation Check

Similar to Study 2, multivariate ANOVA (MANOVA) was conducted to further test the effectivity of emotion priming manipulation. The awe priming manipulation was successful, $F(3,170) = 49.90$, $p < 0.001$, $\eta_p^2 = 0.47$. Participants in the social ($M = 5.70$, $SD = 1.09$) and natural ($M = 5.42$, $SD = 1.16$) awe conditions reported higher levels of awe than those in the mundane nature condition ($M = 3.35$, $SD = 1.29$; social awe vs. mundane nature: 95% CI for mean difference [1.83, 2.88], $p < 0.001$; natural awe vs. mundane nature: 95% CI for mean difference [1.55, 2.59], $p < 0.001$) and neutral condition ($M = 3.21$, $SD = 1.39$; social awe vs. neutral: 95% CI for mean difference [1.96, 3.02], $p < 0.001$; natural awe vs. neutral: 95% CI for mean difference [1.69, 2.73], $p < 0.001$). The social and natural awe conditions produced similarly high levels of awe (95% CI for mean difference [−0.23, 0.80], $p = 0.28$), and the difference between mundane nature and neutral conditions was not significant (95% CI for mean difference [−0.39, 0.66], $p = 0.62$). Furthermore, the ratings of other emotions, such as anger, disgust, sadness, fear, pride, or happiness did not differ across conditions ($ps > 0.25$, $\eta_p^2 < 0.024$). These results suggest that our manipulation effectively evoked the target emotion.

The Effect of Awe on Pro-environmental Intention

A one-way ANOVA showed that there was a significant main effect for emotion manipulations on participants' pro-environmental intention, $F(3,170) = 8.93$, $p < 0.001$, $\eta_p^2 = 0.14$. *Post hoc* analysis revealed that participants' pro-environmental intention was higher in the social ($M = 5.70$, $SD = 0.73$) and natural ($M = 5.60$, $SD = 0.75$) awe conditions compared with the mundane nature condition ($M = 5.02$, $SD = 0.90$; social awe vs. mundane nature: 95% CI for mean difference [0.31, 1.04], $p < 0.001$; natural awe vs. mundane nature: 95% CI for mean difference [0.21, 0.94], $p < 0.01$) and neutral condition ($M = 4.92$, $SD = 1.06$; social awe vs. neutral: 95% CI for mean difference [0.40, 1.14], $p < 0.001$; natural awe vs. neutral: 95% CI for mean difference [0.31, 1.04], $p < 0.001$). In addition, the difference between social and natural awe conditions (95% CI for mean difference [−0.27, 0.46], $p = 0.60$), and that between mundane nature and neutral conditions (95% CI for mean difference [−0.27, 0.47], $p = 0.60$) were both not significant. As expected, feeling awe increased participants' pro-environmental intention. Therefore, Hypothesis 1 is again supported.

The Effect of Awe on Social Dominance Orientation

A one-way ANOVA demonstrated that the three types of emotion priming exerted a significant effect on social dominance orientation, $F(3,170) = 4.47$, $p < 0.01$, $\eta_p^2 = 0.07$. *Post hoc* analysis revealed that participants' social dominance orientation was lower in the social ($M = 2.73$, $SD = 0.91$) and natural ($M = 2.69$, $SD = 0.96$) awe conditions compared with the mundane nature condition ($M = 3.17$, $SD = 0.72$; social awe vs. mundane nature: 95% CI for mean difference [−0.83, −0.06], $p < 0.05$; natural awe vs. mundane nature: 95% CI for mean difference [−0.86, −0.09], $p < 0.05$) and neutral condition ($M = 3.26$, $SD = 1.03$; social awe vs. neutral: 95% CI for mean difference [−0.92, −0.14], $p < 0.01$; natural awe vs. neutral: 95% CI for mean difference [−0.95, −0.18], $p < 0.01$). In addition, the difference between social and natural awe conditions (95% CI for mean difference [−0.35, 0.42], $p = 0.86$), and that between mundane nature and neutral conditions (95% CI for mean difference [−0.48, 0.30], $p = 0.66$) were both not significant. Also as expected, feeling awe reduced participants' social dominance orientation.

Mediation via Social Dominance Orientation

As reported above, the experience of awe led to lower levels of social dominance orientation and greater levels of pro-environmental intention compared with the mundane nature and neutral condition. Furthermore, social dominance orientation was negatively associated with participants' pro-environmental intention, $r = -0.46$, $p < 0.001$. Thus, a mediation analysis was conducted to examine whether the awe conditions influenced participants' pro-environmental intention through social dominance orientation. Model 4 of Hayes' PROCESS ($N = 5000$) was also utilized (Hayes, 2013). As in Study 2, we clarified the mediating role of social dominance orientation by controlling for gender, age, and self-diminishment.

As illustrated in **Figure 3**, the positive association between awe and pro-environmental intention is reduced significantly when social dominance orientation is included in the model. Bootstrapping results indicate that the link between awe and pro-environmental intention is mediated by social dominance orientation ($\beta_{indirect} = 0.12$, $SE = 0.04$, $F(5,168) = 14.04$, $p < 0.001$, 95% CI [0.05, 0.21]). Thus, Hypothesis 2 is again verified.

Discussion

The findings of Study 3 advance our understanding of the relationship between awe and environmentalism in several ways. First, eliciting awe using awe-inspiring natural scenes increased participants' pro-environmental intention in contrast to mundane nature and neutral condition. This helps confirm the unique effects of awe on environmentalism and rule out the influence of mere nature exposure. Second, eliciting awe using nature-based or social elicitors similarly enhanced participants' pro-environmental intention, indicating that the effect of awe on environmentalism is not limited to experiences in extraordinary nature scenes. Moreover, the awe conditions also lowered participants' social dominance orientation, which partially mediated the effect of awe on environmentalism. Taken together, these findings lend support to our two hypotheses.

GENERAL DISCUSSION

The current study extends preliminary research on environmental behavior by providing correlational and experimental evidence to explore the relationship between awe and environmentalism. More importantly, we examined why awe enhances environmentalism. Across the three sub-studies, our investigation yielded consistent evidence that awe encourages environmentalism partially because it can reduce individuals' social dominance orientation. Awe ameliorates the pervading belief in human hierarchical dominance over nature, which in turn increases the likelihood to act on environmental issues.

The results of the three sub-studies indicated that awe positively predicts environmentalism, which is in line with Hypothesis 1. Specifically, in Study 1, individuals with a stronger awe disposition demonstrated more ecological behaviors. In Study 2, participants who recalled an awe experience reported higher willingness to make self-sacrifices for the environment than their counterparts in the happiness and neutral conditions. The effect on environmental sacrifice was specific to awe and was not the result of happiness. This result is highly consistent with those of prior research indicating that the moral consequences of awe are specific to awe and not the effect of other positive emotions, such as amusement (Rudd et al., 2012; Piff et al., 2015). In Study 3, compared to mundane nature and neutral condition, awe experiences elicited by nature-based or social stimuli both increased participants' pro-environmental intention. The significant effect of awe on environmentalism induced by the childbirth video allowed us to generalize our findings to nonnature-based awe experiences to some extent. These results are in accordance with previous evidence reporting a positive relationship between awe and prosocial behaviors (Rudd et al., 2012; Piff et al., 2015; Prade and Saroglou, 2016), and highlight that awe can broadly influence environmentalism.

The effect of awe on environmentalism was partially explained by social dominance orientation and thus supports Hypothesis 2. The experimentally induced awe decreased individuals' social dominance orientation, which in turn encouraged the individuals to express high willingness to sacrifice for the environment (Study 2) and exhibit high intentions to engage in pro-environmental behaviors (Study 3). Awe induction weakened individuals' views of human dominance over nature, which indicates a relative diminishment of the sense of entitlement and superiority, paralleling prior research (Piff et al., 2015; Stellar et al., 2017, 2018). Moreover, the lower the individuals' social dominance orientation was, the higher they endorsed environmentalism. These findings dovetail with prior empirical work showing that social dominance orientation is a reliable negative predictor of environmentalism (Milfont et al., 2013, 2017). Awe is a self-transcendent emotion that can decrease individuals' sense of superiority and importance, and shift their focus away from personal interests toward the concerns of others and the broader natural environment (Piff et al., 2015; Stellar et al., 2017, 2018). Humans always believe that they can dominate over nature; however, awe experiences make them realize the smallness and insignificance of the self and the equality between human and nature. In other words, awe can preclude people's desire to dominate over nature. Consequently, this irrational hierarchical belief is ameliorated, and actions to protect the environment

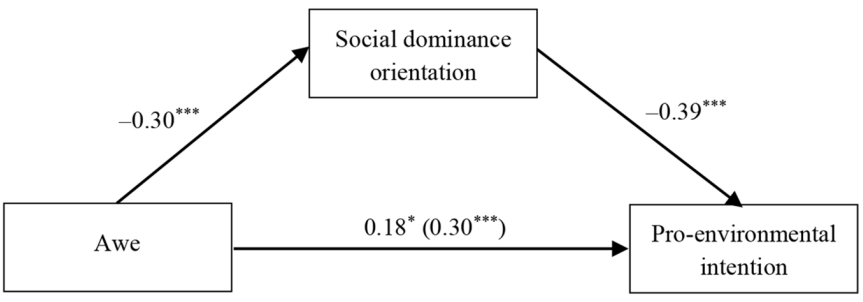

FIGURE 3 | Mediation model for Study 3. *$p < 0.05$; ***$p < 0.001$.

are increased correspondingly. The positive association between awe and environmentalism is rooted in a highly egalitarian view of the world. Taken together, these results suggests that social dominance orientation plays an important role in explaining the relationship between awe and environmentalism. Notably, the present study again provides empirical evidence that social dominance theory can be extended to understand the relations between humans and the natural environment (Milfont et al., 2013, 2017; Milfont and Sibley, 2014; Panno et al., 2017).

Implications

The present research has several theoretical and practical implications on environmental protection. First, the results concur with the view that awe is a potent predictor of genuine concern for the environment. Our research examined the social function of awe and extended the study of awe to environmentalism. Meanwhile, understanding the role of awe in shaping individuals' environmental behaviors contributes to scholarly knowledge on the predictors of environmentalism. Second, very few studies have identified social dominance orientation as an underlying psychological mechanism between awe and environmentalism. The mediating role of social dominance orientation provides an insightful explanation of why individuals highly endorse environmentalism after awe is enhanced. The present study not only improved the research on the social dominance theory, but also verified that social dominance theory can explain the relationships among social groups and between humans and natural environments.

At a practical level, apart from seeking macro-level solutions (e.g., sign the international Paris climate agreement) (Hale, 2016), government spare no efforts to encourage people to behave in highly environmentally sustainable ways. However, no one-size-fits-all solution to environmental problems exists. Our study suggests that the elicitation of awe may encourage people to engage in behaviors that protect the environment. For example, in addition to the external stimulus that is characterized by vastness and need for accommodation (Keltner and Haidt, 2003), loving-kindness meditation can also help evoke individuals' awe experiences (Stell and Farsides, 2016). Moreover, the negative link between social dominance orientation and environmentalism indicates that directing interventions aimed at reducing social dominance orientation is also a useful mean to address environmental issues. For example, in addition to developing a highly egalitarian view of the world through mindfulness training (Panno et al., 2017), building an equal and environmentally oriented society may attenuate the belief of human dominance over nature and may cushion the negative effect of social dominance orientation on environmentalism (Milfont et al., 2017).

Limitations and Future Directions

This work has several limitations, which could also serve as future research directions. First, although we manipulated the experimental procedures as rigorously as possible, the use of conventional methods for inducing awe in experimental settings (i.e., narrative recall and watching awe-inspiring videos) may limit the external and ecological validity of the study to some extent. Hence, aside from field study, virtual reality may be a promising technique to elicit awe effectively in subsequent research because of its capability to enhance the intensity of emotional states by providing participants with a sense of "presence" (Chirico et al., 2018). Second, our study primarily manipulated positively valenced varieties of awe, although this has been proven true in many experimental studies on awe (e.g., Shiota et al., 2007; Van Cappellen and Saroglou, 2012; Prade and Saroglou, 2016). Nonetheless, the negative experience of awe elicited by threatening stimuli (e.g., tornadoes and volcanoes) was ignored. This situation brings about an interesting question: does negative awe exert a similar effect on promoting environmentalism as that exerted by positive awe? Future research could explore the effect of negatively valenced varieties of awe on various environmental behaviors. Third, social dominance orientation served as a partial mediator in this study, which suggests the existence of other potential mediators (e.g., personal norms). The path from awe to environmentalism may be complex and needs further research. Lastly, the moderator variables between awe and environmentalism should be explored further to uncover the boundary conditions, which may help us elucidate the degree to which awe experiences increase environmentalism.

CONCLUSION

The present research contributes to the growing literature on emotions in the field of environmental psychology and enriches the exploration of the social function of awe. The three sub-studies not only clarify the crucial role of awe in enhancing environmentalism, but also support the role of social dominance orientation as a mediator in this relationship. Specifically, this study emphasizes the importance of awe in attenuating people's desire to dominate over nature. The findings are novel and theoretically and practically insightful, and they create a valuable foundation for future research.

AUTHOR CONTRIBUTIONS

HuZ designed the study and wrote the manuscript. HuZ and HeZ acquired and analyzed the data. HeZ, YX, JL, and WH provided instruction and advice for the study. The manuscript was approved by all authors for publication.

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SUPPLEMENTARY MATERIAL

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Using Card Sorting to Explore the Mental Representation of Energy Transition Pathways Among Laypeople

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Meeting international emission targets will require major changes in the energy system. This paper addresses the public perception of different pathways to energy transition, and their mental representation in particular. A study is reported that employed card sorting to explore how laypeople categorize possible pathway components with respect to their perceived similarity (Norwegian sample, n = 61; German sample, n = 71). Data sets that were obtained by this method were subjected to multidimensional scaling and cluster analysis. Results for both samples consistently indicate that people differentiate components located at the individual level (e.g., vegetarian food, avoid long flights, walking and cycling), components located at the societal level (e.g., taxes, regulations, urban planning), and components concerned with technological solutions (e.g., hydropower, wind farms, solar panels). These results give reason to assume that laypeople from Norway and Germany share a multifaceted understanding of energy transition, yet some differences between samples were present with regard to the substructure of the individual level category. Future research can build on the present results to explore the subjective meanings of these structures, possibly identifying barriers to public engagement with energy transition.

Keywords: mental representation, climate change, energy transition, card sorting, perceived similarity, cross-national, Norway, Germany

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INTRODUCTION

There is a large scientific consensus that human activities contribute to global climate change, most notably through carbon dioxide emissions (IPCC, 2014). It follows from this scientific insight that the decarbonization of society is paramount in order to meet international targets for limiting global temperature increases (UNFCCC, 2015). One prerequisite for meeting these targets are fundamental changes in energy systems, for instance through increasing the market share of renewables (European Commission, 2011). This paper focuses on exploring the public perception of pathways connected to this energy transition, and on people's

mental representation of such pathways particularly[1]. It has been argued in the psychological literature that studying mental representations can help ensure that interventions designed to implement changes in energy use are communicated and presented in ways that are meaningful for the target audience (Gabe-Thomas et al., 2016).

Böhm et al. (in press) reported findings to suggest that pathways to energy transition are distinguishable according to the level at which they are located: individual actions, societal actions, and technologies. Individual actions are energy-related behaviors performed by individuals, for example at home or at the workplace. Examples are turning down the heat or traveling by public transport rather than by car. Societal actions operate at a larger scale such as through legislation introduced by local or national governments. Typical examples are regulatory policies implemented with the intention to foster low-carbon products and business practices. Technologies refer to the availability and usage of energy sources such as renewables (e.g., hydro, solar, wind). The distinction of these levels has proven useful in several respects. For example, they have emerged as different categories of risks that differ in their public perception and acceptability as well as in the degree of controversy they elicit in public discourse (Fox-Glassman and Weber, 2016; Bassarak et al., 2017). Individual versus collective have also been used to describe levels of action that might differ in their perceived efficacy in tackling problems such as climate change (Lubell, 2002; Koletsou and Mancy, 2011). And preferences for climate action seem to be related to different worldviews such as individualism, egalitarianism or hierarchy (Jones, 2014).

One distinction that has proven fruitful in the psychological literature concerns the type of action that is undertaken, namely curtailment versus efficiency (Gardner and Stern, 2008; Dietz et al., 2009). Curtailment actions reduce energy consumption by cutting back on desired or habitual levels of activity, such as by turning down the heating, usually implying some degree of restriction and limitation of consumption or convenience. Efficiency actions improve the efficiency of energy behaviors without reducing the level of activity and without imposing substantial restrictions. An example are investments in improved housing insulation. Böhm et al. (in press) suggested that this distinction could furthermore prove useful in classifying energy-related actions beyond individuals and households. Examples are transport policies aimed at reducing carbon intensive commuting (e.g., restrictions on inner-city car use, i.e., curtailment action at the societal level), as well as legislation implemented for raising the attractiveness of possible alternatives (e.g., subsidies for electric cars; i.e., efficiency action at the societal level). On a related note, technologies can contribute to making the energy sector less reliant on fossil fuels (e.g., through renewables; i.e., curtailment action at the technological level), whilst other technologies can provide means to cope with carbon emissions that stem from the burning of fossil fuels (e.g., carbon capture and storage; i.e., efficiency action at the technological level).

Baird and Brier (1981) highlighted the role of similarity judgments when laypeople think about energy consumption. Participants were placed in front of paper cards showing a large variety of small-scale (e.g., toaster) and large-scale (e.g., airplane) items. Instructions were to first group the items in whatever manner they wished, and then to rank the items according to their energy requirements. It turned out that the outcome from these two tasks differed in that participants only categorized items alongside their respective energy requirements after explicit instruction. When participants could group the items without explicit instruction, they rather chose to build categories around similarities in function and size. Physical volume was further the dominating feature when participants ranked household appliances based on their anticipated energy consumption per hour. Gabe-Thomas et al. (2016) used a similar method for exploring views about energy consumption among households in another context. Participants received a selection of household appliances with instructions to categorize these appliances according to their similarity and/or dissimilarity. Three separate categories emerged from the participants' sorting of the appliances. Two of these categories could be interpreted as reflecting a shared meaning, one comprised activities and the other one comprised locations. The appliances in the remaining category shared no dominant theme other than that they were seemingly unrelated to the appliances assigned to the other categories. Other studies have shown that laypeople emphasize curtailment before efficiency when ranking energy devices (or activities) according to their saving potential (Kempton et al., 1985; Attari et al., 2010).

The research presented in this paper utilizes a methodological approach that is reminiscent of the studies conducted by Baird and Brier (1981) and Gabe-Thomas et al. (2016). Rather than directing the participants toward concepts considered relevant by experts, this approach applies card sorting to gain knowledge about how laypeople themselves think about energy issues. Having people judge the similarity between objects is a non-directive way of eliciting mental representations about some issue of interest (Rosenberg and Kim, 1975). This approach leaves it up to the participants how they define similarity and which features of the objects they consider relevant (Barnett, 2008). The general strategy is to derive a structure of the objects from the sorting and then to interpret this structure by trying to identify the underlying criteria that people relied upon throughout the process. The derived structure can be dimensional (yielded by, for example, multidimensional scaling techniques) or categorical (yielded, for example, by cluster analysis). The interpretation of the structure can be enriched by comparing it with data material from relevant reference groups (Canter et al., 1985) and/or by taking into account additional information such as respondents' knowledge about the concepts under investigation (Barnett, 2008).

In the following, we will report on an empirical study that explored how laypeople think about pathways to change current energy systems into more sustainable ones, for instance by reducing carbon emissions resulting from energy harvesting and

[1]The term energy transition describes "a change in the state of an energy system as opposed to a change in an individual energy technology or fuel source" (Grubler et al., 2016, p. 18).

use. A card sorting task was used to gain insights into the mental representation of actions, policies, and/or technologies that may contribute to this energy transition. Any single measure to promote change in energy systems will hereafter be referred to as an *energy transition pathway component*[2]. The aim was (i) to investigate how laypeople structure different components in terms of their perceived similarity, and, if possible, (ii) to identify shared patterns underlying these structures. Participants were recruited in Norway and Germany, which are countries shown to differ alongside their current energy profiles (Arnold et al., 2016) and public energy preferences (Steentjes et al., 2017). This allowed us to explore similarities and/or differences in the mental representation of energy transition pathways in a cross-national context.

MATERIALS AND METHODS

Participants

Data were collected between November 2016 and August 2017 at university campuses in Norway and Germany. Participants were invited to take part in the study through e-mail lists, flyers distributed in cafeterias, announcements in classes, and word-of-mouth advertizing. Everybody who took part in the study was offered either a gift voucher worth NOK50 (Norway) or a monetary incentive of €10 (Germany). Each participant was informed about the general aim of the study, that their responses would be anonymous, and that they could withdraw from their participation at any time. Informed consent was assumed through completion of the card sorting task.

In Norway, n = 61 students participated in the study, most of which (n = 49) were enrolled in the "professional studies in psychology" programme. The remaining participants (n = 12) studied work and organizational psychology, comparative politics, constructional and environmental engineering, data technology, design, energy engineering, history, law, product development and production, sociology, or web design. Participants were between 19 and 34 years of age (M = 22.97, SD = 2.66), and n = 48 were female. Only a minor portion of the participants indicated that they had heard the term "energy transition" before (n = 16).

In Germany, the sample consisted of n = 71 students, thereof n = 61 were enrolled in the "business psychology" programme. The remaining participants (n = 10) studied information law, social work, or sociology. The age range was from 19 to 53 years (M = 24.27, SD = 6.82), and n = 44 reported to be female. All participants indicated to have heard the term "energy transition" before (n = 71).

Materials

A selection of 25 different energy transition pathway components was presented on paperboard cards, each card featuring one component; an overview is provided in **Table 1**. The components resemble those used in a study by Böhm et al. (2018) who based their selection upon desk research, interviews with laypeople (i.e., university students), as well as interviews with experts (i.e., climate and political scientists). Each component belonged to one of three implementation levels (i.e., individual actions, societal actions or technologies) and one of two types of energy-related activities (i.e., efficiency or curtailment) described earlier in the introduction.

Procedure

Participants were invited individually to facilities at the local psychology department. Upon arrival, they were welcomed and seated by a research assistant who introduced the general topic of the study (i.e., the study is about different actions related to energy transition). A definition of the term "energy transition" was provided as well (i.e., long-term changes in energy systems that aim at contributing to a more sustainable society).

The paperboard cards featuring the pathway components were randomly distributed on a table in front of the participants, who were instructed to sort the cards into piles on the basis of perceived similarity. Cards featuring pathway components that were perceived to be similar were to be piled together. Participants were told they should form at least two and a maximum of 25 piles of cards, according to what they considered appropriate. They could leave out cards that they did not want to sort.

After the sorting task, participants were asked what criteria they had used for piling the cards (open response format). The sorting of each participant was documented on a paper form along with the sorting criteria that were mentioned by the participants. Cards that were piled together were assigned the same number. A unique number was used for each pile of cards; the number "0" was assigned to those cards that were not sorted by the participants. The form also provided space for filling in socio-demographic information (i.e., age, gender, and study program), whether participants had heard the term "energy transition" before (yes or no), and possible concluding remarks. Each participant was thanked by the research assistant for taking part in the study and received the voucher or monetary incentive. On average, individual participation took 15 min.

Analyses

From the sorting that was done by the participants, we derived a measure of similarity of the energy transition pathway components by counting for each pair of components how many participants had placed the pair in one mutual pile and by that had expressed that they considered the two components of the pair similar. Thus, we obtained two similarity matrices of the pathway components, one for the Norwegian and the other for the German sample. The rows as well as the columns of each similarity matrix correspond to the pathway components. Each cell represents a pair of components and contains the number of participants who had placed the pair in a mutual pile. This pairwise similarity measure can range from zero (none of the participants regarded the two components in a pair as similar) to the sample size (all participants regarded the two components in a pair as similar). For technical reasons,

[2]This is different to an *energy transition pathway*, which can be described as "a combination of steps that are taken with the aim of reducing carbon emissions and improving the sustainability of energy use and production"(Böhm et al., 2018, p. 2).

TABLE 1 | List of energy transition pathway components included in the materials.

Label	Energy transition pathway component (translation)	Norwegian sample (original)	German sample (original)
appliances	Energy efficient home appliances (e.g., light bulbs)	Energieffektive husholdningsartikler (f.eks. sparepærer)	Energieeffiziente Haushaltsartikel (z.B. Glühbirnen)
offsets	Climate compensation (e.g., when booking flights)	Klimakvoter	Klimakompensationen (z.B. beim Flüge buchen)
share	Sharing economy (e.g., carpooling)	Delingsøkonomi (f.eks. samkjøring)	Sharing economy (z.B. Fahrgemeinschaften)
vegetarian	Vegetarian food	Vegetarmat	Vegetarisches Essen
no-fly	Avoid long flights	Unngå lange flyreiser	Vermeidung langer Flugreisen
cycle	Walking and cycling	Gå og sykle	Gehen und Rad fahren
political	Political engagement	Politisk engasjement	Politisches Engagement
saving	Energy saving (e.g., turn down heating)	Energisparing (f.eks. skru ned varmen)	Energiesparen (z.B. Heizung herunterdrehen)
science	Science	Vitenskap	Wissenschaft
subsidies	Subsidies (e.g., for renewable energy)	Subsidier (f.eks. for fornybar energi)	Subventionen (z.B. für erneuerbare Energien)
int-agree	International agreements (e.g., on carbon emissions)	Internasjonale avtaler (f.eks. på karbonutslipp)	Internationale Abmachungen (z.B. für Kohlenstoffemissionen)
public-trans	Public transportation	Offentlig transport	Öffentlicher Transport
int-marked	International trade with carbon offsets	Internasjonalt karbonmarked	Internationaler Handel mit Kohlenstoffemissionen
educ	Environmental education (e.g., in school, at work)	Miljøundervisning	Umweltbildung (z.B. in der Schule, bei der Arbeit)
tax	Taxes (e.g., on carbon intensive goods and services)	Skatter (f.eks. på karbonintensive varer og tjenester)	Steuern (z.B. auf kohlenstoffintensive Waren und Dienstleistungen)
regulate	Regulations (e.g., laws to reduce sales of fossil fuel cars)	Reguleringer (f.eks. lover for å redusere salg av fossile biler)	Regulierungen (z.B. Gesetze, um den Verkauf benzin- und dieselbetriebener Autos zu reduzieren)
urban-dev	Urban planning (e.g., car free zones)	Byutvikling (f.eks. bilfri soner)	Stadtplanung (z.B. autofreie Zonen)
nuclear	Nuclear power	Atomkraft	Atomkraft
wind	Wind farms	Vindmølleparker	Windparks
solar	Solar panels	Solcellepaneler	Solarmodule
e-car	Electric cars	Elektriske biler	Elektroautos
water	Hydropower	Vannkraft	Wasserkraft
IT	Information technologies (e.g., monitor home energy use)	Informasjonsteknologier (f.eks. monitorering av energibruk i hjemmet)	Informationstechnologien (z.B. Überwachung des Energieverbrauchs im Haus)
buildings	Energy efficient houses (e.g., geothermal heating)	Energieffektive hus (f.eks. jordvarme)	Energieeffiziente Häuser (z.B. geothermale Wärme)
CCS	Carbon capture and storage	Karbonfangst og -lagring	Kohlenstoffabscheidung und -lagerung

Paperboard cards concerned with climate compensation [offsets] and environmental education [educ] included an example in parentheses in the German sample but not in the Norwegian sample.

the similarities were converted to dissimilarities simply by subtracting the count from the sample size, so that higher numbers now represented greater dissimilarity. This resulted in one dissimilarity matrix for the Norwegian sample and one for the German sample.

The analyses will be reported in the following order: First, we explore the dimensional structure of the dissimilarities by means of a multidimensional scaling analysis (MDS), which represents the empirical dissimilarities as Euclidean distances in a low-dimensional space. This is done separately for the Norwegian and the German data, followed by a discussion of their correspondence. Second, we explore the categorical structure of the dissimilarities by means of a cluster analysis, again analysing the Norwegian and German data separately. Third, we describe an analysis of the open response data provided by participants to report on their subjective criteria employed when completing the sorting task.

All analyses were computed in the R statistical environment (R Core Team, 2018), using the packages smacof, vegan, and Base R for the MDS and cluster analyses, and using the package tm for the analysis of sorting criteria.

RESULTS

Dimensional Structure

We conducted non-metric MDS analyses and used the Stress-1 value (Borg and Groenen, 2005) as an indicator of goodness-of-fit. For both the Norwegian and the German sample, we retained the two-dimensional solution, as is indicated by an elbow-like pattern of the stress values across increasing dimensionality of the configuration (similar to a scree test in exploratory factor analysis; cf. Mair et al., 2016). The stress values for the one- to six-dimensional solutions are for the Norwegian sample 0.317, 0.126,

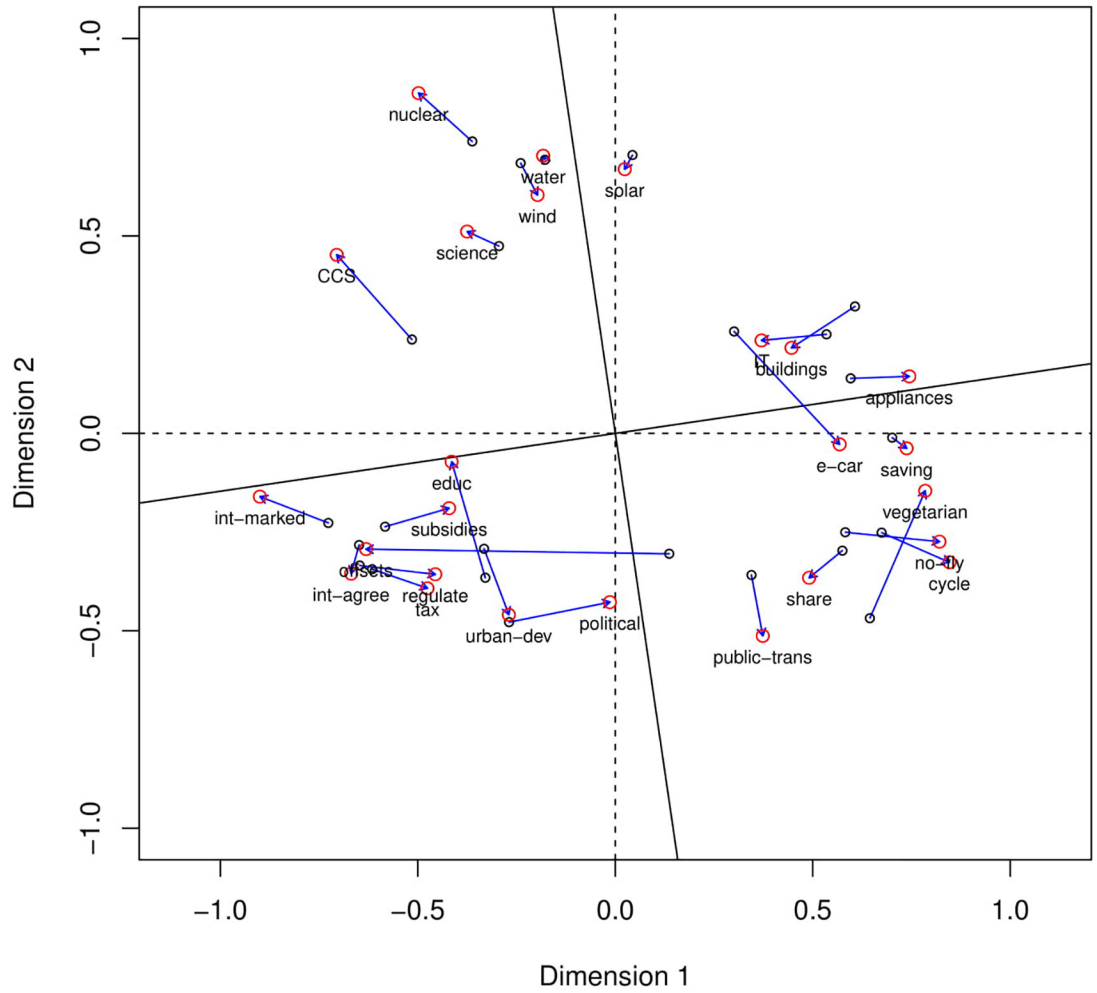

FIGURE 1 | Common plot of the MDS analysis configurations for the Norwegian and the German sorting data after Procrustes rotation of the German configuration. The Norwegian configuration is denoted by red circles, the German configuration by the smaller black circles; arrows indicate the distance between the two locations of an energy transition pathway component in the Norwegian and the German configurations. See **Table 1** for the labels of the energy transition pathway components.

0.075, 0.047, 0.030, and 0.020, respectively, and for the German sample 0.316, 0.120, 0.063, 0.038, 0.028, and 0.019, respectively.

In order to evaluate the goodness-of-fit of the two-dimensional solutions, we conducted a permutation test (500 permutations) as suggested by Mair et al. (2016), which tests the empirical stress value against random permutations of the original data matrix. For the Norwegian sample, the permutation test yielded a mean stress value of 0.31 ($\sigma = 0.01$); and a one-sided test with $\alpha = 0.5\%$ yielded a critical value of 0.303. For the German sample, mean stress was also 0.31 ($\sigma = 0.01$), with a critical value for a one-sided test of 0.301.

Hence, for both the Norwegian and the German sample the observed stress value for the two-dimensional solution was significantly smaller than what would be expected under the null hypothesis of random permutations, indicating a good fit of the configurations to the data. Furthermore, the two-dimensional solutions for both the Norwegian and the German sample proved stable across different starting configurations for the MDS algorithm (Mair et al., 2016). In sum, the two-dimensional configurations can be considered robust and providing good fit to the data.

The two configurations for the Norwegian and German data turned out to be very similar, which is apparent in their visual appearance (**Figure 1**) but is also indicated numerically by the correlation of the pairwise distances of the pathway components in the two configurations, $r = 0.83$, $p = 0.001$.

Figure 1 shows the Norwegian and the German configuration in a common plot. We used the Norwegian configuration as the target configuration (denoted by red circles in **Figure 1**) and the German configuration as the rotated configuration (smaller black circles in **Figure 1**) in a Procrustes transformation. A Procrustes transformation removes irrelevant differences between two configurations by applying admissible transformations (rotation, dilation, translation) to move one configuration (the rotated

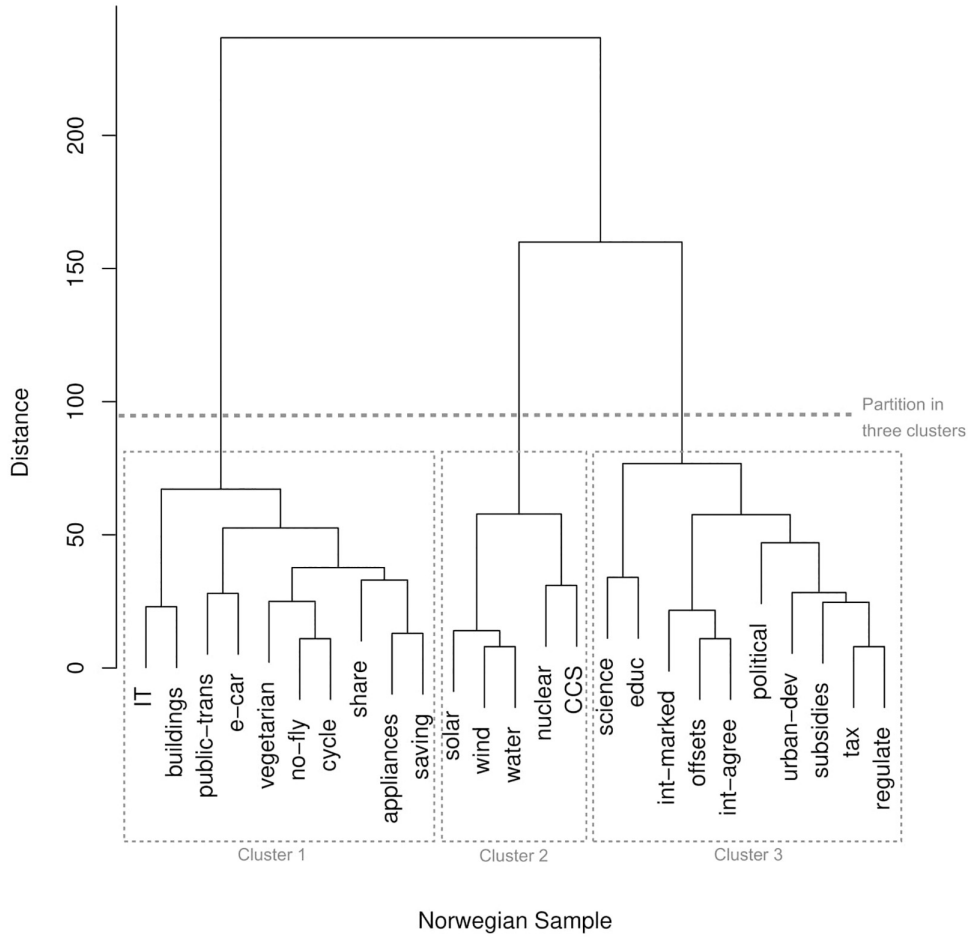

FIGURE 2 | Dendrogram of the hierarchical cluster analysis (Ward) of the Norwegian sorting data. The ordinate axis indicates the distance between merged clusters. Dashed lines indicate the partitioning with three clusters. See **Table 1** for the labels of the energy transition pathway components.

configuration) as close to the other (the target configuration) as possible. The two configurations are then directly comparable. The arrows in **Figure 1** show how far a pathway component in the German configuration is away from the same component in the Norwegian configuration (labels of the pathway components are placed at the Norwegian configuration).

In both samples, the pathway components form three groups that can be interpreted as corresponding to the presumed three levels (in the following, component labels shown in **Figure 1** are given in brackets; see the label column of **Table 1** for an explanation of the labels). The distances between the locations of a component in the Norwegian and the German configuration are generally not large in the sense that all components are in the same group in both samples; possibly with the exception of the component climate compensation (offsets) that was placed somewhat closer toward individual actions in the German sample but among the societal actions in the Norwegian sample.

The horizontal axis may reflect a dimension with individual actions to the right (appliances, saving, vegetarian, no-fly, cycle, e-car, share, IT, buildings, public-trans), and societal actions and technologies to the left (CCS, nuclear, science, water, wind, solar, int-marked, int-agree, educ, subsidies, regulate, tax, urban-dev, political)[3].

The vertical axis may reflect a distinction between ways of implementing behavior change among individuals or groups at the bottom (urban-dev, political, public-trans, int-agree, regulate, tax, share, offsets, no-fly, cycle, int-marked, subsidies, vegetarian, educ, e-car, saving) and technological and engineering solutions at the top (nuclear, water, solar, wind, CCS, science, IT, buildings, appliances).

Categorical Structure

The same dissimilarity matrices that served as input to the MDS analyses were subjected to a hierarchical cluster analysis (Ward method), again separately for the Norwegian and the German data. The dendrograms of the resulting solutions are shown in **Figure 2** for the Norwegian sample and in **Figure 3** for the German sample. The hierarchical nature of the clustering allows considering

[3]The pathway component with the label offsets was left out of this listing because it was positioned somewhat differently in the two samples.

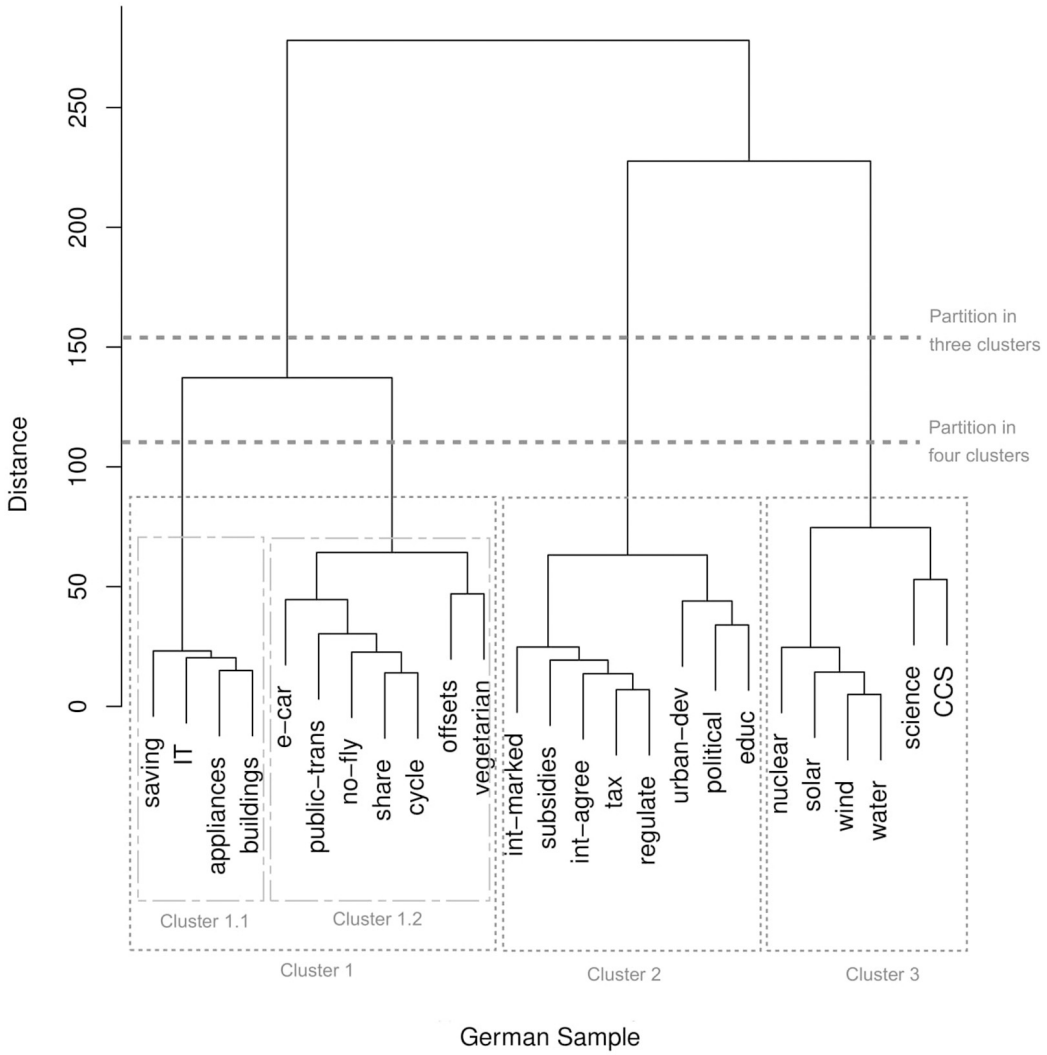

FIGURE 3 | Dendrogram of the hierarchical cluster analysis (Ward) of the German sorting data. The ordinate axis indicates the distance between merged clusters. Dashed lines indicate the partitioning with three and four clusters. See **Table 1** for the labels of the energy transition pathway components.

classifications with different numbers of clusters, which may reflect varying levels of super- and subordinate mental categorizations.

The cluster solution of the Norwegian data clearly indicates that Norwegian participants categorized the energy transition pathway components into three superordinate categories (in the following, component labels shown in **Figures 2**, **3** are given in brackets; cf. the label column of **Table 1**). Cluster 1 makes up pathway components concerned with information technologies (IT), energy efficient houses (buildings), public transportation (public-trans), electric cars (e-car), vegetarian food (vegetarian), flying (no-fly), walking and cycling (cycle), car sharing (share), energy efficient home appliances (appliances) and energy savings (saving). Cluster 2 reflects technologies relating to solar (solar), wind (wind), water (water), nuclear power (nuclear), as well as carbon capture and storage (CCS). Cluster 3 includes policy measures such as science (science), education (educ), international trade (int-marked), climate compensation (offsets), international agreements (int-agree), political engagement (political), urban development (urban-dev), subsidies (subsidies), taxes (tax) and regulations (regulate).

The solution for the German data also indicates three superordinate categories, and the identified structure largely resembles that of the Norwegian data. There are few components whose grouping differed in the two samples. Again, German participants placed offsets together with individual rather than societal actions. Another view at **Figure 3** suggests that – at a more subordinate level – individual actions can be divided in two subcategories, namely, pathway components concerned with energy use in the household (saving, IT, appliances, buildings; Cluster 1.1 in **Figure 3**) and other lifestyle aspects potentially relevant to promote energy transition (e-car, public-trans, no-fly, share, cycle, offsets, vegetarian; Cluster 1.2 in **Figure 3**).

Sorting Criteria

The analysis of the sorting criteria focused on term frequencies based on the open response data provided by the participants in both samples. The trimming of the text corpus involved transforming all letters to lower case, removing all numbers and removing punctuation. Further trimming included the removal of stop words (i.e., words that usually do not carry meaning in the respective language) in addition to the stripping of white space (i.e., removal of excessive blanks etc.). This procedure resulted in a total number of $n = 288$ terms in the Norwegian sample, and $n = 403$ terms in the German sample, each of which represented a unique word.

Table 2 lists the thirty most frequently mentioned terms for both samples in order of descending frequency. Many responses involved repetitions of the wording presented on the paperboard cards, yet references about the level at which these pathway components are located were common in both samples. This is evident, for instance, from looking at the words used most often (top ten) when participants elaborated on their sorting criteria. As **Table 2** shows, a sizable proportion of these words referred to the level of the component (listed in italics in the following): measure, science, transportation, vegetarian food, nuclear power, *individual level*, climate compensation, level, *public*, and *political* (Norwegian sample); *politics*, science, engagement, *political*, *private*, energy, attributed, do, umbrella term, and possibilities (German sample).

DISCUSSION

The present study employed card sorting for tapping into intuitive mental representations about energy transition pathways. The following discussion focuses on two parallel data collections, both asking participants to sort 25 possible pathway components according to their perceived similarity. Results show a close correspondence between the Norwegian and German samples insofar that at least three superordinate categorizations could be distinguished using Ward's criterion for hierarchical clustering (**Figures 2**, **3**). One cluster can be interpreted as referencing actions concerning individuals and/or households, another cluster seems concerned with technological solutions and the third cluster appears to represent actions located at the societal and/or political level. The overall pattern that emerged from the card sorting fits literature suggesting that laypeople construe energy transition as a multifaceted issue (Böhm et al., in press), but that corresponding mental representations are rather broad (Böhm et al., 2018). This interpretation was supported by the analysis of the open response data in which general terms such as "individual level" or "politics" were frequently used when participants stated criteria based on which they conducted the sorting (**Table 2**).

Böhm et al. (in press) suggested that possible pathways to energy transition can be distinguished taxonomically based upon their level (i.e., individual, societal, technological) and type (i.e., curtailment, efficiency). The present findings draw parallels to this taxonomy in that participants sorted various components according to the component's level of implementation. However, the findings do not support the notion that pathway components that concern efficiency (e.g., energy efficient home appliances) are distinguished from those that concern curtailment (e.g., avoid long flights). Apart from showing that different analytical approaches may elicit different mental representations, the proposed distinction in type does not seem to be a readily available concept when laypeople think about energy systems at large. This was unexpected since the proposed distinction emerged in an earlier study exploring impact judgments for some of the pathway components (Böhm et al., in press) addressed in the present study. The finding is also in contrast with studies that have reported empirical evidence to support the distinction between curtailment and efficiency within the context of energy saving behaviors (e.g., Barr et al., 2005; Gardner and Stern, 2008; Karlin et al., 2014; Boudet et al., 2016).

Looking more closely at the results of the hierarchical clustering, there were some differences with respect to the grouping of pathway components focusing on individual actions. In the German sample, participants tended to separate these actions into components related to energy use at home (e.g., energy saving, energy efficient home appliances) and components related to other possible lifestyle choices (e.g., vegetarianism, electric cars, public transportation). This separation corresponds with other studies in which location was identified as a shared theme based on which laypeople categorize behaviors and/or objects related to household water saving (Kneebone et al., 2018) and energy appliances (Gabe-Thomas et al., 2016), amongst others. In the Norwegian sample, in contrast, there was no clear pattern in the data to suggest that Norwegian participants form, similarly, consistent subcategories of individual actions, or of the other two superordinate categories. This difference between the German and the Norwegian sample hints at the direction that German participants' cognitive structure of energy transition is somewhat more differentiated than that of their Norwegian counterparts. Possibly, this reflects a difference in amount of knowledge about energy transition, as it is known from cognitive psychology that higher expertise in a content domain goes together with finer distinctions; experts use more specific categories than novices (Rosch et al., 1976). Support for assuming that the German sample had more experience with energy transition than the Norwegians did comes from the fact that all German participants but only a small fraction of the Norwegians indicated that they had heard the term energy transition before participating in our study.

The cluster structure emerging from the data closely resembled the spatial patterns obtained in the MDS configurations; both samples yielded three separable regions (**Figure 1**). An inspection of these configurations suggests at least two dimensions that could possibly underlie the mental representation of energy transition pathways. One dimension seems to indicate varying levels of social aggregation, ranging from pathway components that individuals can implement on their own to pathway components that reflect more of a concerted societal response (cf. horizontal axis in **Figure 1**). For example, "International agreements (e.g., on carbon emissions)" and "Walking and cycling" were located at opposing ends from another in the spatial structure. Another dimension appears

TABLE 2 | List of term frequencies for the sorting criteria in each sample.

Norwegian sample			German sample		
n	**Terms (original)**	**Terms (translation)**	***n***	**Terms (original)**	**Terms (translation)**
42	Tiltak	Measure	25	Politik	Politics
41	Vitenskap	Science	25	Wissenschaft	Science
28	Transport	Transportation	17	Engagement	Engagement
27	Vegetarmat	Vegetarian food	15	Politisches	Political
25	Atomkraft	Nuclear power	15	Privat	Private
21	Individnivå	Individual level	13	Energie	Energy
20	Klimakvoter	Climate compensation	13	Zugeordnet	Attributed
19	Nivå	Level	12	Tun	Do
19	Offentlig	Public	12	Überbegriff	Umbrella term
19	Politisk	Political	11	Möglichkeiten	Possibilities
18	Energi	Energy	10	Staat	State
16	Skatter	Taxes	10	Transport	Transportation
15	Energisparing	Energy saving	8	Energiewende	Energy transition
15	Internasjonalt	International	7	Private	Private
15	Subsidier	Subsidies	6	Ebene	Level
14	Vannkraft	Hydropower	6	Erneuerbare	Renewable
13	Elbiler	E-cars	6	Haushalte	Household
13	Gjøre	Do	6	Internationale	International
13	Kast	Throw	6	Maßnahmen	Measures
12	Byutvikling	Urban planning	6	Überbegriffe	Umbrella terms
12	Hus	House	5	Atomkraft	Nuclear power
12	Internasjonale	International	5	Eigenes	Own
11	Energikilder	Energy sources	5	Energien	Energies
11	Teknologi	Technology	5	Essen	Eating
10	Fornybar	Renewable	5	Haushalt	Household
10	Sykle	Cycling	5	Karten	Cards
9	Biler	Cars	5	Öffentlicher	Public
9	Elektriske	Electric	5	Politische	Political
9	Energieffektive	Energy efficient	5	Subventionen	Subsidies
9	Rest	Rest	5	Vegetarisches	Vegetarian

Shown are the top-thirty most frequently used terms in descending order. n indicates the term frequency, that is, the number of times that the term was detected in the open response data.

to show different degrees of public involvement, ranging from pathway components that emphasize initiatives to change how individuals and households interact with the energy system to those that comprise technological and engineering solutions to reduce carbon emissions without having to impose substantial restrictions on the everyday activities from individuals and households (cf. vertical axis in **Figure 1**). For instance, "Nuclear power" and "Urban planning (e.g., car free zones)" were located at opposite locations in the spatial structure.

Research shows that studying meanings ascribed to carbon and energy in everyday contexts can yield insights in public engagement with decarbonization (Whitmarsh et al., 2011). While the present study indicates that certain pathway components are perceived as less similar than others, more data collections are needed to clarify the meanings attached to each one of the identified clusters. One useful addition would be to include materials referencing themes that are prevalent in the public discourse on climate change. Rather than focusing only on single pathway components like renewable energy sources, the sorting may cover more generally phrased paperboard cards such as "climate change mitigation" and "climate change adaption." This would be informative with respect to the roles laypeople may (or may not) ascribe to themselves in response to climate change, and possible associations with energy use and storage in particular. Another possible extension could be to explore which pathway components are considered most effective with regard to promoting energy transitions. This could be done, for instance, by asking laypeople if they believe that individual actions are less, equally, or more effective in bringing about change in the present energy system than politics and technology. Answering this question would provide insights for researchers and policymakers alike, given that perceived effectiveness in climate mitigation tends to be associated with support for low-carbon policies (Bostrom et al., 2012; Rosentrater et al., 2012).

This study holds several limitations. First, the sorting task was limited to 25 paperboard cards labeled with one energy transition pathway component each. This was done to comply with recommendations in the literature that consider a number between 15 and 25 cards as appropriate in such tasks (Canter et al., 1985). As this selection cannot cover the full range of possible energy transition pathways, interpretations concerning pathways or components not covered in this study must be undertaken with caution. Second, data were collected using single sorting (i.e., without any repetition) rather than multiple sorting (i.e., with one or several repetitions). It is possible that this methodological choice has come at the cost of leaving one or more subordinate categories unidentified, given that multiple sorting tends to be more suitable if the interest is to explore all possible categorization dimensions (Rosenberg and Kim, 1975). Third, the component descriptions on the cards were not entirely consistent across samples. The two cards labeled "Climate compensation (e.g., when booking flights)" and "Environmental education (e.g., in school, at work)" included parenthesized examples in the German sample that were missing in the Norwegian sample. Maybe supplementing pathway component descriptions with an example triggered other interpretations than when no such additional information was provided. For example, this difference might account for the fact that climate compensations were seen closer to the individual actions in the German than in the Norwegian sample. Future studies that employ a similar methodology should try to avoid such inconsistencies to allow for a more unambiguous interpretation of possible sample differences.

CONCLUSION

There has been an increasing literature on factors that shape interactions from individuals and households with energy systems (e.g., Stern, 2014). The present paper adds to this literature by shedding light on an aspect that has received relatively little attention, namely on the structures emerging from intuitive categorizations when laypeople think about pathways relevant to energy transition. A study was conducted that employed card sorting to gain insights into the mental representation of possible energy transition pathways in two different countries. Results were consistent in the sense that laypeople structured different pathway components in terms of their respective level of implementation: individual/household, society/politics, or technology. While current initiatives to promote sustainable energy transitions seem to already address pathways at different levels, this study is among the first endeavors to investigate how laypeople mentally represent these pathways and their components. Our results provide new insights also because the allocation of a component to one of the aforementioned levels not always seems obvious. For example, electric cars were grouped together with individual and household actions rather than being allocated to technology. Granted that the findings of this study replicate within the population at large, ideally with representative samples from both countries, this knowledge has potential to improve communication strategies to promote sustainable energy transitions. Including additional measures (e.g., perceived effectiveness) in forthcoming studies could further help identify correlates associated with each super- or subordinate category. This would enable comparisons between different pathway components, and capturing these perceptions would allow systematic comparisons between countries. Policymakers could use this knowledge to identify where public perception matches expert opinion, and if needed, attempt to correct possible misperceptions.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

ETHICS STATEMENT

This empirical study complied with the Norwegian Social Science Data Services (NSD) privacy regulations and the ethical principles of research by the National Committee for Research Ethics in the Social Sciences and the Humanities (NESH). Formal approval from NSD was not sought as the collected data material was anonymous, see www.nsd.uib.no/personvernombud/en/notify/index.html.

AUTHOR CONTRIBUTIONS

RD and GB contributed conception and design of the study. DH organized and conducted the lab session for the German data collection, and collected the German data. GB performed the statistical analysis. RD wrote the first draft of the manuscript. GB and DH wrote sections of the manuscript. All authors contributed to manuscript revision, read and approved the submitted version.

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The *Environmental Commons* in Urban Communities: The Potential of Place-Based Education

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The reflections of 205 4–12th graders (most from racial/ethnic minority backgrounds) on what they learned from participating in place-based stewardship education (PBSE) projects in their urban communities were analyzed. All projects involved hands-on collective learning/action by teams of students, teachers, and community partners in the communities where students attended school. Reflections were analyzed using an iterative process of deductive and inductive coding and identifying emergent themes. Deductive coding was informed by the authors' earlier theoretical and empirical studies on the environmental commons (EC) and the key principles outlined in Elinor Ostrom's work on effective group practices for stewarding common pool resources. Reflections were coded for up to 8 discrete references to the two elements of the *environmental commons*: (1) the natural resources on which life depends (awareness of nature in the urban space; nature's diversity and ecological balance; interdependence of humans with nature; healthy environments and species' well-being; students' environmental identities; and human impact and agency); and (2) collective actions to protect a community's resources (benefits and responsibilities of team work; within-group dynamics and civic skills; collective efficacy; generativity; and identification with the broader community). We found that students articulated, with varying levels of understanding, the two key EC elements. Most referred to positive human impact and one-third mentioned negative human impact. When discussing the community benefitting from their work, a majority mentioned humans; yet nearly half referred to other species or living systems; and a quarter referenced generativity, i.e., the legacy of their work for the future. Concerning the collective orientation of projects: one-third felt collective action was imperative for solving environmental issues, half expressed feelings of collective efficacy, and over one-third referenced their increased attachment and identification with a broader community (school, city, or nature). Core practices in this PBSE model parallel the elements of effective groups identified by Ostrom. We conclude with a discussion of the potential of PBSE projects in urban communities for developing young people's sense of the public realm more broadly and their stake in the natural environment and their communities.

Keywords: environmental education, place-based learning, citizen science, youth civic action, environmental commons, urban ecology

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INTRODUCTION

Human impact on the Earth's natural environment poses major challenges for current and especially future generations. To address these challenges, policies at national and international levels are critical. However, as the political economist, Elinor Ostrom (2012), argued, national and global solutions will only work if people are committed to them at local levels. In this paper, we explore a model of environmental education that emphasizes what young people can do at the local level and examine its role in nurturing their environmental awareness and commitments. Specifically, we assess what 4–12th grade students learn about the *environmental commons* by participating in place-based stewardship education (PBSE) in their urban communities. First, we define PBSE and describe the specific model. Next we discuss the *environmental commons theory* informing our work and review key elements of PBSE as enacted in these urban contexts. Finally, we summarize students' reflections on what they learned from participating in this PBSE model.

Place-Based Stewardship Education

Place-based stewardship education refers to experiential education about the natural environment in the local community (Gallay et al., 2016b). The focus on local *place* is two-fold: as a source for learning and as a community to which students can contribute by applying what they learn. In the PBSE model we are assessing students, teachers, and community partners work in teams to define an environmental issue impacting their community, collect and analyze data, and take actions to mitigate the problem. An evaluation of this model with middle-school students in a rural community found significant increases in students' enjoyment of nature, pro-environmental behavior, community attachment, and confidence in their civic capacities for environmental action (Gallay et al., 2016a). However, youth in rural areas have a different experience of the natural environment. For example, compared to their peers in urban communities, these rural youth spent more time outdoors and enjoyed nature more (Gallay et al., 2016a).

Here we examine the insights of urban students who participated in similar PBSE projects. Many projects take place in racial/ethnic minority communities and thus explore an increasing focus in environmental education (EE) (Bouillion and Gomez, 2001; Barnett et al., 2006; Russ and Krasny, 2015, 2017). Although urban communities of color are disproportionately affected by environmental pollution, until recently, neither the mainstream environmental movement nor the lion's share of environmental education has concentrated on the experiences of people of color (Taylor, 1996, 2014). Scholars also have criticized the racialized representation of nature in policy and popular culture with African-Americans rarely depicted in natural spaces (Finney, 2014). Notably, when youth of color get engaged in environmental activism it is typically because they see connections between the health of the environment and that of their community and culture (Quiroz-Martinez et al., 2005).

In contrast to a view of nature as a pristine landscape apart from the city, urban environmental education and projects emphasize the interdependent relationships of humans and natural systems in the city and the civic potential of local residents (including children) to assess the quality of the environment and to act to improve it. The PBSE projects discussed here include practices that are common in urban environmental education including the city as classroom, problem-solving, stewardship, youth as assets in community development, and the city as a social-ecological system (Russ and Krasny, 2015). The potential of such projects for children's development inheres in the combination of environmental learning, direct experiences with nature, and civic actions to mitigate environmental problems and improve the community. In line with a "civic ecology" framework, the projects discussed here emphasize resilience and human agency. They combine the restorative benefits of being in nature with development of the capabilities to observe and improve the natural environment and to see how human behavior and choices (including the students' own) affect the ecosystem (Krasny and Tidball, 2009).

In documenting the PBSE projects, we have aimed to advance theory about the *environmental commons* which we define as: (1) the natural resources and systems on which life depends, and (2) the public spaces and processes in which people work together to determine how they will care for those resources and for the communities they inhabit (Flanagan et al., 2016; Gallay et al., 2016a,b). In earlier studies, we arrived at this definition through a grounded approach to analyzing students' reflections regarding what they learned from participating in projects (Gallay et al., 2016a). Our theory also has been informed by the work of Ostrom and colleagues who identified the characteristics of groups that make them effective in sustaining common pool resources (CPRs) such as fisheries or forests that provide benefits to everyone but can be depleted if overused. Characteristics of effective groups include: proximity to the specific CPR; the strength of members' identification with the team and its goal of sustaining the resource; and dynamics within the group including mutual respect, responsibility and communication over time that enable members to know one another and to build trust (Cardenas and Ostrom, 2006).

Core practices in the PBSE projects we have been studying parallel these elements of effective groups outlined in Ostrom's work. With respect to proximity, students' attention is drawn to the natural environment as it operates and is affected by humans in the *local place* where they live and attend school. Ostrom's second element, identification with the group and its goal, is emphasized via a *collective structure for learning and action* about the natural environment in teams of students, teachers, and adult community partners. Finally, diversity in the experiences and perspectives of team members is considered an asset in the PBSE projects and dynamics within groups emphasize *mutual respect and communication*. Since most teams work over a period of a few months to a year, members should get to know and trust one another.

Natural Systems in Urban Contexts

The emphasis on local place in these projects means that nature is not treated as a wilderness remote from urban life. Rather, the interdependence of humans with natural systems within the urban ecology is emphasized. Toward that end, two things are

needed. First, youth must *notice* nature and natural systems as they operate in and are an integral part of their everyday lives. In addition, they must realize that human behaviors impact the natural environment in positive and negative ways, that people can choose what impact they will have, and that the youth themselves can be agents of positive change.

The latter emphasis on young people's agency contrasts with the inertia identified in Kahn's (2002) studies in a Texas bayou which led to his coining the term, *environmental generational amnesia*. Although the youth he interviewed knew in the abstract that pollution is bad for the environment, many did not take notice of the polluted settings they lived in. Kahn theorized that, over time, environmentally degraded settings had become the new normal. The possibility that they might reverse environmental harm seemed not to be within the youths' purview. By contrast, in the projects we are documenting, students engage in collective action with the goal of mitigating environmental harm. Consequently they should realize that *what is* need not define *what could be*.

The collective action to improve the community's environment that is at the core of these PBSE projects is a form of civic engagement that may continue into adulthood. National longitudinal studies indicate that opportunities for community contribution and a public voice in adolescence increase the likelihood of civic action (voting and volunteering) in adulthood (McFarland and Thomas, 2006). Identifying with their local community and ways they can contribute to it may be especially empowering for youth in urban areas that have been marginalized from the mainstream. The very fact that they are engaging in collective action to improve the debilitative conditions in their neighborhood may be a means whereby these young people can challenge negative narratives and reclaim their community's identity (Ginwright and Cammarota, 2007).

SITES AND PROJECTS

All of the projects described in this paper take place in metropolitan areas where over half of the state's population resides. All projects are school-based and are part of a regional network of school-community partnerships organized by the Southeast Michigan Stewardship Coalition (SEMIS)[1]. The region has been affected by deindustrialization but the combination of economic change, migration, and social dis/investments have had differential effects on the three communities where the students in our sample attend school and engage in projects.

The first site, a former industrial and manufacturing powerhouse, is now a predominantly African-American urban community of concentrated poverty in which abandoned houses and vacant lots dot the landscape. The second site is an ethnically diverse urban community where population and median income are growing but where the poverty rate remains high. Students in these first two communities may live within a few miles of a river or natural area and some may have woods or greenspaces within walking distance. However, many have had little experience with the natural environment. In contrast, students in the third community, with a well-educated middle-class population, have ample and accessible neighborhood parks, natural landscapes, and outdoor recreation.

Students' projects are responsive to local conditions but share a common set of practices including: ecological observations, data collection and analyses, learning and action in teams of students, teachers, and community partners, and presentation of results in public venues (with students, teachers, and community partners from other schools, city or county administrators, elected officials). The specific content of projects discussed in this paper focus on one of the following: a study of the ecological history of land use in the community and humans' relationships to their food which led to permaculture practices in growing food on the school grounds; investigation of a local urban park's ecological and social history, water quality sampling and storm water management leading to flood mitigation through installation of a bioswale; community mapping and investigations which led to studies of local food economies and urban gardens; water quality and habitat health investigations of local water bodies which led to design and creation of water filtration systems; studies of sustainability, biodiversity, local agriculture and food systems, incorporating climate change research, invasive species removal, construction and maintenance of school food garden and harvesting vegetables; community surveys, planning, design and creation of a community park by reclaiming neighborhood abandoned houses and vacant lots; photo-essays of strengths and opportunities in the community's natural and built environments and community murals of local African American history; and a study of availability and access to healthy, pesticide free food which led to planting and care of an urban community garden.

MATERIALS AND METHODS

The study was completed as an evaluation in collaboration with SEMIS, who has permission to conduct programming and evaluation in the schools. The study was reviewed by the University of Wisconsin Education and Social/Behavioral Science Institutional Review Board and the IRB determined that the project is evaluation and does not constitute research as defined in 45 CFR 46.102(d). While parental consent was not required, we have followed ethical considerations in informing participants of the study, obtaining verbal assent, and maintaining the confidentiality of participants.

Sample

The sample includes 205 4–12th graders (78% high-, 6% middle-, and 16% upper elementary school; 52% male) who participated in a SEMIS project. Students' race/ethnicity was available for 92% of the sample: 66% identified as African American, 15% European American, 7% Latinx/Hispanic, 6% Multiracial, 3% Asian American, and 3% Arab American. The racial/ethnic composition of the sample is consistent with the demographic characteristics of public schools in the three communities. In two

[1] Organizational website is http://semiscoalition.org/. SEMIS is one of nine regional hubs of the Great Lakes Stewardship Initiative (GLSI) which engages schools and community partners in PBSE.

of the communities, just under 75% of students qualify for free or reduced lunch, and 21% qualify in the third community.

Measures

After completing their projects, a reflective prompt was developed by the study team asking students to: Write a letter to the SEMIS Coalition telling them why you think the work you did in (project specific) was important. What did you learn about your community, other people or species in your community or the environment from the work you did? What did you learn about what kids can do to solve environmental problems in their communities? How has your community or the environment changed because of your work? Students were told that the purpose was not to assess knowledge but to reflect on their experience in their own words. Reflections were written during class time. Students were told that their responses were confidential and would not affect their grades.

Analyses

Coding of these data was informed by two earlier studies with different samples of students participating in similar PBSE projects. In the first study with a small group of urban students, grounded theory was employed to coding reflections on what students learned and valued about their projects (Strauss and Corbin, 1998). Categories included references to humans' need for natural resources, interdependence between humans and other living things, depletion and sustaining of resources, negative impact of humans on natural systems, civic learning, skills in civic action and agency, and pride in being community environmental leaders (Gallay and Flanagan, 2016).

In the second study, rural students reflected on what they valued most about their projects. Inductive and deductive methods were used to develop a coding scheme that built on: categories from the first study, research on environmental identity (Clayton, 2003; Jia et al., 2015), and Ostrom's work on common-pool resources (Cardenas and Ostrom, 2006). Although students in the second study were not asked how their work had affected their community, many discussed the impact on people or nature as something they valued (Gallay et al., 2016a). Categories included references to: the human community (people who would benefit from their work); the environmental commons (benefits to natural systems and non-human species); feelings of attachment to and responsibility for their local community; commitments to continuing environmental monitoring; and generativity (the legacy of their actions on future generations).

For the current project, three of the co-authors began with categories that emerged in the studies cited above, a code-recode process to capture emergent themes, and a final codebook reflecting the two elements of the environmental commons. Codes capturing the first element, (i.e., concepts related to the natural resources and systems on which life depends) included references to: the natural environmental community or commons; the human community or commons; interdependence between humans and other living things and correlations between the health of humans and the quality of natural environments; environmental identity (sense of connection and of care for the natural world); positive and negative human impact. Codes capturing the second element, (i.e., references to people working together to determine how they will attend to and make decisions about their community and its natural resources) included references to: community attachment and pride; generativity; the imperative of collective (not just individual) action; dynamics within their group including civic skills such as communicating, negotiating, finding common ground; feelings of efficacy and agency in effecting change; applying or using scientific and environmental knowledge to address a community need. In addition to these references to some aspect of the Environmental Commons, we coded for references to: individualism, i.e., addressing environmental problems on one's own; helping that was not directed specifically toward the community or environment; and negative experiences.

Inter-coder agreement was computed (Cohen's kappa of. 81) and each coder independently coded one-third of the reflections with questions flagged and discussed to reach consensus. Students' responses were coded for a maximum of 8 categories. For the 205 students, the fifteen codes were applied a total of 944 times with an average of 4.6 codes per student (min = 1, max = 8). After coding, the team conducted a memoing process of all responses connected to a specific code to identify key themes about the Environmental Commons revealed in each code.

RESULTS

Analyses are organized under the two overarching themes in our definition of the Environmental Commons (EC). The first section (natural resources/systems that support life) summarizes: students' awareness of nature; its diversity, value, and ecological balance in the urban context; the importance of healthy natural environments to sustain life; the interdependence of humans with other species; students' environmental identity or sense of personal connection to the natural environment. In the last part of this section we discuss students' references to human impact (negative and positive) on the environment and awareness of their own agency and resolve to protect natural resources. This last theme – human impact and agency – is a bridge to the second overarching EC theme, i.e., what students learned through the process of collective action in public spaces. Here they discuss the benefits and need for team work, dynamics within their group, and ways that through collective action they have come to have a stake in and identify with a broader community.

The Environmental Commons: (1) Natural Resources and Systems on Which Life Depends

To appreciate this first dimension of the Environmental Commons, students must become aware of nature and natural systems as part of their urban experience and also understand that the well-being of humans and other species are tied to natural resources.

Awareness of Nature

Indications that they were aware of nature included references to "meeting the nature that is right here in our neighborhood," "what animals' roles are in our environment," "that my community has two water systems that come from two different rivers," and "my community around my school has more wildlife than I thought." Some noted how they had changed as a result of attending to other living things:

> Since I have been in permaculture it had changed me so much I start to like plants and learned new stuff about the plants it showed me how to love plants, if I want to be a permaculture student you should ask about plants and learn about them.

Diversity and Ecological Balance

By attending to the details in nature, some students were beginning to notice biodiversity. For example, one pointed to the value of distinguishing plants by their names as a basis for attending to their unique features:

> I was able to identify plants. It helps to tell things apart. I used to look at stuff and say, "That's a plant," but now I can see differences. It's important to know names of nature. Things with names have different features.

Others who worked on a community garden noted the needs and functions of different plants and the roles they play in an ecosystem, "that all plants are special in there [*sic*] own special way like trees filter out the air and tomatos need lots of water" and "I learned that some plants will thrive better in more acidic or more basic Ph *[sic]*." Some projects introduced students to the ecological balance of natural systems and threats to that balance, "I learned how the population of animals go down when the water is bad"; or, alluding to invasive species:

> With us removing some of the garlic mustard, along with other invasive plants, other plants had a chance to grow and animals I guess got to eat their food again as invasive species were slowly wiping out the food supply they needed.

A new vocabulary indicating increased ecological awareness was evident in some reflections such as, "The most important thing I learned about our community is how important frogs are to our environment. I also learned that frogs are bioindicators which will tell us if the ecosystem is healthy or not."

Healthy Natural Environments and Species' Well-Being

Understanding that natural resources support life raises questions about the quality of those resources and an awareness that the well-being of species depends on a healthy ecosystem. In the following reflection on the importance of their water testing project, the student connects the problem of polluted water and land to the survival of different animals:

> It was important because it saved the frogs and cleaned the water which is good for the other species and environment too . . .. And how animals rely on many things to survive and if factories pollute rivers, lakes or any type of land, animals can die off, which can make other animals die off too.

Another student whose group worked on water filtration, observed that water was a resource that sustained life for humans and other animals. "Clean water is important because animals can die from dirty water. It is important for water to be clean because dirty water is not good for your health." Through the project, her awareness of natural systems in the urban ecology had also changed: "My community/environment has changed because of the filtration project. It has changed the way I see things of water."

Interdependence

Other students referenced the natural systems on which life depends by emphasizing that the well-being of humans and of other living systems were interdependent. Often, that awareness revealed anthropocentric views, i.e., the benefits or utility of nature for humans: "If I clean the water that's in lakes I can save the species that live in the water such as fish, tadpoles, frogs, snails etc., because those things kill insects and that helps human beings out"; or "I think what we did in permaculture was important because we need plants to 'survive."' Similarly, when discussing the importance of water resources, another student explained that water is:

> one of our most vital resources and when our water is polluted it is not only devastating to the environment. This clean, potable water is then used for cooking, drinking, cleaning, bathing, watering our lawns and so forth. We learned that the water/river was very polluted and unhealthy for the residents of this area to swim, drink, or fish in. Also for the wildlife that occupies the river.

Although the reliance of other species on healthy rivers sounds like an afterthought in this quote, some students signaled a more biophilic perspective, i.e., an appreciation, even a love of the natural world – not for its utility for humans, but for its own sake (Wilson, 1984/2003). Some felt that learning about nature increased their sense of connection to and desire to care for it: "I felt it was important to do this because it helps us learn about our eco-system, and feel connected with our Earth." For another student, learning about plants increased her respect and desire to care for them: "Learning about how plants grow, eat, and live in general, has boosted my appreciation for plants. Learning how plants provide for us and caring for them does great wonders."

Environmental Identity

A feeling of connection to nature has been referred to as an environmental identity (Clayton, 2003) and is associated with time spent in nature (Chawla, 1999) and education about the environment (Ernst and Theimer, 2011) in childhood. Not surprisingly, an environmental identity is correlated with caring for nature (Schultz, 2001; Arnocky et al., 2007; Bamberg and Moser, 2007). Some students commented that their relationship to nature had changed as a result of their PBSE projects: "The walk through 'River Park' has been so wonderful. I never cared about nature but now I do. We did so much thinking, gathering

ideas with ways we can make the park better (River Park)." Use of the possessive pronoun in the following reflections (e.g., our river, our watershed) indicated both an awareness that life-sustaining resources belonged to everyone and a collective responsibility to care for those resources: "I've learned that if we continue to do harmful things to our river, we will regret it in the future" and "if we litter that will end up being in our watershed." In some cases, students interpreted their new awareness of and relationship with nature as a moral imperative that should impact behavior:

> The environment is a wonderful thing that must be treasured and taken care of and not be abused. We should remind or selfs [*sic*] and future generations to not abuse this power and love the environment for all it does for us.

Human Impact and Agency

Perhaps because they were both learning and acting, students became aware not only that human behavior affects the environment but also that they have agency and can choose how to act: "I learned that things could be cleaner in our town and that its up to us to fix it"; "We just learned how to give back to our environment, instead of taking it and destroying it"; "The work I did in learning about community gardens was important because it was brought to my attention how much of a food desert our town is and how creating something like a community garden can combat it"; and "by understanding nature we can solve problems and search for more sustainable ways of living."

In some instances, awareness of human impact was very personal and signaled a resolve to change their ways: "I learned how I have been polluting for years in ways I didn't know." References to changes in everyday behavior were common. After working on a community garden project a student explained, "Participating in this opened our eyes to other things we could improve on in our daily lives to further help the environment. From food, to transportation, and at home energy consumption"; while another stated, "This project was amazing! It lead me to watch the foods my family and I intake as well as allowing me to become aware of the corrupt processing placed [*sic*] just to have a home-cooked meal." In some cases, students resolved to redress the negative impacts of others. For example, "people damage our water by throwing things into the water. So people like us have to know how to clean the water people have damaged." Ultimately, stewardship of the environment implies a need for constant vigilance to maintain healthy ecologies as captured in the following reflection from a student who worked on a bioswale, "The things we did in the community. I check up on it every time I leave school. The community is doing good people basements [*sic*] are not flooding no more."

The Environmental Commons: (2) Collective Action in Public Spaces

Students' reflections also were coded for references to collective action in public spaces, the second Environmental Commons (EC) theme, i.e., the public spaces and processes in which people work together and make decisions about how they will care for the resources they share and the communities they inhabit. It bears repeating that projects take place in local public settings – schools, abandoned lots, parks, rivers. Students' attention might be drawn to actions they could take to mitigate flooding in their school's baseball field, to growing food in a school garden, or to lobbying the city to remove abandoned houses and working with residents to turn the space into a public park.

Besides the public settings of projects, the PBSE model emphasizes collective learning/action in teams of students, teachers, and community partners. In analyzing their reflections on this dimension of the Environmental Commons, we were interested in students' perceptions of the benefits of team work and whether any students felt that they could do this work on their own; their insights into group dynamics and what skills or capabilities they gained from being part of the team; and how, through their civic contributions, they developed an identification with and helped to define the broader community (the school they attended or town where they resided) and the public or common good.

Benefits of and Need for Team Work

Although our coding scheme included a category for individualism, i.e., doing work on one's own, no responses were assigned to this category. In contrast, many students said they learned that teams were more effective than were individuals for achieving their project goals: "you get more done with a team than by yourself"; and "we can solve problems if we work together." With environmental restoration a goal, one student felt that collective action was imperative: "We found out we need a group to bring back the environment we once had twenty years ago." Another noted the benefits of multiple perspectives and ideas for solving public problems: "doing this filter project was a great chance to see what doing something together can get you. I also learned that with teamwork and everyone's brain working together you can accomplish anything"; and "from this experience, I learned that if students work together and 'brain storm' they can create and do just about anything." Some concluded that working together is not only beneficial, but also enjoyable, "with them being there it was more fun and interesting to express everyone's ideas."

Dynamics Within the Group

According to Ostrom, groups that are effective in stewarding environmental resources prioritize the group's goal over individual goals and gain trust by communicating and getting to know one another. In their own words, students captured similar group dynamics:

> I think this gardening project was important to gain knowledge and trust. After this project I feel closer more connected to my class. We didn't work individual. We worked as a team. What I learned through this project is that my class isn't just a class were [*sic*] a family.

Trust involves giving others the benefit of the doubt (Flanagan and Stout, 2010) and the following student observed how his trust in team members developed through the experience of hearing their different approaches to problem solving: "I learn that everybody has their own ways to learn and figer [*sic*] out, ways to solve problems. I learn to always trust my teams no

matter what." Another mentioned the patience that collective work demands and, ultimately, the satisfaction of a team effort:

> It was very tricky and irritating but at the end I really didn't want the project to end. I also learned that you have to deal with all different kinds of attitude while in a group. I think that when the students come together to actually work, they come up with good work.

Civic Dispositions and Skills Gained Through Team Work

Besides trust, students alluded to the enlarged sense of community they had gained through projects. Recall that the PBSE projects are done by teams of students, teachers, and adult partners from the community, working together on behalf of the environment. Due to their intergenerational character and exposure to community organizations, the projects have unique potential for expanding youths' community networks and developing their social capital, opportunities that are missing in the lives of many young people (Hart et al., 2008).

Like adults who work with youth in community service (CS) projects, the adult partners in these projects tend to be people with strong commitments to the common good. Working alongside such dedicated adults should enlarge the sense of community and boost the social trust of the young participants. Studies of CS show that, compared to other kinds of extracurricular activities, participation is associated with more affirmative views of a community's intergenerational relations and of people in general (Flanagan et al., 2014).

Similar positive views about the people and organizations in their communities were invoked in the following students' reflections: "What I learned about the community is that we have a lot of helpful and meaningful people all around us. They don't mind helping us out either." In the face of challenges, students' commitments were buoyed when they realized they weren't the only ones working on the issue: "there are a few organizations that have already implemented their strategies to combat the food desert in our town" and "I learned that my community had a lot of these invasive species, but I also learned that there were people who cared a lot about that woods and spent a lot of time helping."

Other skills that students felt they gained are civic competencies that facilitate public problem-solving including communication, perspective taking, tolerance, and an identification with and sense of belonging to the team. One learned that "kids can solve environmental problems, that they can come together and listen to ideas and think of ways to make change and make everyone feel involved." In order to find common ground, students also have to listen to different perspectives and work through disagreements. One student learned that people are all different and that "sometimes you have to work with people we don't agree with" while another noted the need to "communicate with others even when there is a problem." Communication learned within groups was a skill carried over to students' interactions beyond their team: "I have learned how to understand, help, and communicate with people in school as well as total strangers."

Collective Efficacy

Students were proud of and felt a sense of efficacy from their work. When expressing what they learned about what kids can do to solve environmental problems, many emphasized the power of youth: "I learned that we can and will do everything that an adult can do" and "I learned that age doesn't matter." When discussing why projects were effective, some referred to the collective nature of the work: "I learned how local grown food can help the community prosper and that it takes team effort to run such a big garden"; "My work with 'River Park' has helped me learn that with the help of my peers, I could make a difference in my community. Kids have much more power than they think."

At times, students enjoyed public recognition for the mark they were making in their community, as captured in the following account of a student whose group was reclaiming abandoned land: "We were outside and somebody driving past said, 'I like what you all are doing to this community. Before there were boarded up houses."' Other students wondered if their actions might have a ripple effect:

> The work we have done is important because it's a way to help our community. When a community does not care, it reflects when you look at the community. This is also true when a community does care. This work makes everyone more positive and can inspire people to go out and continue the work of others.

Positive public recognition of their work enabled youth to reframe the narrative about who they are and what their school or community could be. Referring to the experience of their team presenting their project at a community forum, one student felt that presenting in that public venue "helped the way people look at us. Everyone thinks our town or school is just so bad and full of uneducated kids but we think different." Another commented: "My community has changed a lot because now they are starting to see we students, teenagers, and children mean business and we are going to be successful."

Generativity

Not only did some members of the public change their beliefs about the youth but some of the young people themselves alluded to the new self-image they were developing, including the sense that their work could leave a legacy for those who would come after them: "it also made me think about the world in a different/better way that could help future generations"; "the work that we did at [River Park] was very important because we need to protect our environment. The environment that we live in needs to be preserved for our future generation."

Identifying With the Broader Community

Making a palpable contribution to the communities where they live and learn is a core element of these projects and several students described how they came to identify with and have a stake in their communities as a result. References to "*our* school" or "*my* community" were common: "Over the 2 years I worked on these projects, my community has changed physically. Our school use to look like a back alley and now its beautiful." A student who worked on a community mural, felt that the work was "important

because I felt like I finally made a mark in my community." In the following quote, another student notes how his attitude toward the broader community changed because work on the environmental team taught him to "be in" and be responsible for his community:

> It was important for me to work and be a member of the "Eco Team" because it helped me believe in my community. At first I really didn't care about my surrounding but working with the "Eco-Team" made me realize I need to do something about it. Also my community changed a lot because it looked better than it was before *I started being in the community* (italics added).

Summary

We have emphasized themes relevant to an understanding of the Environmental Commons that emerged in our coding. Here we summarize the percentages of students' responses that referenced each code. A majority (76%) referred to positive human impact whereas only 32% noted ways that people negatively affect the environment. The stronger emphasis on positive behaviors may reflect the proactive nature of these projects and the sense of agency students feel, which is also affirmed by the fact that 51% alluded to feelings of empowerment and efficacy. Although we coded for negative statements (boring, don't like being outdoors), only 5 students said anything negative about their projects.

When discussing the *community or commons* that would benefit from their work, a majority of the statements referred to people (57%) although 42% mentioned other species or natural systems as part of the community and 21% specifically referenced the interdependence of healthy natural systems and human well-being.

Students also alluded to a sense of connection or attachment to a broader community gained through their projects:15% of the reflections referenced sensitivity to the natural environment and 35% a sense of attachment and pride felt as a member of the community at school or in the city. The imperative and benefits of working as a team to solve environmental problems were noted in 34% of the reflections and 12% specifically cited the civic skills (e.g., communication, trust) and dynamics that made their group effective. Finally, 25% suggested that the environmental contributions that they and others were making could leave a legacy by having a positive impact on the natural environment that future generations would inherit.

DISCUSSION

In their own words, these students from urban communities articulated, with varying levels of understanding, the two key elements of the environmental commons: awareness of natural resources that support life and the processes whereby humans can sustain those resources through collective action. Concerning the first element, students referenced their experiences with the natural world, sometimes noting how they had not previously noticed nature or its diversity and now attached greater value to the natural world – the rivers, the fish, the plants, the "environment" more broadly. Some used possessive pronouns (e.g., our river, our earth, our water, our ecosystem, our environment) alluding to the Environmental Commons principle that the resources that sustain life belong to everyone.

With rare exceptions, students' descriptions were positive and pointed to their increasing affinity for the natural world. As they paid attention to nature, became familiar with the names of plants, got to know the needs, functions, and roles of various species and the connections between humans and those species, some expressed an ethic of care for the natural world and a responsibility to sustain it for future generations.

Awareness of the natural world in their urban space was coupled in many reflections with references to the impact of human behavior (and often their own) on the natural world. Importantly, references to negative human impact did not often result in cynicism or pessimism. Perhaps due to the emphasis on collective action in this PBSE model, the negative impact of humans was seen as a choice and was met with students' resolve to turn things around, including, for some, changing personal behaviors. Students said that their eyes were opened to things they could improve and that, "people like us have to know how to clean the water people have damaged." Human agency and personal resolve were a far more common reaction than passivity and acceptance of the status quo. In some cases, students' dawning awareness of the finite nature of natural resources and of the impact of human choices sparked what others have referred to as "generative concern," i.e., a sense of unrest or worry about how one's actions in the present might affect the conditions of life in the future (Jia et al., 2015).

According to national trend studies, adolescents in the United States are more likely to engage in environmental conservation behaviors if they are aware that some natural resources are finite and that technology may not provide an easy fix (Wray-Lake et al., 2010). Thus, the combination of building awareness of the fragile natural environment in the urban ecology and learning what people can do to sustain and protect it as outlined in the PBSE model presented in this paper is a win-win.

A meta-analysis of research on pro-environmental behavior indicates that awareness of one's interdependence with other people and species motivates actions to protect that larger community (Bamberg and Moser, 2007). Through their projects, some students felt that they had gained an understanding of the interdependence of humans with the natural world. This awareness may be a foundation for moral responsibility for the natural environment. According to Bandura (2007) one of the ways people morally disengage from environmental responsibility is to disregard or demean the recipients (whether human or other living things) of their actions. To combat this ignorance, it is important that people understand that their actions impact other living things. The fact that 42% of the reflections referred to non-human species as beneficiaries of the environmental projects suggests that students are developing a regard for these recipients of their actions.

With respect to the second dimension of the Environmental Commons, through their collective actions with fellow community members – from their own and other generations – students develop a stake in the local environment and community

and an awareness of their own capacity to act. Consistent with an action competence model of environmental education, knowledge is combined with action in these projects (Jensen and Schnack, 1997). The emphasis on problem solving should help younger generations cope with the environmental challenges they will inevitably face armed with ideas, resolve, and a language of possibility (Jensen and Schnack, 1997; Mogensen and Schnack, 2010). The collective action emphasis in these PBSE projects is somewhat unique in education but may be a valuable tool for curbing pessimism in light of the scale of problems such as climate change. To cope with climate change, leveraging the social context in which people make decisions and emphasizing the power of the group to effect change are effective strategies (Roser-Renouf et al., 2014).

Statements coded in the second dimension evoke the defining features of the public realm as outlined by the political theorist, Hannah Arendt (1958). For example, students' sense of identification with the broader community and pride in their team's civic contribution echo Arendt's argument that the public realm is the common world that gathers people together, that it represents a diversity of experiences and perspectives, and that activity in that realm helps people to realize their personal stake in the common good. Arendt (1958) also points out that people will bring a diversity of experiences and standpoints to discussions and actions in this realm. Indications that students were developing an impression of this aspect of the public realm were revealed in comments about the value of different perspectives ("everyone's brain working together") for group problem solving and how trust developed as members of the group listened to one another's ideas about how to achieve their shared goal. Because they partnered with adults from the community, students also were exposed to different generations of people active in the public realm. References to meeting people and getting to know organizations that were "helpful" and "cared a lot" point to the success of these projects in expanding youths' social networks and developing their social capital (Hart et al., 2008).

In some projects students worked to get abandoned properties in blighted neighborhoods removed and then to replace the empty spaces with public parks. Such projects are examples of what scholars have called *critical civic praxis* in which urban youth of color exercise collective agency to change debilitative neighborhood conditions (Ginwright and Cammarota, 2007). Through such praxis, students asserted their right to beautiful public spaces where they and fellow residents can gather. They also assumed responsibility for their communities, and, by making their mark, showed that they cared about and believed in those communities. Not only had they reclaimed public space but they also rewrote the narrative about themselves and their communities.

Recognition of students' critical civic praxis from fellow members of the community echoes another characteristic of work in the public realm, as outlined by Arendt (1958), i.e., it is seen and heard by everyone. When residents of the community witnessed the students' work and thanked them, students realized that they were transforming the public's image of young people, that, as one young person put it, "they are starting to see we mean business and are going to be successful." The fact that their positive public contributions can be seen and heard by everyone holds particular promise in the more blighted communities where stereotypes and prejudice persist. The resolve to change those stereotypes was captured in a student's observation that their project, "helped the way people look at us. Everyone thinks our town or school is just so bad and full of uneducated kids but we think different."

The projects documented here also challenge dominant representations of humans in the natural environment (in advertising, consumption, and outdoor recreation) as people who are White and middle-class. As Finney (2014) suggests in her book, *Black Faces, White Spaces,* such images constrain our imagination and our beliefs about who has knowledge and who cares about nature. In fact, contrary to these stereotypical images, many contemporary environmental justice organizations are led by youth of color who apply an intersectional analysis linking race, class, and the natural environment to address the root causes of environmental injustice and offer hopeful solutions (Quiroz-Martinez et al., 2005; Gallay et al., 2016a). In addition, the focus on nature in urban areas opens new possibilities for human awareness and vigilance about protecting the natural environment, an awareness that is critical as urban communities deal with the challenges of climate change.

Limitations and Future Directions

The limitations in our study were based, in part, on our goal of building theory grounded in a particular model of PBSE in urban communities. We relied on students' own words about what they learned from their practice and thus our work is emergent. Because relatively little is known about how youth in these communities experience and perceive the natural environment, hearing from them first-hand is a necessary foundation for constructing valid instruments (Karabenick et al., 2007). That said, claims about change in students' environmental understanding are limited by the fact that data were not collected prior to their engagement in the PBSE projects. Future studies should establish a baseline of students' understanding of the natural environment as experienced in their urban context before they participate in projects and then assess change associated with participation. In addition, insofar as students apply subject matter (science, math, etc.) to address a local environmental issue, future work should explore whether their academic interests are piqued by making a meaningful contribution to their communities and whether they see the affordances of learning environmental science for realizing community goals.

CONCLUSION

Students' reflections on what they learned from engaging in these PBSE projects resonate with the elements of groups that make them effective in managing common-pool resources: proximity to the issue and immersion in work in the local context, identification with the shared goals of the group, and the trust and respect that stem from engagement with the group over time (Cardenas and Ostrom, 2006). Our focus on

youth and the environmental commons brings the elements that Ostrom identified into the field of youth civic development. Whereas Ostrom focused on the qualities of effective groups for preserving common-pool resources, the field of youth civic development examines the practices and relationships through which young people develop the skills, dispositions, and motivations that foster life-long civic commitments.

Scholars of youth civic development have pointed to the civic-science nexus as a rich context where younger generations can gain skills they will need to grapple with 21st century challenges (Hart and Youniss, 2018). Likewise, a new model of ecological citizenship suggests that children's stake in environmental justice and civic decision-making should be simultaneously nurtured through practices that combine collective agency, deliberation, and self-transcendence (Hayward, 2012). Perhaps the most urgent issue of the 21st century is how people will adapt to changes in the Earth's natural environment that humans have created. Educating younger generations about human interdependence with nature and nurturing a sense of vigilance about that delicate balance is critical. However, knowledge of the issues and motivation to do something must be balanced with collective actions in communities where young people can gain both a sense of agency and the reassurance that they do not have to solve the problems on their own.

AUTHOR CONTRIBUTIONS

CF was the PI on the project and took the lead on the conceptualization and writing of the manuscript. EG took the lead on data collection while EG, AP, and MS coded and analyzed the data and provided feedback on the manuscript.

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Individualist–Collectivist Differences in Climate Change Inaction: The Role of Perceived Intractability

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The willingness to take action against climate change may be shaped by cultural orientations. The present study investigated individualist–collectivist differences in climate change inaction as well as the mediating role of perceived intractability. In Study 1, a survey of 182 undergraduates showed that greater perceived intractability of climate change was significantly related to a lower frequency of climate-friendly actions in the preceding 6 months. In Study 2, participants who were exposed to information concerning the intractability of climate change (experimental group, n = 98) reported a significantly greater perceived intractability of climate change and lower intention to assume a low-carbon lifestyle than those presented with neutral information (control group, n = 83). Based on Studies 1 and 2, participants with collectivist or individualist orientations were recruited from a pool of Chinese undergraduate students in Study 3. We found that participants with a more individualist orientation (n = 62) are more subject to perceived intractability, and less likely to take climate-friendly action than those with a more collectivist orientation (n = 94), and individualist/collectivist status affects climate change inaction through perceived intractability as mediator. The implications of these findings are discussed in relation to the promotion of public engagement with climate change by mitigating perceived intractability.

Keywords: climate change inaction, perceived intractability, climate change, collectivism, individualism

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INTRODUCTION

Despite increasing pressure to deal with climate change, individuals have been hesitant to respond effectively. As stated by Pölzler (2015), "we consume as much as we always did, drive as much as we always did, eat as much meat as we always did." Indeed, public opinion polls and previous studies have also indicated that our action on climate change is limited. According to the results of a Eurobarometer survey carried out in 2009, just over half (53%) of European Union citizens say they took some kind of action to combat climate change over the previous 6 months (European Commission, 2009). Likewise, Fu et al. (2015), in a survey of 2,100 respondents, found that only 57.05% of Chinese individuals reported always or often engaging in energy-saving activities to alleviate climate change. Now that climate change is one of the greatest challenges facing global society, why are we so reluctant to take action against it? Recently, individual inaction over climate change mitigation, so-called climate change inaction, has been attracting increasing attention.

Climate Change Inaction and Its Psychological Barriers

Though climate change inaction has appeared periodically in public discourse and scientific literature, a clear definition is still lacking. Roughly, any form of an actor's inactive state in

addressing climate change could be described as climate change inaction. The concept of "climate change inaction" is widespread in the environmental economic literature. This line of inquiry aims to calculate the cost of climate change inaction versus inputs caused by action on climate change (e.g., Rodríguez-Labajos, 2013). Recently, this concept was introduced into the field of environmental psychology in order to address the question of why we do not take action on climate change. Climate change inaction occurs at various levels involving individuals, businesses, and governments. Individual inaction on climate change may be manifested in indifference to climate change in daily routine, e.g., denying climate change as a vital issue (Engels et al., 2013; Liu, 2015) or continuing a high-carbon lifestyle (Boucher, 2016). On a macro level, psychological (e.g., short-termism) and structural (e.g., restricted financial resources) factors could hinder companies and governments in actively responding to climate change (Slawinski and Bansal, 2012; Slawinski et al., 2015; Finke et al., 2016). Obviously, forms of climate change inaction intersect at different levels. For instance, governmental non-supportive policy will discourage companies' investment in climate-friendly products, which will in turn foster consumers' climate change inaction.

In the present article, we focus on individual climate change inaction. For most of us, one of the most feasible ways to tackle climate change may lie in low-carbon lifestyle changes. Clearly, individuals face a wide range of options. For example, Wynes and Nicholas (2017) suggested that annual personal carbon emissions could be reduced by 0.8t via eating a plant-based diet. Despite the feasibility and efficiency of low-carbon lifestyles, many of us still engage in behaviors that are detrimental to the environment or fail to engage in ameliorative actions.

Traditionally, conventional wisdom ascribes individual inaction against climate change to attitudinal deficit, i.e., people tend to underestimate or deny the threat posed by climate change. Of fundamental interest to researchers is determining how and why we perceive climate change as we do. Research related to climate change risk perception has indicated that people are inclined to perceive climate change as a psychologically distant risk that might occur far in the future, impacting distant places and affecting people dissimilar to themselves (Leiserowitz, 2004; Jones et al., 2017). Other factors that sway climate change risk perceptions were also documented by several researchers, e.g., age, personal experience, and cultural worldview. The underlying assumption behind these studies is that climate-friendly behavior could be nudged by revising individuals' perceived risk. However, this assumption has not been consistently confirmed (e.g., Safi, 2011).

Unlike the above-mentioned research, climate change inaction research places a direct emphasis on the circumstances in which people stay inactive in the face of climate change. This research argues that we must first clarify the causes of climate change inaction in order to overcome it (Pölzler, 2015). There is a large body of researchers attempting to identify the constraints of climate change inaction. Among these, psychological barriers have attracted much attention, as they are more susceptible to interventions than are other factors (Stern, 2011; Swim et al., 2011). A number of psychological (as opposed to structural) barriers have been proposed (Lorenzoni et al., 2007; Johnson and Levin, 2009; Moser and Ekstrom, 2010; Gifford, 2011; Mäkiniemi and Vainio, 2014; Gifford and Chen, 2017). Utilizing a mixed-method approach, Lorenzoni et al. (2007) identified a range of barriers that members of the United Kingdom public perceive to engaging with climate change, i.e., uncertainty, skepticism, and reluctance to change one's lifestyle. Likewise, Gifford and Chen (2017) demonstrated that three kinds of psychological barriers are significantly associated with fewer climate-ameliorative food choice intentions (e.g., purchase organically grown food, eat less meat): denial (e.g., "There's no need to make these changes because I'm not convinced that a serious environmental problem even exists"), conflicting goals and aspirations (e.g., "I'm concerned that these changes will take up too much of my time"), and tokenism (e.g., "I'm satisfied with my current way of doing things").

Individualism–Collectivism and Climate Change Inaction

As mentioned above, barriers to climate change action have been attracting increasing attention, but few studies have explored how cultural orientation may result in climate change inaction. There is a wealth of literature concerning climate change, demonstrating that cultural orientation plays a crucial part in an individual's attitudinal response to climate change (e.g., Shi et al., 2015; Xue et al., 2016). For instance, a large body of research drawing on Cultural Theory (Douglas and Wildavsky, 1982) has well documented that the ways in which people perceive climate change risk are shaped by the cultural worldviews that they hold (Weber, 2010; McNeeley and Lazrus, 2014). However, individual action against climate change does not necessarily depend on our risk perception of climate change (Bain et al., 2016). Certainly, there are studies of behavioral responses to climate change, but most of them have largely focused on the difficulty of implementing certain practices rather than on the phenomenon of climate change inaction itself (Slawinski et al., 2015). The results of a study conducted in Kiribati by Kuruppu (2009) suggested that people's capacity to diversify water resources (a way of adapting to climate change) is constrained by cultural values attached to the material resources they possess. Still, we cannot infer that cultural processes cause climate change inaction based on Kuruppu's findings.

Given that individual responses to climate change could be shaped by cultural orientation, it is reasonable to assume the reverse-that is, climate change inaction may also vary as a function of certain cultural factors. We believe that individualism-collectivism might be one such factor. A great deal of research has utilized individualism–collectivism as a key dimension to analyze and differentiate cultural orientation. According to the existing research, individualism (vs. collectivism) is characterized by the view of an independent self (vs. interdependent self) (Markus and Kitayama, 1991). Specifically, individualists focus on personal autonomy and individual uniqueness and place personal goals over group goals. By comparison, collectivists care about group norms

and collective harmony and subordinate personal goals to the group goals (Wagner and Moch, 1986; Strunk and Chang, 1999; Voronov and Singer, 2002). Though most works related to individualism–collectivism have been cross-cultural (e.g., differences in individualism/collectivism across countries), there is some evidence to suggest that a distinction between individualism and collectivism can exist within a single culture in the form of individual differences (Moorman and Blakely, 1995). Following this, the current investigation focuses on individualism–collectivism at the individual, psychological level.

We propose that individualism is more related to climate change inaction than is collectivism. This assumption derives support from the following considerations. First, individualist versus collectivist orientations have been found to influence pro-environmental behavior (Cho et al., 2013). Roughly, collectivist individuals are more likely to engage in a variety of pro-environmental behaviors than are those with individualist tendencies, including resource conservation (Dunlap and Liere, 1984) and green purchasing behaviors (Kim, 2005). Further, a survey conducted in New Zealand by Semenova (2015) found that the more environmentally active group (sampled from the sustainable communities) was more collectivist in its value orientation than was the less environmentally active group (sampled from the general population). Similar findings were also reported by Jia et al. (2017), who demonstrated that environmental activists were more likely to endorse self-transcendent values (similarly to collectivism, e.g., universalism-concern), while non-activists were more likely to endorse self-interest values (similarly to individualism, e.g., self-direction). In addition, several studies within the framework of cultural worldview have also suggested that individualist worldviews are negatively related with concern about climate change, willingness to behave in climate-friendly ways, and acceptance of related policy measures (e.g., Xue et al., 2016).

Perceived Intractability, Individualism–Collectivism, and Climate Change Inaction

In addition to the individualism–collectivism difference in climate change inaction, we seek to further demonstrate that this difference might be caused by individuals' perceptions of the intractability of climate change. To the best of our knowledge, the concept of intractability in the environmental psychology domain was originally developed by Campbell (1983) as one of the five characteristics of ambient stressors. According to Campbell (1983), intractability refers to objective features of ambient stressors, where the isolated efforts of individuals do not bring about substantial changes in the presence of ambient stressors. The fact that climate change is a global problem that requires the combined actions of millions of individuals working together has been accepted by the international community. However, this fact also yields an objective dilemma, that is, climate change is intractable to the action of individuals to change it. Therefore, perceived intractability of climate change in the present study refers to one's belief that climate change cannot be addressed by individual action. As an intrinsic characteristic of climate change, intractability is distinguished from other closely related concepts, such as climate change helplessness (Salomon et al., 2017). Climate change helplessness was defined by Salomon et al. (2017) as the belief that climate change is beyond personal control, which emphasizes individual experience instead of climate change.

Given that individual actions or the collective actions of many individuals cannot ameliorate climate change within a limited space-time frame, it appears intuitively reasonable that individuals who realize the intractability of climate change are likely to be inactive against climate change. Taking carbon emissions as an example, a recent report on the Global Carbon Budget, 2017 published by the Global Carbon Project (GCP) claimed that global CO_2 emissions in 2017 reached a new record of 36.8 Gt (Global Carbon Budget, 2017). Although many actions with the potential to reduce annual personal emissions have been recommended, e.g., living car-free (2.4 tCO_2e saved per year), avoiding airplane travel (1.6 tCO_2e saved per roundtrip transatlantic flight), and eating a plant-based diet (0.8 tCO_2e saved per year) (Wynes and Nicholas, 2017), emissions reductions realized by individual lifestyle changes still seem rather trivial. In this case, it is possible that individuals may consider climate change an intractable issue, since their low-carbon behavior is ineffective or meaningless for climate change, which in turn limits their action on climate change.

Furthermore, individualism and collectivism may relate to different propensities to perceive climate change as intractable. Individualism and collectivism may involve the perceived intractability of climate change in two ways. In the first, when confronted with climate change, individuals with individualist orientations usually rely on a self-reliant coping style, that is, viewing behavioral changes related to climate change as a personal matter and tackling climate change on their own. In this case, individualists may feel that climate change is so intractable that it cannot be solved by their individual actions. By contrast, when confronted with climate change, collectivists may regard fighting climate change as a collective mission, and thus, although individual contributions are small, they still matter. Hence, it is less likely for collectivists to perceive climate change as intractable. As a second example, it has been found that individualism and collectivism differ in social desirability: collectivists are more likely to be socially desirable than individualists (Lalwani et al., 2006; Riemer and Shavitt, 2011; Oh, 2013). Given that members of society are expected to take action against climate change, it is evident that collectivists are more responsive to this social expectation than individualists. In this case, in order to maintain a positive and normative image, collectivists are less prone to acknowledge that climate change is intractable.

OVERVIEW OF THE PRESENT RESEARCH

Based on the above descriptions, the present research aimed to demonstrate individualism–collectivism differences in climate change inaction and test whether the perceived

intractability of climate change could account for this phenomenon. To this end, three studies were conducted. Given that the relationship between perceived intractability and climate change inaction has thus far received little empirical support, the first two studies were conducted to provide initial evidence for it in the general population. The third study specifically investigated individualism–collectivism. Specifically, Study 1 was designed to identify the possible correlation between perceived intractability and climate change inaction. We hypothesized that climate change inaction is correlated positively with perceived intractability. The aim of Study 2 was to provide more convincing evidence for the causal effect of perceived intractability on climate change inaction. We expected that participants who were reminded of the intractability of climate change would show a greater tendency to climate change inaction than participants in the control condition. In Study 3, we investigated and compared perceived intractability and climate change inaction among collectivist and individualist participants. We hypothesized that collectivist participants would perceive higher intractability than individualist participants, and thus be less likely to take climate-friendly action.

It is noted that because other factors (e.g., beliefs, risk perception, or knowledge related to climate change) have been shown to relate to action on climate change (Ohe and Ikeda, 2005; Hidalgo and Pisano, 2010; Vainio and Paloniemi, 2013; Shi et al., 2015; Mase et al., 2016), we tested these factors in conjunction with the variable of the perceived intractability of climate change. We expected that climate change inaction is related to the perceived intractability of climate change, even when controlling for other related variables.

STUDY 1

Methods

Participants

In total, 182 undergraduates (56% males) participated in this survey. Their ages ranged from 17 to 24 years (M = 18.79, SD = 1.46). Participants were recruited from a large subject pool from Nanjing University. They received a small gift (worth around 5 USD) for their participation.

Procedure and Materials

Participants were asked to access the online survey and complete a series of questionnaires via Wenjuanxing, a Chinese online survey website. In addition to perceived intractability, two other related variables were measured: belief in climate change and climate change risk perception. The measures, which were developed based on English scales, were translated into Chinese so that respondents could understand them. Equivalence between the Chinese and the English versions was ensured through careful checking and back-translation.

Belief in Climate Change (BCC)

Belief in Climate Change (BCC) was measured with the three-item scale developed by Vainio and Paloniemi (2013). This scale asked participants if they agreed or disagreed with three statements: "Climate change is an unstoppable process; we cannot do anything about it," "The seriousness of climate change has been exaggerated," and "Emission of CO_2 (carbon dioxide) has only a marginal impact on climate change." Participants were asked to answer on a 4-point scale from 1 (*totally agree*) to 4 (*totally disagree*). Cronbach's α for this scale was 0.608.

Climate Change Risk Perception (CCRP)

The Climate Change Risk Perception (CCRP) was a measure based on Leiserowitz's (2006) Climate Change Risk Perception Index. The measure includes nine items rated on a 4-point scale, with higher scores indicating that participants display greater CCRP. A sample item is "How concerned are you about climate change?" Cronbach's α for this scale was 0.864.

Perceived Intractability of Climate Change (PICC)

A 4-item Likert-type scale was developed to measure Perceived Intractability of Climate Change (PICC). PICC was operationalized with the following items: (1) my individual action would likely do little to aid the fight over climate change; (2) I can bring a fundamental change in climate change in everyday life; (3) climate change couldn't be relieved by my day-to-day behavior; and (4) my daily action could have a positive impact on climate change. Participants were asked to answer on a 4-point scale from 1 (*totally agree*) to 4 (*totally disagree*). The second and fourth items were reverse-scored so that high scores represented a high perceived intractability. Cronbach's α for this scale was 0.758.

Climate Change Inaction (CCI)

Climate Change Inaction (CCI) was measured with one straightforward question: "How often, on a scale of 1 (*not very often*) to 7 (*very often*), have you taken some kind of action to combat climate change over the last 6 months?" The values were reversed so that high values represented high climate change inaction.

Results

All data analyses were performed with SPSS 20.0. We first computed descriptive statistics, and then explored the relationship between PICC and CCI with hierarchical multiple regression.

The means, standard deviations, and Pearson correlations of the variables are presented in **Table 1**. We found that CCI was significantly related to PICC (r = 0.476, $p < 0.01$). That is, higher perceived intractability of climate change was related to lower frequency of climate-friendly behavior over the past 6 months. In addition, there was a significant negative correlation between CCI and BCC ($r = -0.269$, $p < 0.01$), as well as CCRP ($r = -0.227$, $p < 0.01$).

Using a hierarchical multiple regression analysis, we tested our hypothesis that individuals who rated climate change as more intractable less frequently took climate-friendly action in the preceding 6 months. In the model, CCI was treated as the dependent variable, and BCC and CCRP were entered into the first block as control variables, and PICC score into

TABLE 1 | Descriptive statistics and correlations for major variables of Study 1.

	M	*SD*	*Max*	*Min*	1	2	3	4
1. BCC	8.92	2.06	12.00	3.00				
2. CCRP	23.79	5.16	36.00	12.00	0.044			
3. PICC	12.43	5.43	16.00	4.00	−0.413**	−0.187		
4. CCI	3.39	2.01	7.00	1.00	−0.269**	−0.227**	0.476**	

*BBC, Belief in Climate Change; CCRP, Climate Change Risk Perception; PICC, Perceived Intractability of Climate Change; CCI, Climate Change Inaction. *$p < 0.05$; **$p < 0.01$.*

TABLE 2 | Summary of hierarchical multiple regression analyses for predicting CCI of Study 1.

	Model 1		Model 2	
Variables	***B* (*SE*)**	**β**	***B* (*SE*)**	**β**
BCC	−0.252 (0.068)	−0.260**	−0.090 (0.069)	−0.093
CCRP	−0.084 (0.027)	−0.216**	−0.057 (0.026)	−0.146*
PICC			0.151 (0.027)	0.410**
R^2		0.119**		0.253**

*BBC, Belief in Climate Change; CCRP, Climate Change Risk Perception; PICC, Perceived Intractability of Climate Change; CCI, Climate Change Inaction. *$p < 0.05$; **$p < 0.01$.*

the second block. The results (see **Table 2**) indicated that CCI was significantly negatively related to BCC ($\beta = -0.260$, $p < 0.01$) and CCRP ($\beta = -0.216$, $p < 0.01$). The results also indicated that after controlling the effect of BCC and CCRP, the effect of PICC on CCI was still statistically significant ($\beta = -0.151$, $p < 0.01$).

Discussion

Since no study has been conducted so far to explore the relationship between CCI and PICC, Study 1 aimed to provide preliminary evidence for this issue. Clearly, the results of Study 1 showed that CCI, which is operationalized as a low frequency of climate-friendly action over the preceding 6 months, is significantly correlated with the level of PICC. This correlation remains significant even when we control for other related variables, such as BCC and CCRP. These findings support our hypothesis that climate change inaction is correlated positively with perceived intractability. However, it is still unclear whether an activation in PICC salience would result in CCI. We would like to further examine the causal effect of PICC on CCI experimentally. In addition, as CCI in Study 1 was operationalized as a retrospective evaluation of past behavioral patterns, such self-reported results may be swayed by recall bias whereby participants are indifferent to their past behaviors. Therefore, prospective intention (rather than retrospective frequency) relating to climate-friendly actions was used alternatively in Study 2. Another potential deficiency is the knowledge deficit, that is, participants do not know which daily behaviors are helpful in curbing climate change. This problem was avoided in Study 2 by assessing the participants' knowledge of climate change action (KCCA).

STUDY 2

Methods

Participants

One hundred and ninety-eight undergraduates initially volunteered to participate in the study, recruited from a large subject pool from Nanjing University. All participants were evenly distributed to the experimental or control group. Seventeen cases were deleted for not returning their questionnaires. Thus, the final sample was based on a total of 181 participants (experimental group: $n = 98$; control group: $n = 83$). Their mean age was 20.80 ($SD = 1.98$), and 51% of them were females. They were paid 30 CNY (around 5 USD) for their participation.

Procedure and Materials

Participants were asked to complete the survey experiment via Wenjuanxing. The experimental procedure was as follows. First, given that Study 1 showed that BCC and CCRP are potential contributors to climate change inaction, the experimental and control groups first completed the BCC and CCRP instruments, which were the same as those used in Study 1, before receiving subsequent interventions. We aimed to test whether the baseline levels of BCC and CCRP were similar between the experimental and control groups in order to control for their confounding effect on CCI. Second, participants read a passage about climate change, which served to manipulate the PICC variable. Specifically, the experimental group was presented information indicating climate change is inherently intractable, whereas participants in the control group were presented with neutral information describing the manifestations of climate change, i.e., global warming, acid rain, and ozone depletion (see **Appendix 1**). After reading these distinct passages, both groups reported their perceived intractability of climate change as in Study 1. Third, all participants finished the measurement of CCI. Unlike Study 1, a novel measure of CCI was employed in the present study. Considering that individuals' climate change (in)action may depend on the level of knowledge about climate-friendly behaviors, we created a questionnaire to measure participants' KCCA. Participants were presented with a checklist containing ten daily behaviors. Sample items include "Cut meeting times as short as possible," "Eat less meat if you can," and "Machine-wash clothing only when there is a full load." We instructed them to identify whether each item in their view is climate-friendly with yes or no (yes = 1, no = 0). As a matter of fact, all the items are climate-friendly. We calculated the measure of KCCA by adding the participants' answers, so that higher scores indicate higher levels of KCCA. Participants were then asked to report how likely they were to perform their chosen behaviors in the future on a 7-point Likert-type scale ranging from 1 (*highly unlikely*) to 7 (*highly likely*). The values were reversed so that high values represented high CCI.

Results

Table 3 presents the descriptive statistics. An independent-samples *t*-test was performed on PICC between the experimental and control groups. Consistent with the manipulation, there was a significant difference for PICC between the experimental and control groups, with the experimental group showing higher scores: $t(179) = -5.48$, $p < 0.001$, $M_d = -3.85$, 95% CI = [−5.23, −2.46], Cohen's $d = -0.82$. Furthermore, the results showed that the CCI scores of the experimental group were significantly higher than those of the control group [$t(179) = -4.86$, $p < 0.001$, $M_d = -0.91$, 95% CI = [−1.28, −0.54], Cohen's $d = -0.73$]. An ANCOVA was conducted to assess between-group differences in CCI, with BCC, CCRP, and KCCA as co-variates. The effect of group remained significant for CCI [$F(1,176) = 5.649$, $p < 0.001$, $\eta_p^2 = 0.111$]. This result showed that the difference in PICC and CCI between the two groups was independent of BCC, CCRP, and KCCA.

Discussion

Participants who had just been exposed to intractability-inducing information reported higher levels of perceived intractability of climate change than those exposed to neutral information, whereas the differences in other related variables (i.e., BCC, CCRP, and KCCA) between the experimental and control groups were not statistically significant. Moreover, participants in the experimental group were more likely than those in the control group to exhibit climate change inaction, i.e., being reluctant to perform climate-friendly action. Taken together, these results support our second hypothesis, which postulated that those who were reminded of the intractability of climate change would be less likely to take climate change action than those in the control condition.

In short, Study 2 provided preliminary evidence for the causal effect of perceived intractability on climate change inaction. This finding further ruled out the possibility that perceived intractability may be used as self-justification by individuals to defend their inaction on climate change. Thus Study 2 provided the preconditions for Study 3, which examined the effect of individualistic/collectivistic status on climate change inaction and the mediation of perceived intractability.

TABLE 3 | Descriptive statistics and independent samples *T*-test for major variables of Study 2.

	Experimental group		Control group		*Max*	*Min*	*t*
	M	*SD*	*M*	*SD*			
BCC	8.98	2.21	8.65	2.16	12.00	3.00	−1.009
CCRP	26.14	6.08	26.41	5.40	36.00	9.00	0.310
KCCA	4.91	2.47	4.75	2.12	10.00	1.00	−1.253
PICC	14.52	5.58	10.67	3.80	16.00	4.00	−5.483**
CCI	3.48	1.56	2.57	0.94	7.00	1.00	−4.861**

*BBC, Belief in Climate Change; CCRP, Climate Change Risk Perception; KCCA, Knowledge of Climate Change Action; PICC, Perceived Intractability of Climate Change; CCI, Climate Change Inaction. *p < 0.05; **p < 0.01.*

STUDY 3

Methods

Participants and Procedure

The initial sample included 788 freshmen (148 women, 640 men; age ranging from 17 to 23) from Zhejiang Ocean University. Participants were initially recruited for the Chinese Values Changing Survey (CVCS) conducted in August 2017, which was planned to trace changes in values annually from 2017 to 2020 among Chinese adolescents. All participants were instructed to finish a battery of questionnaires online at the time of the survey, including an individualism–collectivism measure. Specifically, individualism–collectivism was assessed by a 16-item scale. This version of the scale was derived from the Individualism–Collectivism Scale (Singelis et al., 1995), which differentiates between horizontal and vertical types of individualism and collectivism, and the items related to horizontal individualism (e.g., "I often do 'my own thing'"; Cronbach's α = 0.744) and collectivism (e.g., "I feel good when I cooperate with others"; Cronbach's α = 0.717) were used. The participants responded to 16 items on a 9-point Likert scale ranging from 1 (*strongly disagree*) to 9 (*strongly agree*).

Chinese Values Changing Survey provided a starting point for the Study 3, which was conducted in October 2017. Because of our conceptualization of individualism–collectivism as an individual-difference variable, we only selected participants with extreme individualist or collectivist orientations for Study 3. Following a previously documented procedure (for greater detail, see Caldwell-Harris and Ayçiçegi, 2006), 227 participant candidates were picked and identified as either individualists ($n = 96$) or collectivists ($n = 131$) according to their initial scores on the individualism–collectivism measure. [1] All participant candidates received an email inviting them to undertake the survey. In addition to the variables assessed in Study 2, the identical measure of individualism–collectivism was also included. A total of 156 surveys were completed and returned (67% response rate), with participants in both an individualist group ($n = 62$) and a collectivist group ($n = 94$). Therefore, the final sample of Study 3 consisted of 156 freshmen (43 women, 113 men), with a mean age of 18.85 years ($SD = 1.458$). Participants received an honorarium of 30 CNY for participating in the study.

Results

The means, standard deviations, and Pearson correlations of the variables are presented in **Table 4**. An independent-samples *t*-test was performed on the various measurements between the individualist and collectivist groups (see **Table 5**). As expected, the scores on the individualism dimension of the individualist

[1]Similiar grouping procedures are common in research related to individualism/collectivism, especially those conduced within a single cultural background. In these studies, participants were artificially categorized as individualists or collectivists based on their scores on an instrument (e.g., Liddell et al., 2015) or through individualism/collectivism priming (e.g., Goncalo and Staw, 2006). Despite latent limitations, the individualism/collectivism dichotomy could methodologically avoid a situation in which individuals simultaneously exhibit individualist and collectivist orientations.

TABLE 4 | Descriptive statistics and correlations for major variables of Study 3.

	M	*SD*	*Max*	*Min*	1	2	3	4	5
1. BCC	8.65	2.10	12.00	3.00					
2. CCRP	24.40	5.30	36.00	12.00	−0.004				
3. KCCA	4.78	2.22	10.00	1.00	0.250	−0.002			
4. PICC	11.99	4.71	16.00	4.00	−0.333**	−0.120	−0.205		
5. CCI	2.73	1.34	7.00	1.00	−0.321**	−0.160*	−0.133	0.400**	

*BBC, Belief in Climate Change; CCRP, Climate Change Risk Perception; KCCA, Knowledge of Climate Change Action; PICC, Perceived Intractability of Climate Change; CCI, Climate Change Inaction. *$p < 0.05$; **$p < 0.01$.*

TABLE 5 | Means (SDs) and independent samples *T*-test for major variables of Study 3.

	Individualist group	Collectivist group	*t*
	M (*SD*)	*M* (*SD*)	
Individualistic orientation	58.02 (7.68)	49.32 (11.06)	5.460**
Collectivistic orientation	49.80 (10.07)	59.94 (8.98)	−6.307**
BCC	8.31 (2.16)	8.87 (2.04)	−1.656
CCRP	23.97 (4.45)	24.07 (5.79)	−0.867
KCCA	4.42 (1.96)	5.02 (2.37)	−1.664
PICC	13.69 (4.33)	10.87 (4.64)	3.815**
CCI	3.24 (1.64)	2.39 (0.96)	3.682**

*BBC, Belief in Climate Change; CCRP, Climate Change Risk Perception; KCCA, Knowledge of Climate Change Action; PICC, Perceived Intractability of Climate Change; CCI, Climate Change Inaction. *$p < 0.05$; **$p < 0.01$.*

group were significantly higher than were those of the collectivist group: $t(154) = 5.77$, $p < 0.001$, $M_d = 8.22$, 95% CI = [5.40, 11.03], Cohen's $d = 0.95$. Similarly, scores on the collectivism dimension of the individualist group were significantly lower than were those of the collectivist group, $t(154) = -6.31$, $p < 0.001$, $M_d = -10.61$, 95% CI = [−13.95, −7.28], Cohen's $d = -1.04$. No significant difference was found in BCC, CCR, or KCCA between groups ($p > 0.05$).

An ANCOVA was conducted with BCC, CCRP, and KCCA as co-variates. The effect of group remained significant for PICC [$F(1,151) = 10.150$, $p < 0.01$,$\eta_p^2 = 0.063$] and CCI [$F(1,151) = 12.447$, $p < 0.01$, $\eta_p^2 = 0.076$]. These results show that the differences in PICC and CCI between the two groups were independent of BCC, CCRP, and KCCA. Participants in the individualist group reported higher levels of PICC, $t(154) = 3.87$, $p < 0.001$, $M_d = 2.82$, 95% CI = [1.38, 4.26], Cohen's $d = 0.64$, and higher levels of CCI, $t(154) = 3.68$, $p < 0.001$, $M_d = 0.85$, 95% CI = [0.39, 1.31], Cohen's $d = 0.61$, than did those in the collectivist group.

To further investigate whether PICC has a mediating role between participants' individualist/collectivist status and CCI, a mediation analysis was performed with CCI as the dependent variable, individualist/collectivist status as the independent variable, and PICC as the mediator. In addition, BCC, CCRP, and KCCA were treated as control variables. For this, M-plus 7.4 was used with 5,000 bootstrap samples (Preacher and Hayes, 2008). Individualist/collectivist status was dummy coded with collectivist = 0 and individualist = 1, and all variables were standardized prior to analysis so that the results would provide standardized coefficients. Individualist/collectivist status had a significant effect on CCI ($b = 0.204$, $p = 0.006$) and PICC ($b = 0.294$, $p < 0.001$). Additionally, PICC positively predicted CCI ($b = 0.262$, $p = 0.002$). As hypothesized, the tests of indirect effects demonstrated that there was a significant indirect effect of individualist/collectivist status on CCI through PICC (99% CI [0.008, 0.174], $p = 0.018$).

Discussion

The results of Study 3 indicate that individuals with a more individualist orientation rated climate change more intractable and reported a greater incidence of climate change inaction than did individuals with more collectivist orientation. Further data analysis showed that the perceived intractability plays a mediating role in the relationship between individualist/collectivist status and climate change inaction. The findings were consistent with our hypothesis. Therefore, we infer that there are individualist–collectivist differences in climate change inaction, which may contribute to the level of perceived intractability of climate change.

GENERAL DISCUSSION

A central focus of the present article was to examine whether individualists would report a greater incidence of climate change inaction due to higher perceived intractability than collectivists. For this purpose, three studies were conducted. The main findings can be readily summarized. Study 1 showed that participants' self-reported frequency of climate change action in the preceding 6 months was negatively related to their perceived intractability. In other words, the more intractable participants felt climate change to be, the more demotivated they were to take climate change action. This result was supported in Study 2, which suggested that participants exposed to information concerning the intractability of climate change showed a significantly greater perceived intractability of climate change and lower intentions to assume a low-carbon lifestyle than those presented with neutral information. Based on the first two studies, participants with a collectivist or individualist orientation were recruited from a pool of Chinese undergraduate students in Study 3. We found that participants with more individualist orientations were more subject to perceived intractability and more likely to demonstrate climate change inaction than those with more collectivist orientations. Moreover,

the mediating role of perceived intractability in relations between individualist/collectivist status and climate change inaction was also confirmed.

The present findings may contribute to increasing our understanding of climate change inaction. The critical role of psychological barriers in climate change has been underlined by the recent researches (Gifford, 2008). Existing theories and empirical studies have proposed a wide variety of psychological barriers that trigger climate change inaction (Frantz and Mayer, 2009; Aitken et al., 2011; Salomon et al., 2017). However, the literature is still limited on how the latent psychological barriers incur climate change inaction. In this article, we argue that the construct of perceived intractability provides a useful perspective from which to examine this matter. Without doubt, climate change is intractable in itself because greenhouse gas emission cannot be drastically reduced by the efforts of scattered individuals. This perceived intractability of climate change may further induce individuals to remain inactive against climate change. Our work is the first to show that the incidence of climate change inaction is indeed related to perceived intractability even when other related variables were controlled for. This result is in line with findings reported by previous literature. Aitken et al. (2011) found that stronger perceptions of powerlessness were related to lower levels of action to mitigate climate change. Likewise, Salomon et al. (2017) suggested that energy conservation behavior was connected with climate change helplessness-the belief that one's actions cannot affect climate change. In this sense, perceived intractability offers another avenue of insight to help us to understand why we are so reluctant to take action against climate change.

Clearly, climate change inaction is not a homogeneous phenomenon, and hence investigating individual differences in climate change inaction should contribute to a better understanding of why and how this phenomenon occurs. Individualism–collectivism-based differences in pro-environmental behavior have been reported in earlier studies (Mccarty and Shrum, 2001; Cho et al., 2013), which provided the impetus for this investigation of individualism–collectivism-based variations in climate change inaction. Consistent with existing findings, our results demonstrated that collectivist orientations may be more related to climate-friendly behaviors than are individualist orientations. Not only this, we further showed that these differences could be attribute to the perceived intractability of climate change. Extensive evidence indicates that our responses to climate change could be shaped by cultural orientations (Heyd and Brooks, 2009; Hoffman, 2010) at both the attitudinal and behavioral levels. The significance of our results lies in the fact that they make a unique contribution to the existing knowledge about climate change inaction by showing that individualism–collectivism shapes barriers to perform climate-friendly behaviors.

The present findings may shed some light on nudging public engagement in climate change. Public engagement, as one critical aspect in addressing climate change, has been repeatedly emphasized in public policy agendas worldwide. From an instrumental perspective, climate change is in no small part due to human activity, or more accurately, innumerable individual activities. Thus, any policy or action aimed at climate change mitigation and adaptation will largely depend on public support and participation. However, the resounding calls for public engagement raises one challenge for academics and practitioners, namely, how to promote public engagement in climate change (Whitmarsh et al., 2013; Van et al., 2015). In line with Campbell (1983), climate change is not intractable in itself given the potential efforts of every member of human society. Nevertheless, the results of the present paper suggest that perceived intractability may induce climate change inaction. Thus, it is inadvisable to rush to calls for public engagement in fighting climate change; instead, policymakers should encourage the public to believe that their individual actions are necessary as well as efficacious. More importantly, risk communication in the context of climate change should inform the public that climate change is not just potentially catastrophic, but solvable. This promising tactic is specific to special groups with individualist orientations, as they are more inclined to view climate change as intractable.

The present findings may also be of special significance to climate change mitigation in Chinese cultural context. As we all know, China is the world's largest carbon dioxide emitter. According to Global Carbon Budget, 2017 published by the Global Carbon project, China covered 28% of global emissions in 2017 (Global Carbon Budget, 2017). This big number may be hard to plummet, due to China's pursuing economic growth. What is more, conspicuous consumption and materialism are emerging in contemporary China (Podoshen et al., 2011; Sun et al., 2014, 2017), which may in turn hinder individuals to perform low-carbon lifestyles. In this case, policymakers and researchers will be confronted with a tough issue of promoting public engagement in climate change. On the other hand, there is enough evidence to indicate that individualism is increasing and collectivism is decreasing in contemporary China (Yang, 1996; Yi and Takeshi, 2014; Cai et al., 2018). As indicated by our findings, the rise of individualism may further pose a challenge for public engagement in climate change, because individualism is more related with climate change inaction. The above-mentioned fact should not be interpreted with pessimism. Instead, it reminds us that public engagement in climate change is possible only when psychological barriers of climate change inaction are overcome.

Nevertheless, some aspects of the current research require further consideration. First, the measures of belief in climate change used in the present study have face validity, but the internal consistency was lower than optimal. Although belief in climate change was treated as an irrelevant variable, study results may still be swayed by this flaw, suggesting that our findings should be interpreted cautiously. Second, the individualism–collectivism orientation was examined only within Chinese cultural background. To generate more conclusive support for the individualist–collectivist differences in climate change inaction, research conducted in other cultural backgrounds or using a cross-cultural comparative approach is necessary. Third, another limitation of the present studies is that we used self-report measures rather than measures of actual climate change (in)action. For future research, it is worthwhile to examine climate change inaction with objective measurements

related to a low-carbon lifestyle. Fourth, given that examining individualist–collectivist differences in climate change inaction was the original goal of the present research, an intervention study was not conducted. Meleady and Crisp (2017) redefined climate change inaction as temporal intergroup bias, and found that temporally adapted interventions for reducing prejudice may help elicit environmental protection. Similarly, future studies are expected to investigate how to encourage climate change action by overcoming the perceived intractability of climate change. Fifth, future studies could explore the boundary conditions of climate change inaction. Although, we distinguished intractability from helplessness, with an emphasis on the view that climate change is inherently intractable whereas helplessness may be a subjective experience concerning climate change, it is possible that perceived intractability make people feel helpless, which in turn results in climate change inaction. Therefore, it will be important to further explore the mediating role of helplessness in the relation between perceived intractability and climate change inaction. Moreover, the effect of perceived intractability on climate change inaction may be moderated by collective efficiency. Collective efficiency, people's shared belief in their collective power to produce desired results (Chen, 2015), may act as a buffer against the perceived intractability of climate change and further promote climate-friendly behavior.

ETHICS STATEMENT

This research is approved by the Institutional Review Board of Nanjing University. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Institutional Review Board of Nanjing University.

AUTHOR CONTRIBUTIONS

PX designed the study and drafted the manuscript. PX and HZ did the majority of the work on data collection and data analysis. LG contributed to the conception and design of the work. LG, KZ, and YW polished the manuscript.

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APPENDIX 1: PASSAGE USED FOR STUDY 2.

Experimental Group

Considering excessive carbon emission Is one of the larger contributors to climate change, it Is possible to lower carbon emission via reducing energy consumption in order to tackle climate change. According to a report published by the Global Carbon Project, global carbon emissions in 2013 reach a record high of 36 billion tons, and this number Is still growing. However, the amounts of carbon emissions reduced by a single individual seem to Be rather limited. for example, it Is estimated that if we Can decrease the time for having the television on by 1 h each day, the amount of carbon emission May Be reduced by 4.71 kg each month.

Control Group

Global warming Has Been identified as one of the most pressing issues human Is facing. Global warming occurs because of greenhouse gases effect, that is, atmospheric concentration of greenhouse gases (i.e., carbon dioxide) increases sharply due to human activities, and further absorb large amounts of the infrared radiation From the Earth, hence resulting in the rise of average global temperature. In order to obtain the energy, human burn fossil fuel such as oil, coal, and natural gas, which in turn emit an overwhelming quantity of greenhouse gases Into the atmosphere. Furthermore, forests' role as absorbers of carbon dioxide Has Been impaired by large-scale deforestation.

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Nature Relatedness and Environmental Concern of Young People in Ecuador and Germany

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Today's societies are confronted by a daily biodiversity loss, which will increase in the face of climate change and environmental pollution. Biodiversity loss is a particularly severe problem in so-called biodiversity hotspots. Ecuador is an example of a country that hosts two different biodiversity hotspots. Human behavior – in developing as well as in industrial countries such as Germany – must be considered as one of the most important direct and indirect drivers of this global trend and thus plays a crucial role in environmentalism and biodiversity conservation. Nature relatedness and environmental concern have been identified as important environmental psychological factors related to people's pro-environmental behavior. However, the human–nature relationship depends on a variety of other factors, such as values, gender, nationality, qualities of environmental concern and time spent in nature. This study compared young people from Ecuador and Germany with regard to their nature relatedness and environmental concern. Furthermore, the role of the aforementioned factors was investigated. In total, we surveyed 2,173 high school students from Germany (M_{age} = 14.56 years, *SD* = 1.45; female: 55.1%) and 451 high school students from Ecuador (M_{age} = 14.63 years, *SD* = 1.77; female: 55.3%). We found that young Ecuadorians were more related to nature than young people from Germany. Additionally, we found country-specific differences in the structure of environmental concern and in the role of gender in the explanation of biospheric environmental concern and nature relatedness. In both samples, the self-transcendence value cluster was a significant positive predictor for biospheric environmental concern and nature relatedness. Time spent in nature was a significant positive predictor for nature relatedness in both samples. The results are an empirical basis for the assumption of culture-specific differences in human–nature relationships.

Keywords: biodiversity, students, values, cross-cultural, environmental concern, gender, sustainable development, self-transcendence

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INTRODUCTION

The rate of biodiversity loss, among other environmental problems, such as climate change and biogeochemical cycles, has already exceeded its safe planetary boundary (Rockström et al., 2009; Steffen et al., 2015). Biodiversity loss not only affects the functioning of ecosystems (Cardinale et al., 2012) but also the ecosystem services for humanity (Costanza et al., 1997; Millenium Ecosystem Assessment, 2005). Even though the negative consequences of environmental destruction are globally relevant, some ecoregions, especially biodiversity hotspots, are of particular

importance in terms of biodiversity conservation. These biodiversity hotspots are characterized by an extraordinary plant and animal endemism as well as high levels of habitat loss (Mittermeier et al., 2011). By definition a hotspot must contain at least 1,500 endemic plant species (0.5% of the worlds' plant species) and should have lost at least 70% of its primary vegetation (Myers et al., 2000).

Ecuador is extremely rich with respect to biodiversity, as it is covered by two biodiversity hotspots, namely, the Tumbes-Chocó-Magdalena and Tropical Andes Hotspot (Mittermeier et al., 2011). For instance, Ecuador has the highest density of vertebrates species in the world (Myers et al., 2000). It hosts about 7.3% of the vertebrate species described worldwide and 7.6% of the vascular plant species (Ministerio del Ambiente del Ecuador, 2015). However, Ecuador is a so-called developing country in which a large part of the population suffers drastic socio-economic inequalities (Lopez-Cevallos and Chi, 2010). Therefore, socio-economic development is required, which is often considered to be associated with environmental degradation (Panayotou, 2016). For instance, Ecuador is still reporting a decrease in forest area (Food and Agriculture Organization of the United Nations [FAO], 2016) and an increased number of endangered species (Ministerio del Ambiente del Ecuador, 2015). The International Union for Conservation of Nature and Natural Resources (International Union for Conservation of Nature [IUCN], 2017a) lists nine extinct and 518 critically endangered, endangered, or vulnerable animal species, whereas nine plant species are considered to be extinct, and 1,857 plant species are classified as critically endangered, endangered, or vulnerable (International Union for Conservation of Nature [IUCN], 2017b).

However, the Ecuadorian government has developed new approaches for sustainable development with a focus on biodiversity conservation. For instance, Ecuador was the first country to incorporate the rights of nature and the indigenous concept of *Buen Vivir* in its constitution (Asamblea Constituyente de Ecuador, 2008). The basic idea of *Buen Vivir* is the good way of living in harmony with nature and other human beings (Lalander, 2016). However, Ecuadorian state policies are characterized by economic interests that are hindering the effective implementation of new biodiversity conservation measures (Lalander, 2016). Nevertheless, the debate about *Buen Vivir* and the rights of nature has contributed to a growing socio-cultural awareness regarding environmental issues (Rieckmann et al., 2011; Lalander, 2016). In addition, in industrialized countries such as Germany, efforts are being made to adapt some aspects of the basic concept of *Buen Vivir* (Acosta, 2015).

In a worldwide comparison, Germany, one of the most industrialized countries in the world, is counted as an area with relatively low biodiversity, on the basis of geological history development and geographic location. For instance, it hosts only 1.2% of the vertebral species described worldwide and 1.4% of the vascular plant species (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety [BMU], 2014). Additionally, the Federal Ministry for the Environment Nature, Conservation and Nuclear Safety observed a statistically significant deterioration of species diversity (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety [BMU], 2014). In Germany, four animal species are considered to be extinct and 101 critically endangered, endangered, or vulnerable (International Union for Conservation of Nature [IUCN], 2017a). With regard to plant species richness, 36 species are considered to be critically endangered, endangered, or vulnerable (International Union for Conservation of Nature [IUCN], 2017b). Thus, Germany and Ecuador are both affected by a progressive loss of species.

To reduce biodiversity loss, both countries have drafted a national biodiversity strategy with ambitious goals regarding biodiversity conservation (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety [BMU], 2007; Ministerio del Ambiente del Ecuador, 2016). Furthermore, Germany cooperates internationally to support biodiversity on a global scale (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety [BMU] and Federal Ministry for Economic Cooperation and Development [BMZ], 2016). Both countries have acknowledged human behavior as core challenge in all efforts to protect biodiversity. Thus, in addition to political efforts to conserve biodiversity, human behavior, and thus, people's attitudes and values are becoming increasingly significant worldwide in preserving biodiversity (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety [BMU], 2007; Nisbet and Zelenski, 2013). Besides the aforementioned personality traits that may be related to environmental behavior, it seems that people – and especially young people – have lost their inner connection with nature due to modern societal development that hinders a human–nature interaction (Louv, 2008; Brämer et al., 2016; Soga and Gaston, 2016). A disturbed human–nature relationship, however, has been considered one of the main reasons for people's harmful behavior toward the environment and for decreasing environmental concern (Nisbet and Zelenski, 2013). Given that young people are approaching the stage of taking responsibility for their own lives, including a critical reflection of their own environmental behavior, these results seem particularly alarming. Moreover, young people are in an important period of value formation (Wray-Lake et al., 2010). As they are still students, appropriate educational programs can help to promote the formation of important values fostering pro-environmental behavior (von Braun, 2017). Regarding the impact of environmental education, Otto and Pensini (2017) showed that the frequency of children's visits to nature-based environmental education institutions is positively related to pro-environmental behavior, mediated by an increased environmental knowledge and nature relatedness. Furthermore, they found nature relatedness to explain a high percentage and environmental knowledge a low percentage of the variance in pro-environmental behavior (Otto and Pensini, 2017).

Nature relatedness can be understood as a perceived cognitive, affective, and experiential connection to the natural world that is regarded to be "trait-like," because it is relatively stable over time and across situations but not completely fixed (Schultz, 2002; Mayer and Frantz, 2004; Nisbet et al., 2009; Brügger et al., 2011; Nisbet and Zelenski, 2013). The cognitive

component of nature relatedness can be considered as the extent to which people include nature within their cognitive representation of self, which in turn is regarded as the fundamental aspect of human–nature relations by some authors (Schultz, 2002). Other authors place the affective connection, the sense of feeling connected, at the center of the human–nature relationship (Mayer and Frantz, 2004). The experiential connection is often neglected but is an important aspect in some concepts of nature relatedness (Nisbet et al., 2009). It represents an individual's physical familiarity with the natural world and the level of perceived comfort with being in nature. Since we refer to the nature relatedness construct of Nisbet et al. (2009) all three aspects of individual connection with the natural world are regarded as equally important.

Nature relatedness can be explained theoretically by the biophilia hypothesis (Wilson, 1984) that assumes an innate tendency of humans to approach and contact other living and natural things. The biophilia hypothesis postulates that it is inherent in human beings to learn from and value the natural environment (Kellert and Wilson, 1993).

Additionally, studies have shown that having frequent nature contact promotes nature relatedness and may lead to increased environmental concern (Mayer et al., 2009; Nisbet and Zelenski, 2013) and that nature-related people spend more time outdoors in a natural environment (Nisbet et al., 2009; Raymond et al., 2010). Moreover, Kals et al. (1999) found the frequency of time spent in nature to be a powerful predictor for emotional affinity toward nature.

In addition to nature relatedness, environmental concern plays an important role in explaining environmental behavior. As part of their 'value basis of environmental concern' theory, Stern and Dietz (1994) suggest that environmental concern can be based on egoistic, social-altruistic, and biospheric value orientations and on beliefs about the consequences of environmental changes for valued objects. Based on this, Schultz (2001) could show a three factorial structure of environmental concern. These three factors are egoistic concern, altruistic concern, and biospheric concern about the environment, depending on whether individuals care about themselves, other people, or all living things. Thus, he explained that one person's environmental concern and behavior are not necessarily based on their nature relatedness but may have egoistic or altruistic motives (Schultz, 2002). Yet a positive relation to pro-environmental behavior could only be demonstrated for biospheric concern about the environment (Schultz, 2001). Stern et al. (1993) showed that women have stronger beliefs about the harmful consequences of bad environmental conditions for self, others, and the biosphere and that pro-environmental behavior is predicted by these beliefs. These gender differences are attributed to socialization processes (Gilligan, 1982; Beutel and Marini, 1995; Baron-Cohen and Wheelwright, 2004; Jolliffe and Farrington, 2006) that are regarded as culture-specific (Davidson and Freudenburg, 1996).

Value orientations determine the actions of people, their beliefs, and attitudes in general as well as toward nature (Schwartz, 1994; Schultz et al., 2004). In order to explain value-based environmental behavior in cross-cultural studies, the Schwartz theory of basic human values (Schwartz, 1992, 1994) has proven to be particularly appropriate since certain values could be identified in more than 30 nations. The basic human Schwartz-values of the self-transcendence value cluster have proven to be a powerful predictor for a connection to nature (Sothmann and Menzel, 2017). The self-transcendence value cluster represents prosocial norms oriented toward the welfare of close others in everyday interaction humans (benevolence) and all people and nature including all living beings (universalism; Schwartz, 1992). Furthermore, it correlated positively with biospheric and altruistic concern but negatively with egoistic concern about the environment (Schultz, 2001; Schultz et al., 2005). The basic human values of the self-enhancement value cluster showed a positive relation with egoistic environmental concern but a negative relation with biospheric and altruistic concern (Schultz, 2001; Schultz et al., 2005). It represents values orientated toward success, the demonstration of competence (achievement), social status and prestige (power), pleasure and enjoyment of life (hedonism) (Schwartz, 1992).

Up to now, there has been no comparison of young people from Latin America and those from Europe with regard to their nature relatedness and environmental concern and the factors that predict them. Therefore, the present study aims at providing insight into the relatively unexplored topic of intercultural differences of young people's human–nature relationship.

The Present Study

When considering biodiversity and its loss globally, we assume that Ecuadorian young people, who live in a biodiversity hotspot, and German young people, who grow up in one of the most industrialized countries in the world, show differences in their human–nature relationship. Our assumption is reinforced by studies that show that Ecuadorian college students score higher on environmental concern than United States and European college students (Schultz, 2001). Regarding an international comparison of nature relatedness, there is insufficient empirical evidence to develop a literature-based hypothesis. However, due to the higher biodiversity in Ecuador and the fact, that the Ecuadorian people triggered current political debate on the rights of nature, we assume that Ecuadorian people in general as well as young people are higher in their nature relatedness than German young people. Additionally, we are interested in the factors that are related to nature relatedness and environmental concern. Based on the aforementioned studies, we expect self-transcendence, time spent in nature, and having a female gender to positively predict nature relatedness and biospheric environmental concern in both samples. A cross-cultural investigation into the relations between young people's nature relatedness, environmental concern, and the basic human values of the self-transcendence value cluster should provide important information that could be used to design adequate environmental education and outreach projects in both countries.

Thus, the present study aimed at comparing Ecuadorian and German young people's nature relatedness and environmental concern and at elucidating the factors that are related to them.

Three research questions and subsequent hypotheses were addressed:

Q1: How do Ecuadorian and German young people differ in their nature relatedness and environmental concern?

H1: Ecuadorian young people show higher nature relatedness and environmental concern.

Q2: How do young people's gender and nationality, their basic human values, and time spent in nature affect their nature relatedness and environmental concern?

H2: Self-transcendence, time spent in nature, and having a female gender positively predict nature relatedness and biospheric environmental concern.

H3: Self-transcendence positively predicts altruistic concern and negatively egoistic concern.

H4: Self-enhancement positively predicts egoistic environmental concern.

MATERIALS AND METHODS

Participants and Procedure

The sample was divided into two subsamples. The first sample consisted of 2,173 anonymously surveyed high school students from ten Northwest Germany secondary schools in and around the cities of Osnabrück and Hanover (M_{age} = 14.56 years, *SD* = 1.45; female: 55.1%). Five schools were located on the outskirts of the city, close to forest areas or agricultural land. In contrast, five schools were located in the center of the city, without direct access to forest areas or agricultural land. The second sample consisted of 451 anonymously surveyed high school students from four private secondary schools located in Southern Ecuador in and around the city of Cuenca (M_{age} = 14.63 years, *SD* = 1.77; female: 55.3%). While one school was located on the outskirts of the city, close to forest areas and agricultural land, three schools were located in the center of the city, far from forest areas or agricultural land.

The variables addressed in this article were embedded in a paper-and-pencil questionnaire. The survey contained 66 items and was conducted during regular school hours. The students had the length of one school lesson (45 min) to complete the questionnaire. The time limit was not exceeded in any case. Some students finished the questionnaire 15 min before the end of the time limit. Without measuring the average time precisely, we can conclude from our classroom observations that the Ecuadorian students needed more time to complete the questionnaire than the German students. The differences between the two samples in the time taken to complete the questionnaire can be explained by the differences in reading literacy between Latin American and German students. The assumption that the German sample achieved a higher level of reading skills than the Ecuadorian sample is based on large-scale assessments in education (OECD, 2016). Of course, this is only one possible explanation. It may be the case that Ecuadorian students paid closer attention to the questions than the German students did.

Anonymity was guaranteed, and participation was voluntary. Ethical approval for the study was obtained in July 2016 from the responsible State Board of Education in Germany - Niedersächsische Landesschulbehörde (NLSchB), which is the body responsible for providing ethics approvals for studies carried out in schools. The participating German schools were informed about the research conducted and provided their written consent. All participants had the chance to decline to participate and to withdraw from the research at any time. Since we surveyed Ecuadorian students from private schools, we asked the respective headmasters, in advance, for permission to carry out the questionnaire study. In all schools, the questionnaire was reviewed by the school psychologist, who did not raise any objections to the study. Permission from the headmasters was granted for all schools.

In both countries, the parents of the students were informed about the study by a letter, in which the voluntary participation and anonymity of the study was pointed out. The possibility to contact us was given by the attached contact data. According to the APA's Ethical Principles of Psychologists and Code of Conduct (American Psychological Association, 2016) psychologists may dispense with informed consent where research would not reasonably be assumed to create distress or harm. As our investigation was conducted by an anonymous questionnaire in an educational setting and in the presence of the respective teacher, an informed consent was not necessary (American Psychological Association, 2016). Moreover, the responsible State Board of Education in Germany only requires written consent in the case of surveys involving the processing of personal data. However, this was not the case in the present study. Furthermore, since the students were not asked about their parents or family circumstances, racial and ethnic origin, political opinions, religious beliefs, health, or sex life, no informed consent of the legal guardian is required (Niedersächsische Landesschulbehörde, 2015). The consent procedures followed were also approved by the State Board of Education in Germany – Niedersächsische Landesschulbehörde (NLSchB).

Materials

We measured the amount of time spent in nature as a basic socio-demographic sample characteristic and used established psychometric scales to assess altruistic, egoistic, and biospheric concern about the environment as well as nature relatedness and value orientations.

Time spent in nature was measured by one item asking how much time the participants generally spend in nature. They answered on a 5-point Likert scale ranging from 1 (*very little*) to 5 (*very much*). We deliberately refrained from providing a definition of nature and an exact indication of time, as several studies have already shown that humans can have very different concepts of nature. For example, an artificial park can be viewed as nature for a person from the city, whereas a cultural landscape with farmlands can represent nature for a person from the countryside (Thompson et al., 1990; Kleinhückelkotten and Neitzke, 2010). Thus, we preferred to assess students' subjective perception of nature. In addition, some people may have easier access to nature than others, which might influence their perception of the time they spent in nature. For instance, for a person who lives and works in an urban environment, 20 min

per day in a park may be a lot of valuable time in nature, whereas for a person from the countryside, 20 min in a forest may not be considered very much time. We intended to address these potential differences between the subjective conception of nature and time by asking in this way. Nevertheless, this single item is a relatively soft indicator of time spent in nature, which should be taken into account when interpreting the results.

The Environmental Concern Scale developed by Schultz (2001) is an established instrument for measuring concern about the environmental problems rooted in human behavior. Following the original scale as suggested by Schultz (2001), 12 items were used to ask participants whether their environmental concern is caused by egoistic, altruistic, or biospheric motives. Participants rated each of the items from 1 (*not important*) to 5 (*important*) on a 5-point Likert scale. The scale starts with the following statement:

> 'People around the world are generally concerned about environmental problems because of the consequences that result from harming nature. However, people differ in the consequences that concern them the most. How important are the consequences of environmental problems for…?'

Each dimension of environmental concern was measured by four items: egoistic concern by (1) me, (2) my lifestyle, (3) my health, and (4) my future; altruistic concern by (1) people in my community, (2) all people, (3) children, and (4) future generations; and biospheric concern by (1) plants, (2) marine life, (3) birds, and (4) mammals. We created the German version of the scale by translation and back-translation. For the Ecuadorian sample, we mainly used the Spanish version by Schultz (2001). In both the German and Spanish versions, we replaced the original biospheric concern item (4) *animals* with *mammals* to illustrate the difference to (3) *birds*. After consultation with native speakers familiar in local dialects, we replaced the original Spanish altruistic concern item (4) *mis paisanos* by *mis compatriotas*, because the latter is more commonly used in the region. Exploratory factor analyses showed that the three environmental concern dimensions loaded on their theoretically separate factors with high reliabilities for both samples (**Table 1**).

The self-transcendence and the self-enhancement values were measured by eight and nine items from the Portrait Values Questionnaire (Schmidt et al., 2007), which is composed of verbal portraits defining a person's goals, expectations, or desires that implicitly indicate the importance of a value. Respondents were asked to rate the similarity of the described person to themselves on a 5-point Likert scale ranging from 1 (*not like me at all*) to 5 (*very much like me*). For the Ecuadorian sample, we used an approved Spanish version of the scale (García Castro, 2014). A cross-cultural construct validity for the Portrait Values Questionnaire could be confirmed in various studies (Schwartz and Sagiv, 1995; Spini, 2003).

There are numerous suitable measures of subjective connectedness with the natural environment. For instance, the Disposition to Connect with Nature Scale (Brügger et al., 2011) is an intellectually simple instrument consisting of 40 items that relies only on simple self-reflection and is therefore well suited to assess the nature relatedness of school students (Brügger and Otto, 2017). In order to avoid respondent fatigue, we decided to measure nature relatedness via the much shorter 6-item version of the Nature Relatedness Scale (NR-6; Nisbet and Zelenski, 2013). Participants were asked to what extent they agreed with statements like 'I feel very connected to all living things and the earth' on a 5-point Likert scale ranging from 1 (*I disagree*) to 5 (*I agree*). The German as well as the Spanish version of the scale were created by translation and back-translation and checked by native speakers familiar with local dialects and the scale.

TABLE 1 | Reliabilities, results of the Kolmogorov–Smirnov test, and sources of the scales used in the current study.

Scale	Germany			Ecuador			Items
	α	*n*	K-S	α	*n*	K-S	
ST[1]	0.72	2,048	0.09***	0.72	432	0.13***	8
SE[1]	0.77	2,065	0.06***	0.72	432	0.06***	7
NR-6[2]	0.80	2,001	0.06***	0.83	426	0.10***	6
EC[3]	0.86	2,064	0.07***	0.85	371	0.14***	12
Egoistic EC	0.77	2,107	0.10***	0.79	425	0.20***	4
Altruistic EC	0.78	2,100	0.13***	0.72	388	0.17***	4
Biospheric EC	0.92	2,115	0.14***	0.91	434	0.26***	4

*ST, self-transcendence; SE, self-enhancement; EC, environmental concern; [1]Source: García Castro (2014) for the Spanish version, Schmidt et al. (2007) for the German version. [2]Source: Nisbet and Zelenski (2013) for the English version; [3]Source: Schultz (2001) for the Spanish and English version, ***$p \leq 0.001$.*

Even though the scales used in this study were originally designed for adults, the Portrait Values Questionnaire has already been validated with young people. For instance, Menzel and Bögeholz (2010) validated the Portrait Values Questionnaire by surveying an international sample of 15- to 19-year-old Chilean and German school students. It is regarded as a relatively intellectually less demanding instrument for measuring human values (Schmidt et al., 2007). There are no known studies using the environmental concern scale and the NR-6 on a comparably young sample. In addition, the current study found good reliability for both scales.

Analyses

First, we conducted exploratory factor analyses in order to empirically test the scales used for the two samples on dimensionality. According to the theoretical basis, the tested were regarded as interdependent, which is why we performed oblimin rotation. Additionally, we conducted a confirmatory factor analysis in order to verify the factor structure of the environmental concern scale. We then checked our scales for normality with a Kolmogorov–Smirnov test and computed reliability with Cronbach's alpha.

With regard to the Portrait Values Questionnaire, we decided to exclude two items of the hedonism value type, which were to be assigned theoretically to the value dimension of self-enhancement, because in the German sample, the items SEHE1 and SEHE3 loaded on the second (self-transcendence) factor. In the Ecuadorian sample, only SEHE3 did so (see **Table 2**). An explanation for this can be found in the dynamic structure of value types presented by Schwartz (1992). He

TABLE 2 | Factor loadings based on an exploratory factor analysis with oblimin rotation for 17 items from the Portrait Values Questionnaire (PVQ) ($N_{Germany}$ = 1,965; $N_{Ecuador}$ = 411).

Items for the collected value types	Germany		Ecuador	
	SE	ST	SE	ST
SEPO1: It is important to him/her[1] to be rich. He/She wants to have a lot of money and expensive things.	**0.57**	−0.25	**0.52**	−0.12
SEPO2: It is important to him/her to be in charge and tell others what to do. He/She wants people to do what he/she says.	**0.68**	−0.26	**0.60**	−0.24
SEPO3: He/She always wants to be the one who makes the decisions. He/She likes to be the leader.	**0.71**	−0.19	**0.67**	0.03
SEAC1: It is very important to him/her to show his/her abilities. He/She wants people to admire what he/she does.	**0.64**	0.04	**0.57**	0.13
SEAC2: Being very successful is important to him/her. He/She likes to impress other people.	**0.69**	0.00	**0.67**	0.08
SEAC3: Getting ahead in life is important to him/her. He/She strives to do better than others.	**0.70**	−0.07	**0.60**	0.07
SEHE1: He/She seeks every chance he/she can to have fun. It is important to him/her to do things that give him/her pleasure*.	0.24	**0.52**	**0.40**	0.35
SEHE2: Enjoying life's pleasures is important to him/her. He/She likes to 'spoil' himself/herself.	**0.47**	0.30	**0.57**	0.38
SEHE3: He/She really wants to enjoy life. Having a good time is very important to him/her*.	0.31	**0.47**	0.29	**0.49**
STUN1: He/She thinks it is important that every person in the world be treated equally. He/She believes everyone should have equal opportunities in life.	−0.15	**0.54**	−0.01	**0.54**
STUN2: It is important to him/her to listen to people who are different from him/her. Even when he/she disagrees with them, he/she still wants to understand them.	−0.12	**0.55**	−0.08	**0.46**
STUN3: He/She strongly believes that people should care for nature. Looking after the environment is important to him/her.	−0.06	**0.46**	0.13	**0.59**
STUN4: It is important to him/her to adapt to nature and to fit into it. He/She believes that people should not change nature.	−0.05	**0.40**	0.08	**0.50**
STBE1: It's very important to him/her to help the people around him/her. He/She wants to care for other people.	−0.13	**0.66**	0.03	**0.66**
STBE2: It is important to him/her to be loyal to his friends. He/She wants to devote himself to people close to him.	0.03	**0.66**	0.07	**0.51**
STBE3: It is important to him/her to respond to the needs of others. He/She tries to support those he knows.	−0.05	**0.71**	0.08	**0.70**
STBE4: Forgiving people who might have wronged him/her is important to him/her. He/She tries to see what is good in them and not to hold a grudge.	−0.20	**0.42**	−0.20	**0.44**
Factor correlations between SE and ST	−0.05		0.08	

[1]*In the German version, we used "the person" instead of "he/she" and "him/her." Factor loadings ≥0.4 are printed in bold. Items marked with asterisk (*) will not be included in further analyses. SE, self-enhancement; ST, self-transcendence, PO, power; AC, achievement; HE, hedonism; UN, universalism; BE, benevolence.*

points out that despite the focus of hedonism on self, it is not characterized by the same competitive motivation that is expressed by achievement and power values. Moreover, hedonism is apparently characterized by the motivation for arousal and challenge, which is not represented in achievement and power since they show a frequent proximity to the conservation value dimension (Schwartz, 1992).

Confirmatory factor analysis verified the three-factor structure of environmental concern (see **Supplementary Material**). All scales showed acceptable, good to very good reliabilities for both samples (**Table 1**). To answer our research questions, we included a total of 27 items from the aforementioned scales in our analyses.

Although some variables did not follow a normal distribution, we calculated independent group *t*-tests to compare the German and the Ecuadorian samples. However, we interpreted the bootstrap with 95% bias corrected and accelerated confidence intervals as recommended by Field (2017) in the case of non-normal distributed variables. Since it is a cross-cultural study, a response bias cannot be ruled out (Hofstede, 1980; Smith, 2004; Schwartz, 2009), which is why we also carried out standardized mean value comparisons, using the method of group mean centering (Fischer, 2004). For creating scores that controlled for differences in response tendency, we produced group-mean centered egoistic, altruistic, and biospheric environmental concern scale scores by subtracting the group mean of all 12 of the environmental concern items (EC-mean$_{Germany}$ = 4.01; EC-mean$_{Ecuador}$ = 4.42) from each of the three scale scores (see also Schultz et al., 2004). Furthermore, we computed the grand mean of all the items of the value clusters self-transcendence and self-enhancement (we only asked for these two value clusters). Afterward, we subtracted the total of all 14 items (PVQ-mean$_{Germany}$ = 3.44; PVQ-mean$_{Ecuador}$ = 3.62) from the scale score of self-transcendence and self-enhancement (see also Schwartz, 2009). The mean-corrected scores are presented in the lower part of **Table 3**. The effect sizes of group differences were calculated by Cohen's *d*, using the two means (raw mean scores and centered mean scores), standard deviations, and the sample sizes of both groups (Hedges and Olkin, 1985).

In order to answer the second research question, we conducted a robust multiple regression, because some scales followed a non-normal distribution. After that, we compared the resulting *b*-values, the standard errors, and the *t*-statistics with the non-robust versions. The robust estimates revealed basically the same results; hence we report the non-robust versions, as recommended by Field (2017). Since we were interested in the effect of young people's socio-demographic factors and values on their nature relatedness and environmental concern, we calculated regression analyses for the independent variables nature relatedness as well as egoistic, altruistic, and biospheric environmental concern for both samples.

RESULTS

Q1: How do Ecuadorian and German young people differ in their nature relatedness and environmental concern?

TABLE 3 | Comparison between the mean scores of the German and Ecuadorian samples.

Variables	Germany			Ecuador			*t*-test	95% BCaCI	Effect size *d*
	M	*SE*	*SD*	*M*	*SE*	*SD*			
Nature relatedness	2.66	0.02	0.78	3.69	0.04	0.83	−24.54***	[−1.12, −0.95]	1.32
Time spent in nature	2.91	0.02	0.88	2.82	0.04	0.88	1.95*	[0,00, 1.18]	0.10
Egoistic EC	−0.14	0.02	0.74	0.02	0.03	0.65	−3.53***	[−0.20, −0.05]	0.17
Altruistic EC	0.11	0.02	0.73	−0.13	0.04	0.71	6.15***	[0.17, 0.32]	0.33
Biospheric EC	0.00	0.02	0.91	0.08	0.04	0.72	−2.01*	[−1.61, −0.01]	0.09
ST	0.39	0.01	0.55	0.47	0.03	0.62	−2.55**	[−0.15, −0.02]	0.14
SE	−0.44	0.02	0.69	−0.57	0.04	0.74	3.42**	[0.05, 0.21]	0.19

*EC, environmental concern; ST, self-transcendence; SE, self-enhancement. Confidence intervals based on 1,000 bootstrap samples, *$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$.*

The results of the independent group *t*-tests are reported in **Table 3**. Since a centering was not possible for nature relatedness and time spent in nature, uncentered scores are reported for these variables. For environmental concern, self-transcendence and self-enhancement, only the centered scores are provided (see **Supplementary Material** for presentation of uncentered scores).

Regarding nature relatedness, the *t*-test revealed differences with large effect sizes between German and Ecuadorian young people, with Ecuadorians scoring higher than Germans.

The comparison between the centered mean scores showed only altruistic environmental concern as differing significantly between the two groups, with a small effect size. In this case, German young people scored higher than Ecuadorians. Additionally, the centered mean score comparison provided insight into the structure of environmental concern for our two samples. Whereas we found a relative preference for altruistic ($M = 0.11$) over biospheric ($M = 0.00$) and egoistic concern ($M = -0.14$) in the German sample, the Ecuadorian sample was most concerned about the consequences of environmental problems for biospheric reasons ($M = 0.08$), followed by egoistic ($M = 0.02$) and altruistic reasons ($M = -0.13$).

Q2: How do young people's gender and nationality, their basic human values, and time spent in nature affect their nature relatedness and environmental concern?

Multiple regressions were conducted in order to determine how the sample's gender, their values, and time spent in nature affected their nature relatedness and environmental concern. To investigate the differences between both samples in explaining nature relatedness and environmental concern, we carried out separate multiple regressions for our two groups (**Table 4**).

In both samples, self-transcendence and time spent in nature showed a positive effect on nature relatedness. Whereas female gender in the German sample predicted the nature relatedness positively, the reverse was true in the Ecuadorian sample. Neither in the German sample nor in the Ecuadorian sample did self-enhancement have an effect on nature relatedness. The regression explained 30% of nature relatedness' variance in the German sample and 24% in the Ecuadorian sample.

Furthermore, multiple regressions accounted for 9% of egoistic concerns' variance in the German sample and 7% in the Ecuadorian sample. In both samples, self-transcendence and self-enhancement showed a positive effect on egoistic concern. In both samples, only self-transcendence predicted altruistic concern. The regression on altruistic concern explained 18% of its variance in the German sample and 8% in the Ecuadorian sample.

In both samples, self-transcendence and time spent in nature had a positive effect on biospheric concern. While there was no relation between female gender and biospheric concern in the German sample, female gender showed a negative effect on biospheric concern in the Ecuadorian sample. The regression on biospheric concern explained 18% of the variance in the German sample and 11% in the Ecuadorian sample.

TABLE 4 | Results of regression analyses predicting nature relatedness as well as egoistic, altruistic, and biospheric environmental concern for the German and the Ecuadorian sample.

	NR		Egoistic EC		Altruistic EC		Biospheric EC	
	β	*t*	β	*t*	β	*t*	β	*t*
German sample								
ST	0.37	17.91***	0.26	11.24***	0.42	18.98***	0.40	18.17***
SE	−0.01	−0.62	0.14	6.33***	0.01	0.53	0.01	0.43
Time spent in nature	0.34	16.79***	0.08	3.41***	0.02	0.97	0.06	2.90*
Female	0.12	5.73***	−0.02	−0.65	−0.01	−0.49	0.00	0.13
Adj. R^2	0.30***		0.09***		0.18***		0.18***	
N	1,820		1,910		1,904		1,912	
Ecuadorian sample								
ST	0.32	7.15***	0.17	3.45**	0.31	5.94***	0.25	5.04***
SE	−0.03	−0.58	0.19	3.74***	−0.01	−0.18	−0.03	−0.53
Time spent in nature	0.31	6.90***	0.08	1.55	−0.02	−0.41	0.14	2.93**
Female	−0.11	−2.42*	−0.01	−0.15	0.01	0.14	−0.13	−2.56*
Adj. R^2	0.24***		0.07***		0.08***		0.11***	
N	390		387		356		395	

ST, self-transcendence; SE, self-enhancement; NR, nature relatedness; EC, environmental concern,$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$.*

DISCUSSION

Q1: How do Ecuadorian and German young people differ in their nature relatedness and environmental concern?

H1: Ecuadorian young people show higher nature relatedness and environmental concern.

With our first research question, we intended to compare young people's nature relatedness and environmental concern between the two samples from Ecuador and Germany.

In a comparison of means across different cultures, a response bias cannot be ruled out, because people from different cultures differ in their response behavior (Smith, 2004) and socially desirable responding influences the self-reported priorities (Schwartz et al., 1997). For this reason, we consider the standardized mean scores (**Table 3**) to be more meaningful and to better represent the priorities of their values and environmental concern than the non-standardized values. Thus, regarding environmental concern, we decided to report only the

comparison of the centered mean scores. The discussion of the differences in nature relatedness refers to the raw scores.

A deeper look into the structure of environmental concern revealed clear patterns in each sample. The prioritization of altruistic concern in the structure of environmental concern, which was the case in the German sample, was frequently found, for example, in nine of eleven adult samples from the United States and different Latin American countries surveyed by Schultz (2001). Only El Salvador and Columbia were most concerned about the consequences of environmental problems for biospheric reasons. However, a German sample was not part of the study mentioned above.

We suspect that living in the biodiversity hotspot Tropical Andes influences Ecuadorian young people's environmental concern, thus presenting a possible explanation for the Ecuadorian young people's structure of environmental concern. A biodiversity hotspot is characterized not only by its high species density but also by its high degree of threat. The biodiversity in such a place is therefore particularly worth protecting and people living there could be more aware of nature's intrinsic value, which could explain the higher biospheric concern of Ecuadorian young people.

Regarding egoistic and altruistic environmental concern, the occurrence and consequences of environmental disasters, which differ extremely in Ecuador and Germany, have to be considered. Ecuadorians live in a biodiversity hotspot and news like the destruction of tropical rainforests for the exploration of oil or the cultivation of crops destined for export to Europe is not uncommon. Many human-made environmental problems have either a direct or indirect consequence on their personal lives, whether through land loss, water pollution, or the loss of traditional food and medicinal plants. For instance, during oil exploitations in the Ecuadorian Amazon by an American multinational energy corporation between 1964 and 1992, millions of gallons of toxic substances were spilled into the Amazon. The contamination covered an area of 1,700 square miles and caused damage not only to flora and fauna, but also to human life (Cely, 2014; Lambert, 2017). In addition, the resulting long-running lawsuit received considerable media attention worldwide, this extended the environmental disaster; and its consequences are still present in the Ecuadorian population today (Krauss, 2014; Reuters, 2017). In contrast, young German people are virtually unaffected by such environmental disasters but are made aware of them and their consequences for people in other parts of the world almost daily by the media. Thus, we postulate that for Ecuadorian young people, the negative consequences of environmental problems for oneself are easier to imagine than for German young people. Due to these circumstances, the prioritization of egoistic motives for environmental concern in the Ecuadorian sample and altruistic motives in the German sample seems plausible.

While environmental concern has already been well researched across samples of different nationalities, there is a lack of cross-national empirical research regarding nature relatedness or equivalent constructs. Since nature relatedness is related to environmental concern, especially to biospheric concerns (Nisbet and Zelenski, 2013), the higher nature relatedness found in the Ecuadorian sample fits well with our result of the relative preference for biospheric over altruistic and egoistic environmental concerns in this sample. Nevertheless, the question arises as to how the different results come about in nature relatedness and the structure of the environmental concern. This question can be answered from two different directions. First, living in the biodiversity hotspot Tropical Andes may encourage Ecuadorian young people's nature relatedness. Furthermore, the indigenous concept of *Buen Vivir,* which is not only deeply rooted in the culture of the indigenous people but also being politically instrumentalized (Lalander, 2016), may have an effect on the socialization process in Ecuador that could increase their nature relatedness. For example, the concept of *Buen Vivir* assumes a central position in the Constitution, in which the construction of "a new form of citizen coexistence in diversity and harmony with nature, to achieve good living (*Buen Vivir*)" (Asamblea Constituyente de Ecuador, 2008, p. 15) is announced. As a result, the indigenous guiding principles of *Buen Vivir* apply to all Ecuadorian citizens and not only to those of an indigenous background.

Second, the debate about *Buen Vivir* and the associated social awareness regarding environmental issues (Rieckmann et al., 2011; Lalander, 2016) may increase the pressure to respond in a socially desirable way (Schwartz et al., 1997; Smith, 2004). Both explanatory approaches probably apply to a certain extent. For instance, the items of the NR-6 "I always think about how my actions affect the environment" and "My connection to nature and the environment is a part of my spirituality" (Nisbet and Zelenski, 2013) are in many respects consistent with the concept of *Buen Vivir,* which is based on the idea of living in harmony with nature to achieve good living (*Buen Vivir)* and of interdependence of society and nature (Asamblea Constituyente de Ecuador, 2008; Vanhulst and Beling, 2014).

To summarize the results of the first research question, the current study showed that Ecuadorian students related more to nature than German students and were most concerned about the consequences of environmental problems for biospheric reasons, whereas German students were most concerned for altruistic reasons.

Q2: How do young people's gender and nationality, their basic human values, and time spent in nature affect their nature relatedness and environmental concern?

H2: Self-transcendence, time spent in nature, and having a female gender positively predict nature relatedness and biospheric environmental concern.

Based on diverse results in the literature, in our second hypothesis, we assumed that self-transcendence (Sothmann and Menzel, 2017), time spent in nature (Mayer et al., 2009; Nisbet and Zelenski, 2013), and having a female gender (Stern et al., 1993; Tam, 2013) would predict nature relatedness. Although the regressions found that time spent in nature is a positive predictor for nature relatedness (**Table 4**), we must consider the ex post facto design of our study, which is why we cannot make a definitive statement about the direction of the relationship between the two variables. Indeed, it is also reasonable to assume

that a sense of nature relatedness motivates people to seek out nature. Nonetheless, we hypothesized a positive effect of time spent in nature on nature relatedness on the basis of experimental studies that showed the positive effect of exposure to nature on college students' nature connectedness (Mayer et al., 2009). However, it may be the case that there is a bidirectional relationship between these two variables, such as that having a desire to connect with nature leads to spending more time in nature, which in turn positively affects connectedness with nature and vice versa (see also Mayer et al., 2009; Nisbet et al., 2011; MacKerron and Mourato, 2013).

In accordance with available literature (Schultz, 2001), self-transcendence was the most powerful predictor for biospheric concern in both samples (**Table 4**). Among other things, self-transcendence represents a pro-environmental value orientation orientated toward the welfare of all living things and nature (universalism; Schwartz, 1992), which explains its positive effect on biospheric environmental concern and nature relatedness.

The positive effect of female gender on nature relatedness found in the German sample can be explained by Tam (2013), who found in an adult Chinese sample that female individuals had more dispositional empathy with nature, which was related to connection to nature. In contrast, in the Ecuadorian sample, female gender had a negative effect on nature relatedness, running contrary to our supposition and pointing to cultural differences regarding the relation between gender and nature relatedness.

The second part of our hypothesis dealt with biospheric environmental concern. As in the case of nature relatedness as dependent variable, self-transcendence and time spent in nature seemed to predict biospheric concern in both samples. However, the different sample sizes must be taken into account. It is very likely that time spent in nature in the German sample was significant only because of the very large sample size (N = 1,912). Such an effect would most likely not occur with a sample size comparable to the Ecuadorian sample. This also applies to the regression of time spent in nature on egoistic concern (**Table 4**).

Although it might seem surprising that female gender had a negative effect on biospheric environmental concern in the Ecuadorian sample, while there was no relation found in the German sample between these variables, Zelezny et al. (2000) came to comparable conclusions, examining gender differences in environmental attitudes and behaviors across 14 countries. They showed that only in three (Colombia, Ecuador, and El Salvador) out of the 14 countries did males have higher environmental attitudes than females. They also found that only in two of the 14 countries did males report higher ecocentric environmental attitudes than females (Dominican Republic and Ecuador). In addition to Ecuador, the mentioned study examined ten other Latin American countries, suggesting that Ecuador is an exception regarding gender differences in the human–nature relationship. Therefore, the findings of Zelezny et al. (2000) in an adult Ecuadorian sample could be replicated by our study for Ecuadorian young people, even if these differences cannot be explained easily.

Gender differences in environmental concern and nature relatedness can be explained by approaches based on gender roles and socialization, according to which behavior is a product of the socialization process, characterized by gender expectations in terms of cultural norms. Females are generally socialized to have a stronger "ethic of care" (Gilligan, 1982, p. 73), to be more compassionate, and to be more involved in caregiving activities than males (Beutel and Marini, 1995). Therefore, females are expected to be more empathic than males (Hoffman, 2008), which has been empirically proven (Baron-Cohen and Wheelwright, 2004; Jolliffe and Farrington, 2006). Based on these findings, Tam (2013) proposed that women have stronger dispositional empathy with nature than men do and could confirm his assumption in a study with Chinese adults. Based on this, gender differences in predicting nature relatedness and biospheric environmental concern could be an expression of culture-specific socialization, and it supports the hypothesis of Davidson and Freudenburg (1996) that gender differences in environmental concern are not universal.

As previously mentioned, we consider the indigenous concept of *Buen Vivir,* which is deeply rooted in the culture of the indigenous people, to be central in the explanation of nature relatedness and environmental concern. On a conceptual level, the variable of nature relatedness and the basic idea of *Buen Vivir* have many overlapping points and similarities (Nisbet et al., 2009). We propose that a life concept of living in harmony with nature that applies to everyone, male or female, influences the process of socialization. The current debate about *Buen Vivir* and the associated social awareness regarding environmental issues (Rieckmann et al., 2011; Lalander, 2016) may reinforce this effect. In addition, Rafael Correa, who was the President of Ecuador from 2007 to 2017 and promoted life in harmony with nature, may have been a role model for many Ecuadorian boys.

In summary, with regard to our second hypothesis we found that self-transcendence predicted students' biospheric environmental concern in Germany and Ecuador. In addition, in the Ecuadorian sample, time spent in nature had a positive effect on biospheric concern, whereas female gender had a negative effect. No relation could be found in this respect in the German sample. In both samples, nature relatedness was predicted positively by self-transcendence and time spent in nature. Surprisingly, female gender predicted nature relatedness negatively in the Ecuadorian sample and positively in the German sample.

H3: Self-transcendence positively predicts altruistic concern and negatively egoistic concern.

With respect to our third hypothesis, self-transcendence was the only predictor for altruistic environmental concern, thus, our results are consistent with those in the literature (Schultz, 2001). As self-transcendence triggers prosocial norms oriented toward the welfare of humans (particularly through the value of benevolence) (Schwartz,

1992), its predictive power for altruistic environmental concern is plausible.

Surprisingly, we found self-transcendence to be a positive predictor for egoistic concern, even though Schultz (2001) and Schultz et al. (2005) found a negative relation between self-transcendence and egoistic environmental concern. However, the mentioned studies were conducted with adult samples, thus results are only applicable for adults. Sothmann and Menzel (2016) found that especially young people were shown to profit from nature as a resource for their own well-being and that this connection decreases with increasing age. Self-transcendence, especially the universalism value type, emphasizes the importance of caring for and adapting to nature, which represents the idea of the nature connection of including nature within the cognitive representation of self (Schultz, 2002). Accordingly, nature connected people are expected to relate the damage to their environment to themselves.

Therefore, it seems true that young people who are high in self-transcendence are concerned about environmental problems because of the biosphere and also because they are afraid of the destruction of the source for their own well-being and relate the damage to their environment to themselves.

However, we have to consider the low percentage of variance explained for egoistic concern by self-transcendence in Germany and Ecuador, which leads us to suspect that other variables besides self-transcendence and self-enhancement are more important in the explanation of egoistic environmental concern.

> **H4: Self-enhancement positively predicts egoistic environmental concern.**

The results support our assumption that self-enhancement predicted egoistic environmental concern in both samples (Schultz, 2001; Schultz et al., 2005), because self-enhancement predicted egoistic environmental concern in both samples (**Table 4**). Self-enhancement reflects goals and ideals that are linked with tangible rewards for self (e.g., success, social power, enjoyment, and pleasure). We propose that people who are orientated toward self-enhancement values do not include other people or other living things within their representation of self (Schultz, 2001). Thus, our results replicated those of earlier studies conducted with adult samples from different countries (Schultz, 2001; Schultz et al., 2005).

CONCLUSION

The aim of the present study was to compare Ecuadorian and German young people's nature relatedness and environmental concern and to investigate its predicting factors. The following conclusions can be drawn from the results described in this article:

(1) Ecuadorian young people were found to be more related to nature than young people in Germany. Living in a biodiversity hotspot and culture-specific socialization are seen as reasons for the differences. However, a social desirability response bias cannot be ruled out, which is why we recommend the application of a scale to measure social desirability for further studies. (2) German and Ecuadorian young people differed in their structure of environmental concern. Living in a biodiversity hotspot, which includes the contact with biodiversity particularly worthy of protection, might be one explanation for the high biospheric environmental concern in the Ecuadorian sample. Differences between Ecuador and Germany regarding biodiversity loss and its immediately noticeable consequences served as an explanation for the high altruistic concern of German students and the high egoistic concern about the environmental problems of Ecuadorian students. (3) Gender differences between Ecuadorian and German young people in the explanation of nature relatedness and biospheric concern were found. These differences were interpreted as an expression of a culture-specific socialization. (4) Contrary to previous studies conducted with adult samples (Schultz et al., 2005), in our samples of young people, their self-transcendence had a positive effect on egoistic concern. We assume that young people will be better able than adults to combine the intrinsic value of nature with selfish goals, such using its positive effect on their well-being. (5) As in other studies conducted with adults, time spent in nature and self-transcendence also had positive effects for high school students' nature relatedness and biospheric environmental concern.

Unlike a variety of previous studies conducted with adults, our results refer to the human–nature relationship of young people. The outcomes indicate that differences exist in the human–nature relationship between German young people, who live in an industrial country, and Ecuadorian young people, who live in a biodiversity hotspot. Nevertheless, the chosen variables could only explain a small proportion of the variance for the three dimensions of environmental concern, and thus our results should be validated with replication studies using a scale to measure social desirability. We assume that the students from Ecuadorian private schools are neither representative in terms of socio-ecological status, nor do they reflect cultural diversity of the country. Therefore, a sampling bias cannot be ruled out.

We assume that Ecuadorian students from private schools are more likely than those from public schools to have their basic material needs met. As the formation of environmental concern might be understood as a consequence of increasing post-materialism, private school students may differ from public school students in terms of their environmental concern (Maslow, 1954; Inglehart, 1995; Stern et al., 1999). On the basis of government expenditure per secondary school student for the year 2014, however, it can be seen that German students receive considerably more financial support from the state (11,180 US$) than do Ecuadorian secondary school students (338 US$; UNESCO Institute for Statistics [UIS], 2018; World Bank National Accounts data and OECD National Accounts data, 2018). For this reason, we assume that the comparison of German public school students with Ecuadorian private school students is more appropriate than with Ecuadorian public

school students. Nevertheless, future studies should survey both private and public school students in order to assess for a possible sampling bias.

Nature relatedness and environmental concern, especially biospheric concern, are important prerequisites for pro-environmental behavior. In the face of a daily biodiversity loss, which is particularly prevalent in biodiversity hotspots, it is imperative to identify factors that contribute to the promotion of nature relatedness and biospheric environmental concern among young people. Our study clearly showed that young people living in Ecuador, a country that hosts two relevant biodiversity hotspots, were most concerned about the consequences of environmental problems for biospheric reasons. They also feel more related to nature than young people from an industrialized country such as Germany. In both samples self-transcendence was the strongest predictor for nature relatedness as well as for biospheric environmental concern. Hence it represents a particularly strong leverage point to stimulate pro-environmental behavior. Self-transcendence values could be fostered in both family life and teaching by addressing and rewarding aspects such as justice and solidarity instead of placing the focus on performance-oriented aspects.

The study indicated a clear positive effect of time spent in nature on biospheric concern only in the Ecuadorian sample. Living in a biodiversity hotspot and directly experiencing complex biotopes constitute a plausible reason for Ecuadorian young people's high biospheric environmental concern and nature relatedness. As a consequence, also in countries with a relatively low biodiversity such as Germany, visiting and experiencing diverse biotopes, in or outside the country, could contribute to the promotion of both variables.

Finally, the effects of time spent in nature on nature relatedness emphasize the importance of giving young people opportunities to learn in and from nature, whether they are living in a biodiversity hotspot or an industrialized country. This can happen by means of family activities, leisure activities, or out-of-school environmental education. In the field of education, the results may encourage teachers to leave the classroom more often with their students and conduct environmental education directly in or close to nature in order to increase young people's pro-environmental behavior.

DATA AVAILABILITY

All data will be available in the **Supplementary Material**.

AUTHOR CONTRIBUTIONS

SM, J-NS, and MD did substantial contributions to the conception of the work. J-NS was responsible for the data acquisition in Germany and MD in Ecuador. MD interpreted the data and wrote the first draft of the work. SM and FF revised the work critically for important intellectual content and supported the statistical analyses.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2019.00453/full#supplementary-material

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Revisiting Environmental Belief and Behavior Among Ethnic Groups in the U.S.

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Maslow's hierarchy of needs (1970) depicts a simple, five-part pyramid with fundamental needs on the bottom and secondary needs near the top. The environmental hierarchy of needs theory, which pulls from Maslow's hierarchy, has commonly been used to suggest that ethnic groups hold less environmental concern and action than their White counterparts (Van Liere and Dunlap, 1980; Taylor, 1989; Mohai, 1990; Sheppard, 1995). The logic is as follows: sociological demographics suggest that minority populations tend to have lesser wealth and education. Therefore, minorities are more likely to focus on physiological needs necessary for survival, and in turn generally have less time and resources to allocate toward other problems. Environmental protection naturally becomes a secondary concern. This style of thinking was first popularized in the 1970s, with one widely cited study conducted by Hershey and Hill (1977). They found that there was a gap between White and African American students on their concerns for the environment. However, many of the cross-ethnic environmental studies conducted in the following decades have produced highly conflicting evidence with regard to the conceptualization of pro-environmental behaviors in different ethnic groups (for a review, see Head et al., 2018). In this article, we first review past studies on environmental belief and behavior selectively from both national surveys and regional representative samples (excluding convenience samples), paying attention to the emergence of ethnicity. These studies generated inconsistent answers to the question of how ethnic minorities respond to the environmental issue. Then, we argue that past studies overestimated the individual level of analysis, such as individual norms and beliefs, but underestimated the power of contextual analysis such as group norms, cultural orientations, and economic factors. We support our viewpoint by identifying conceptual and methodological issues that are important to consider for future research.

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SELECTIVE REVIEWS ON PAST LITERATURES

Environmental behavior varies significantly between ethnic groups. On the one hand, past studies have shown that ethnic minorities in the United States engage in fewer pro-environmental behaviors. This view was shown in a study by Johnson et al. (2004), which thoroughly examined environmental beliefs and action in the National Survey on Environment. They found that when age, gender, education, residence, and political views were all controlled for, African Americans and foreign-born Latinos scored significantly lower on environmental belief [a questionnaire from the New Ecological Paradigm (NEP)] and on four environmental behaviors (recycling, environmental reading, nature participation, and joining of conservation groups) than their White counterparts. A similar result indicated that African Americans scored significantly lower than European Americans on an index of environmental behavior in a sample of 720 residents in Detroit, Michigan (Parker and McDonough, 1999). In addition, African Americans in the public sample showed less concern for both chemical and global risks (e.g., ozone depletion and global warming).

These results are consistent with prior literature regarding ethnicity and environmentalism (Kalof et al., 2002; Slimak and Dietz, 2006).

On the other hand, several recent studies have revealed that non-whites in the U.S. reported greater concerns and engagements about the environment (e.g., climate change and protection of the environment) than Whites (c.f. Pearson et al., 2017). For an example, Whittaker et al. (2005) compiled over two decades of California Field Polls (with the majority of answers coming from Whites, African Americans, and Latinos) with regard to various environmental issues: pollution concern, environmental protection concern, toxic waste concern, increased taxes for environmental regulation, self-identified environmentalist, and opposition to offshore drilling. They found that African Americans and Latinos have been concerning and engaging in more pro-environmental behaviors than White Americans over time except on the topic of offshore drilling after controlling for socioeconomic status, education, age, and gender. Similarly, studies on Gallup polls between 2001 and 2010 (McCright and Dunlap, 2011), and a 2014 national representative sample (Jones et al., 2014) found that non-Whites reported greater concerns about global warming, climate change, and environmental threats to personal lifestyles than Whites. In addition, Macias (2016) investigated environmental risk perception across nine ethnic groups in the U.S. by using the 2010 General Social Survey and pulled from ∼1,500 responses across the nation. They concluded Mexican and Latin American immigrants, as well as African Americans, held a high threat perception of air pollution, nuclear power plants, and climate change.

SUGGESTIONS FOR FUTURE STUDIES

So where does this leave us? As mentioned earlier, a significant limitation in environmental psychology is that there is an inadequate amount of studies conducted with ethnic minority groups. As of now, the literature presents conflicting results regarding the level of environmental concern and pro-environmental behavior within ethnic minority groups. Additional research is needed to resolve the conflicting positions and propose a new perspective on ethnic minorities' environmental attitude and engagement. Therefore, future research should consider different conceptualizations and methodologies regarding environmental beliefs and actions among ethnic minorities.

However, past research on the topic has primarily emphasized individual beliefs toward environmental issues and underestimated the role of social contexts in which members of ethnic minority groups live. Bronfenbrenner's (1979) ecological model has indicated that behavioral development is influenced by interacting with various contexts such as *microsystems* (e.g., individual beliefs), *exosystem* (e.g., local economics), and *macrosystem* (e.g., cultural orientations). In Bronfenbrenner's view, these systems are interrelated, which means that behaviors occurring at the smallest level of context can be influenced by what occurs in the largest context. In other words, individual pro-environmental behaviors are affected by both individual norms, and the norms and expectations within their social contexts (e.g., in-group social norms, local economics, and diverse cultural orientations). In the following sections, we discuss the evidence and suggest that both individual and contextual factors play important roles regarding ethnic groups' attitude and behavior on environmental issues. In the end, we offer a mixed-method approach to synthesize both individual and contextual factors in future empirical studies.

INTEGRATING BOTH INDIVIDUAL AND SOCIAL NORMS IN VALUE-BELIEF-NORM THEORY

Conceptually, previous studies investigating ethnic differences in environmental concerns were largely based on value-belief-norm theory (VBN) (Stern and Dietz, 1994). The theory combines three components (i.e., personal norms, values, and environmental beliefs) into a holistic view of environmental behavior (Stern, 2000; Milfont and Page, 2013). The VBN theory has been shown to predict consumers' decision-making, ecological behavior, environmental policy, and awareness of the consequences of environmental actions (Dietz et al., 2005). However, past environmental research among American ethnic groups have largely focused on the segment of environmental beliefs via the NEP (e.g., Bechtel et al., 1999; Corral-Verdugo and Armendariz, 2000; Schultz et al., 2000; Rauwald and Moore, 2002; Johnson et al., 2004). Despite widespread use of the NEP, recent research suggests that it may be inappropriate for use in diverse populations (Klain et al., 2017). The NEP lacks cultural context because it was designed within a Western individualistic framework. As opposed to a collectivistic framework that places values on the relationships. This is why, for example, the NEP is inappropriate for research use in India: there is a vast East-West difference in traditions, worldviews, and different sociodemographic variables (Chatterjee, 2008).

This VBN framework to environmental behaviors may be influenced by in-group social norms across demographic groups in addition to personal values and beliefs. In-group social norms refer to what other people are doing or what people should do in the context of family, friend, community, and other in-group members (Schultz et al., 2007). A recent study has argued that the in-group social norms may help explain different levels of engagement between minority groups (Ballew et al., 2019) because members in minority groups have valued the needs and goals of in-group more importantly than Whites. Indeed, researchers found that in-group social norms (friends and family are taking environmental actions) positively predicted Latino Americans' environmental engagement (Ballew et al., 2019). A similar result showed that minority groups reported greater concerns on climate change and willing to engage in environmental advocacy than Whites when environmental issues have direct impacts on their local communities (Pearson et al., 2017).

In addition, Eom et al. (2018) proposed that if personal values and norms are not strong factors of environmental

actions, in-group social norms should motivate people to act environmentally, especially with a low SES background. In their experiments, they found personal beliefs about climate change predicted pro-environmental action (probability of donation for sustainability) only in a high SES group. However, social norms (beliefs about their close others such as family, friends, and classmates at the same university) intentions to act pro-environmentally positively predicted the probability of donation in a low SES group.

However, research on "in-group social norms" may serve a stereotypical view of "non-environmentalist" among minority groups. Pearson et al. (2018) pointed out that pro-environmental activities may not be viewed as simply personal choices made individually but rather are perceived as in-group social norms. If pro-environmental activities are supposed as a part of White middle-class social norms, then ethnic minorities members who are not in the "in-group White middle-class" category would be misperceived stereotypically incongruent of their social identities (e.g., as non-environmentalists). For example, Pearson et al. (2018) found the term "environmentalist" was more positively associated with White than with other minority groups. This misperception of being non-environmentalists as a "social norm" in minority groups predicted the minority group's low level of environmental concern, indicating that social norms are inferred through the stereotypical perception of non-environmentalists in minority groups. Taking together, future research should investigate the VBN in a holistic approach by studying multiple determinants including both micro levels (e.g., personal values) and macro levels (e.g., social norms and local communities) simultaneously across different minority groups.

CONSIDERING DIVERSE CULTURAL ORIENTATIONS IN THE U.S

There is a dichotomous focus on White American vs. African American or Latino American differences while disregarding the increasing diversity in the U.S. population from different cultural orientations (e.g., Asian Americans and Native Americans). Little research is available about the impact of various Eastern cultures on the natural environment, even though past literature has revealed cross-cultural differences on environmental behaviors and perception of environmental concerns across different societies (see Milfont, 2012; Milfont and Schultz, 2016). For example, Eom et al. (2016) found that the common logic that concerns-about the environment lead to pro-environmental action is more applicable to Western cultures than to Eastern cultures when comparing results from 47 nations. In addition, certain countries tend to be more resource conscientious than others. When the countries of the world are measured by negative environmental impact (e.g., carbon emissions, endangered species, habitat loss, water pollution), there are distinct ranks, with Asian countries having the most room for improvement (Bradshaw et al., 2010). However, it is important to keep in mind that this rank is not likely entirely reflective of Eastern cultures concern toward the environment. It only measures negative environmental impact, which could be attributed to external factors such as Asian countries' large population and resource requirements or limited availability of clean energy technology.

In addition, research on environmental values and beliefs within indigenous cultures (e.g., Native Americans) have been scarce. A recent study by Washinawatok et al. (2017) explored Native American children's (rural Menominee and urban Native Americans in Chicago) understanding of the natural environment with a unique measure, a 3-dimensional diorama with real models of trees, water, grass, and rock to provide a context in which to interact with toy animals. It is worth noting that a Native American research member rejected the traditional way of measuring human-animal interaction (with plastic toy animals in hypothetical situations) because Native American children would view the plastic animals alone as unnatural and ecologically inappropriate on perceiving nature. They found that Native American children were significantly more interested in playing with the diorama than playing with the toy animals, and were more likely than non-Native American children to engage in perspective taking within nature environment (Washinawatok et al., 2017). In a similar line of research, Cowie et al. (2016) examined the environmental values of indigenous people's (Maori) in New Zealand. They found that the Maori people expressed higher levels of environmental values than European New Zealanders partially due to Maori people's high sociopolitical consciousness. Therefore, historical contexts, economic dynamics, and political orientations need to be considered among the indigenous population in environmental research (Clark, 2002).

Another related, understudied topic of interest to consider is immigrant environmental behavior in the United States. One recent study found that immigrants of New York City, the city with the highest immigrant count in the country, are just as likely and sometimes more likely to engage in environmental behaviors than native-born residents (Pfeffer and Stycos, 2002). However, other studies found no differences in environmental beliefs among immigrants compared to the majority (e.g., Lovelock et al., 2012). Follow-up studies would be necessary to investigate the replicability of this study among different immigrant ethnic groups and within different regions of the country. Future findings may reveal a country of origin effect for immigrant environmental behaviors. After all, cultural biases toward the environment exists based on different society types. For example, individualistic cultures tend to have less environmental engagement, while hierarchical and egalitarian cultures tend to have more (for a review, see Price et al., 2014). Thus, future research should pursue evidence on how people who possess different cultural orientations or countries of origin translate environmentalism into the American cultural context.

INVESTIGATING LOCAL ECONOMICS AND SOCIOCULTURAL FACTORS

Future research needs to investigate external factors that influence ethnic minorities' environmental behaviors, such as economic and sociocultural factors (Kollmuss and Agyeman,

2002; Gifford and Nilsson, 2014), rather than "controlling" the factors (an exception see Schuldt and Pearson, 2016). Economic status plays a large role in environmental behavior, effecting an individual's amount of disposable income and amount of exposure to pollutant. Pro-environmental activists across nations tend to be of higher socioeconomic status. There is a strong association between socioeconomic status and pro-environmentalism in high-income and developed regions, and a slight association in lower-income and developing regions (Pampel, 2014). The greater association in high-income countries can be explained through a willingness to pay. A fundamental shift may occur when people no longer need to spend time and resources meeting their basic needs (e.g., income and property). Instead, people will be able to allocate more funds to addressing environmental issues (e.g., purchasing environmentally friendly products and organic foods) (Jones and Dunlap, 1992; Gifford and Nilsson, 2014). Opposing research argues that wealthy individuals (with agency and power) are more likely to dismiss environmental concerns due to increased access to unpolluted resources in their daily lives (Franzen, 2003; Bickerstaff, 2004). For example, wealthier individuals might have a lower risk perception of air pollution because they can afford to live in less urban, industrialized areas.

Sociocultural factors affect environmental action as well. Past research has indicated that age, cohort, political orientations, and educational levels correlate with environmental concern and behaviors (Gifford and Nilsson, 2014). For example, age negatively predicts environmental concern (Barr, 2007), where recent generations tend to be more concerned about the environment (Jones and Dunlap, 1992) possibly a result of the increased prevalence of environmental initiatives or exposure to environmental issues through social media. Education on environmental issues as well as science literacy, are found to positively correlate with climate change risk perception, meaning that individuals who are more adept at interpreting the scientific, environmental literature are more likely to see climate change as a problem (Leiserowitz, 2006). One recent study has examined the political ideology in relation to climate change (Schuldt and Pearson, 2016). They found that political ideology was less predictive of environmental beliefs among members of ethnic minorities than White in the U.S. Thus, future studies should investigate the interactions of age, SES, levels of education, and political views as potential predictors of environmental concerns and behaviors in an analysis of specified ethnic groups to provide deeper insight into potential mitigating factors.

RECOGNIZING MIXED-METHODS METHODOLOGY

It is generally the case that quantitative analysis is used as the predominant framework in the field of Environmental Psychology. However, the quantitative analysis does not provide a comprehensive explanation addressing the complexity of the human experience. A mixed-methods approach is a strong option to consider for future research because it employs qualitative methodologies to enrich the meaning of the quantitative data (Scharf and Mayseless, 2011). This type of research design searches for different perspectives among individuals under the premise that embracing their personal, cultural, and historical experiences may shape their environmental worldviews (Pratt and Matsuba, 2018). The mixed-methods approach can provide a fruitful ground to investigate motivations of either pro-environmental or anti-environmental behaviors without biasing answers (e.g., moderacy and extremity biases, acquiescence bias, reference-group effect) by providing any preconceived notions (Pratt and Matsuba, 2018). In the following section, two specific approaches of mixed methodology are suggested in the field of environmental psychology.

Triangulation mixed-method design (Creswell and Plano Clark, 2007) has been recently used in the field of environmental psychology. In this approach, researchers collect quantitative data to examine expected relationships as well as parallel qualitative data to address the same research question. Both quantitative and qualitative data are used to confirm, cross-validate, and support findings. This approach also offers researchers the flexibility to convert qualitative data into numerical data (Creswell and Plano Clark, 2007). A recent study conducted by Jia et al. (2016) applied this triangulation mixed-method design. In their study, a positive relationship between generative concern and environmental identity was established by a set of questionnaires. This quantitative result was supported by qualitative interviews of environmental narrative identity. They found that participants with high levels of generative concern tended to tell more meaningful, vivid, and impactful environmental narratives. In addition, different aspects of generative concerns (feeling of empowered to help environment; having children as a focus for crystalizing environment; and passing family traditions in environmental activities) were expressed via environmental narratives (Jia et al., 2015).

In contrast to the triangulation design, the explanatory design offers a two-step approach: a primary focus on quantitative analyses of the study and follow-up qualitative data in an effort to provide a comprehensive explanation for the quantitative analyses (Creswell and Plano Clark, 2007). For example, Jia et al. (2017) conducted two studies to exam how moral identity (both value and motivation) related to levels of environmental engagement. In study one (Jia, 2017), they found that self-transcendent moral values measured using a set of questionnaires (Krettenauer et al., 2016) positively predicted environmental engagement. However, researchers have raised concerns that values do not significantly contribute to the motivation of why people involve in pro-environmental behaviors (Kaiser, 2006; De Groot and Steg, 2007). Qualitative analyses in the follow-up study further explained the motivational factors driving environmental involvements. By using thematic analyses, they found three self-transcendent themes (1. Concern for other species; 2. Vigilance for the environment; 3. Moral emotions toward environmentally irresponsible others) that motivated a group of environmental activists' engagement. Thus, researchers should be encouraged to design mixed-methods studies that provoke ethnic minority participants' perceptions, beliefs, and opinions on environmental issues and capture the rich and complex cultural messages in a meaningful context.

CONCLUSION

In conclusion, globalization and migration have resulted in a growing need to understand ethnic minority members' environmental engagement in a heterogeneous society. However, the literature provides no clear indication of how ethnic minority groups might respond to the environmental issue. This controversy calls for new considerations on theories and methodologies in future research. Bronfenbrenner (1979) ecological model may provide insights on the topic considering individual, social, and cultural levels of analyses. Researchers should favor a holistic approach that evaluates individual, social, cultural, economic, and political influencers. Researchers should consider sociocultural and socioeconomic factors and spans multiple levels of cultural diversity and orientation. Statistical methodologies should strive to use a mixed-methods approach that integrates both quantitative and qualitative data. These strategies can provide researchers with more insight into motivations behind ethnic groups' environmental concerns and behaviors in the United States. Together, this article opens a further inquiry in contexts of concerns and involvements among ethnic groups such as senses of personal agency and social construction in addressing environmental issues.

AUTHOR CONTRIBUTIONS

VM wrote an initial draft. AD added a large section of the manuscript. NR provided an initial literature search and summary. DC wrote one section in the initial draft. FJ conceptualized the framework, wrote and revised a significant portion of the manuscript, and advised the writing process.

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Biology Teachers' Worldviews on the Global Distribution and Loss of Biodiversity: A GIS-Based Mental-Mapping Approach

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This paper explores (1) student teachers' mental maps of the global distribution and loss of biodiversity and (2) their perception of threatened biodiversity at the national, transnational and global levels. Data was collected from a questionnaire study of student biology teachers from Germany (n = 868) and Costa Rica (n = 284). Student teachers' mental maps matched quite well with the scientific view. Nevertheless, they clearly showed a "brazilisation bias," meaning that the first and foremost country associated with high and threatened biodiversity was Brazil. Industrialized countries were often misconceived to have a particularly threatened biodiversity. Except for Brazil (and Costa Rica in the Costa Rican sample), most students neglected a connection between a country's high biodiversity and its high threat as proposed by the biodiversity hotspots concept. Despite this common ground, major ethnocentric distortions merged in the composite mental maps for each sample: German students had a more global perspective on biodiversity and its loss, whereas Costa Ricans students had a more localized view. Student teachers from both countries have largely overestimated the percentage of threatened plant species on a national, transnational and global level ("overestimation bias"). In addition, the estimated percentage of threatened plant species have correspondingly increased with a greater distance from the students' home country ("spatial optimism bias"). Results will be discussed in terms of educational implications.

Keywords: student teachers, education for sustainable development, biodiversity, mental maps, spatial optimism bias, overestimation bias

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INTRODUCTION

The loss of biodiversity progresses on a global scale and is considered one of the most serious environmental problems of our time (Dirzo and Raven, 2003; Millennium Ecosystem Assessment [MEA], 2005). Education for Sustainable Development (ESD) is one important counteraction to this trend by making the public aware of the role and value of biodiversity and the steps needed to conserve it (United Nations Conference on Environment and Development [UNCED], 1992; Secretariat of the Convention on Biological Diversity, 2010). Within the framework of ESD, the distribution and loss of biodiversity has a high potential to be used a model context for discussing global challenges and conservation strategies in the science classroom (Gayford, 2000; Kassas, 2002;

Scheunpflug and Asbrand, 2006; Menzel and Bögeholz, 2008; Lindemann-Matthies et al., 2011). Worldwide school systems provide the largest organized base for such a biodiversity education (Nagra, 2010).

In the past, traditional environmental education was merely focused on local contexts and ecological facts, whereas global cause–effect relationships were largely marginalized (Bolscho and Hauenschild, 2006). In contrast, ESD should be interdisciplinary and global in its scope (Scott and Gough, 2004; Summers et al., 2005; Scheunpflug and Asbrand, 2006; Menzel and Bögeholz, 2008). This is a difficult task as the scientific evidence about global biodiversity and its loss is rather uncertain and often controversial (Kassas, 2002). To adequately teach this complex issue, teachers need a basic understanding about the world, its principal regions and political and biogeographic characteristics (Holm and Farber, 2002). In line with other authors, we argue that teaching about a complex and controversial issue, such as the distribution and loss of biodiversity, raises important questions for teachers concerning bias, balance and personal worldviews (e.g., Pajares, 1992; Holm and Farber, 2002; Moseley and Utley, 2008).

To date, researchers have been predominantly focused on student teachers' understanding of the terminology and socio-scientific aspects of biodiversity issues (Gayford, 2000; Summers et al., 2004; Kyburz-Graber et al., 2006; Lindemann-Matthies et al., 2011). Besides these important aspects, the global dimension of the distribution and loss of biodiversity is often depicted as a major educational challenge for both teachers and learners alike (Bybee, 1991; Chiodo, 1993; Merryfield, 2000; Hicks and Bord, 2001; Holm and Farber, 2002; Bolscho and Hauenschild, 2006; Scheunpflug and Asbrand, 2006; Menzel and Bögeholz, 2008; Lindemann-Matthies et al., 2009). With regards to the student teachers' worldviews and perceptions of the global dimension of biodiversity and its loss, a sound empirical basis is still lacking. How student biology teachers from Germany and Costa Rica perceive the global distribution and loss of biodiversity was investigated in this study. To achieve an effective understanding of this, we explored (1) student teachers' mental maps of the global distribution and loss of biodiversity and (2) student teachers' perceptions of threatened biodiversity at a national, transnational, and global spatial level.

THEORETICAL BACKGROUND

Global Distribution and Loss of Biodiversity

In general, most of the terrestrial biodiversity can be found in tropical ecosystems, especially in the tropical rainforests of the Americas, Africa, and Southeast Asia (Mittermeier et al., 2004). High diversity is also found in temperate regions with a Mediterranean climate, e.g., Southwest Australia, the Cape region of South Africa, California, central Chile, and the Mediterranean basin (Groombridge and Jenkins, 2002; Mutke and Barthlott, 2005; Primack, 2010).

In a strict scientific sense, biodiversity is defined as "the variability among living organisms from all sources, including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems" (United Nations Conference on Environment and Development [UNCED], 1992; p. 3). Data on global plant diversity is assumed to serve as one of the best surrogates for the total diversity of the living creatures found on our planet (Dirzo and Raven, 2003; Mutke and Barthlott, 2005). Moreover, on a global level, estimates for plant diversity are much more precise than those pertaining to animal diversity (Groombridge and Jenkins, 2002; Mutke and Barthlott, 2005; Primack, 2010). Thus, for the purpose of this paper, we used "plant diversity" as an indicator for "biodiversity."

In total, more than 270,000 species of plants have been described scientifically (Walter and Gillett, 1998). The top ten countries that hold the highest biodiversity in terms of number of plant species are: Brazil (56,215), Colombia (51,220), China (32,200), Indonesia (29,375), Mexico (26,071), South Africa (23,420), Venezuela (21,073), United States (19,473), Ecuador (19,362), and India (18,664) (in parenthesis number of total plant species) (Groombridge and Jenkins, 2002).

The Red List of Threatened Species^{TM} (RL), which is compiled by the International Union for Conservation of Nature (IUCN), is "widely recognized as the most objective and authoritative listing of species that are globally at risk of extinction" (IUCN, 2004, p. Xi). According to the RL, the following countries hold the largest number of threatened plant species: Ecuador (1,837), Malaysia (694), China (452), Indonesia (394), Brazil (387), Cameroon (378), India (314), Tanzania (298), Sri Lanka (285), and Madagascar (280) (in parenthesis number of total threatened plant species) (IUCN, 2011). Globally, more than 4.3% of all plant species have been classified as being threatened (IUCN, 2011).

Earth's richest and simultaneously most threatened reservoirs of biodiversity are so-called biodiversity hotspots (Myers et al., 2000). Many biodiversity hotspots are found in the developing countries of the tropics, including Costa Rica. Scientifically speaking, a region has to meet two strict criteria to be designated as a biodiversity hotspot: (1) it has to contain at least 1,500 endemic plant species and (2) 70% of its pristine vegetation has to be destroyed (Myers et al., 2000). On a global scale, the concept of biodiversity hotspots is one of the most established biodiversity conservation templates (Mittermeier et al., 2004).

Costa Rica and Germany are regarded as international role models for the successful implementation of ESD on all educational levels (Guier et al., 2002; Seybold and Rieß, 2006; Blum, 2008). Both countries acknowledged ESD as an important component of their National Biodiversity Strategy and Action Plans (NBSAP's) (Ministerio del Ambiente y Energía [MINAE], 2000; Küchler-Krischun and Walter, 2007). Furthermore, the global dimension of the distribution and loss of biodiversity is an integral part of their national secondary science curriculums (Ministerio de Educación Pública [MEP], 2003, 2005; Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland [KMK], 2004). Thus, Costa Rican and German secondary biology teachers are required to incorporate biodiversity-relevant topics into their secondary classrooms, including its global dimension (Ministerio de Educación Pública [MEP], 2003, 2005; Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland [KMK], 2004).

A Constructivist View on Student Teachers' Mental Maps

Despite their future role as teachers, in this study we viewed student teachers as learners. We defined "learning" as the active and individual construction of knowledge (Piaget, 1971; de Kock et al., 2004) which is shaped and filtered through social interactions and cultural experiences (Vygotskij, 1978; Windschitl, 2002; Bless et al., 2004). Based on this constructivist model of learning, we assumed that student science teachers from Costa Rica and Germany would hold an individually built knowledge toward the global distribution and loss of biodiversity which is partly shaped by their different social and cultural settings.

According to Bell (2009) these "internal spatial representation of the world" constitute our "cognitive maps." Thus, "cognitive maps" exist only in the mind of people and are influenced by social interactions and cultural experiences. The term "mental map" is often attached to different meanings across different disciplines including environmental psychology, anthropology, cognitive science, and human geography (Kitchin, 2002; Bell, 2009). For the purpose of this paper we defined a "mental map" as an external map-like product that represents the worldviews of individuals or groups pertaining to the spatial and environmental relations of geographic space (Kitchin, 2002; Bell, 2009). In geographical and educational research, mental maps can offer a promising way to illustrate and analyze individuals' and groups' geographic literacy and worldviews (e.g., Chiodo, 1993; Saarinen and MacCabe, 1995; Pinheiro, 1998; Chokor, 2003; Saarinen, 2005). As many cultural sources and factors underlie our mental maps of the world, ethnocentric deviations and distortions are likely to occur when they are compared to reality (Saarinen and MacCabe, 1995; Pinheiro, 1998; Saarinen, 2005). Some authors argue that such differences in mental maps can account for many environmental conflicts in our world (e.g., Koger and Du Nann Winter, 2010). In the present study, composite mental maps were used to represent secondary pre-service teachers' worldviews on the distribution and loss of biodiversity. To the authors' knowledge, this study is the first to attempt an assessment of student teachers' biogeographic worldviews regarding the distribution and loss of global biodiversity through the use of mental maps.

Perceived Threat of National, Transnational, and Global Biodiversity

Spatial Optimism Bias

Recent research in environmental psychology revealed that people are generally more concerned about global environmental problems than about national ones (Dunlap and Mertig, 1995; Uzzell, 2000; Gifford et al., 2009). Gifford et al. (2009) demonstrated in a multinational survey with the general public that there seems to exist a so-called "spatial optimism bias" when evaluating environmental problems from the national to the global scale. It was found that assessed environmental problems increased as the spatial level increased from the national to the global level, regardless of whether the subjects were from a developed or a developing country (Gifford et al., 2009).

Overestimation Bias

People seem to have only very vague ideas about the current number of animal and plant species, as well as about respective extinction rates on the national and on the global level (Dunning, 1997). Lindemann-Matthies and Bose (2008) found the general public of Switzerland to drastically overestimate the overall amount of Swiss and global plant species. Dunning (1997) found the same trends when asking United States undergraduates about the total number of species on earth and the number of species going extinct each year. This phenomenon, which we will henceforth refer to as "overestimation bias," may have serious consequences in conservational and educational terms: Convincing people that biodiversity loss is a serious problem becomes more difficult when people's perception of the current situation is so different from reality (Dunning, 1997; Lindemann-Matthies and Bose, 2008). Moreover, scientifically correct numbers of threatened species may appear quite low to people who have much higher numbers in mind. As a consequence, reality may be perceived as better than it really is.

RESEARCH QUESTIONS AND AIM OF THE STUDY

Our study was guided by the following research questions: (1) To what degree do biology teachers from an industrialized country and a biodiversity hotspot share a common view on Earth's biodiversity? (2) And in what ways do they differ? More in detail we aimed at exploring student teachers' mental maps of the global distribution and loss of biodiversity and whether their perceived threat of biodiversity at the national, transnational and global spatial levels will be affected by a "spatial optimism bias" and an "overestimation bias."

With regard to the first aim of the study we assumed that distinctive ethnocentric perspectives, such as living at a biodiversity hotspot (Costa Rica) and living in an industrialized country (Germany) would be likely to merge on aggregated mental maps when compared to scientific data. As the loss of biodiversity becomes especially apparent in biodiversity hotspots (Myers et al., 2000), we were particularly interested in whether student teachers from both countries will hold a naive concept of biodiversity hotspot, meaning that countries of assumed high plant diversity will also be suspected of having a high amount of threatened plant species. As Costa Rica forms part of the Mesoamerica biodiversity hotspot, we expected that Costa Rican students would be more likely to hold a biodiversity hotspot concept than German students.

Regarding our second aim, based on the literature cited above, we hypothesized that: (i) student teachers from both countries will generally overestimate the percentage of threatened plant species on a national, transnational and global level when compared to scientific data; (ii) participants from both countries will perceive the percentage of threatened plant species on a global level as more serious than at the transnational level, and this, in turn, higher than at the national level; and (iii) students from both countries will perceive the threat of

plant species in their own country as less severe than in the respective other country.

MATERIALS AND METHODS

Sample

For the present study we carried out a quantitative questionnaire survey in Winter 2010/2011 with secondary pre-service science teachers in Germany (n = 868; M_{age} = 23.1, SD = 3.3; female: 75.2%) and Costa Rica (n = 284, M_{age} = 25.8, SD = 6.6; female: 55.3%). All Costa Rican participants were secondary natural science (= biology, chemistry, and physics) teachers and all German participants were secondary biology teachers. The German sample comprised of students from 23 different public universities. In Germany participants per university varied between 6 (Berlin – Freie Universität) and 105 students (Osnabrück). In Costa Rica, students from three public and three private universities participated in the study. Costa Rican participants per university varied between 16 (Universidad Americana) and 72 students (Universidad Florencio del Castillo). Within the German sample 46.3% of the students were at the beginning of their studies ($\leq$ 4 terms) and 53.3% were advanced students (> 4 terms) (0.3% no answer). In the Costa Rican sample we found that 37.7% were beginning students and 47.2% advanced students (15.1% no answer). A detailed description of the sample can be found in **Table 1**. The gross enrollment ratio in tertiary education in 2015 is comparable in both countries and was 53.6% in Costa Rica, and 66.3% in Germany (OECD, 2018). Despite the fact that there are good scholarship programs for students, the education systems in both countries still show a strong socio-economical selectivity. School leavers with low socio-economic status are less likely to enter higher education than young people with high socio-economic status (Berthold and Leichsenring, 2012; CONARE, 2015; Autorengruppe Bildungsberichterstattung, 2018).

Data Collection

For data collection the persons in charge of tertiary science teacher education in both countries were contacted and asked for participation within the project. In Germany, all questionnaires were sent to the respective persons in charge accompanied by a standardized information sheet on how to conduct the questionnaire survey. In Costa Rica the corresponding author of the study conducted all questionnaire surveys on-site with the help of local collaborators. In both countries, the questionnaires were administered in a paper-and-pencil format. Prior to the completion the questionnaires, students were informed that the survey was about their ideas and opinions regarding biodiversity. On the first page of the questionnaire, students were given a definition of biodiversity, which was based on the definition of the CBD (United Nations Conference on Environment and Development [UNCED], 1992). To avoid bias, participants in both countries were not informed that they were taking part in an intercultural study until they completed the questionnaire. The questionnaires were presented in the respective mother tongue, Spanish in Costa Rica and German in Germany. Data collection took place in class sets in each university. The questionnaires were filled out by the students individually under exam-like conditions. The time for the completion of the herewith presented measures took about 5 min.

Measures

Socio-Demographic Variables

To gather basic information about our participants, we collected socio-demographic variables such as nationality, attended university, age, sex, and current semester.

Mental Maps of Global Biodiversity

The process of assessing individuals' or groups' concepts about spatial and environmental relations of geographic space with the final objective of generating a map representation is called "mental mapping" (Bell, 2009). In this study we followed an indirect mental mapping approach by asking the participants to name three countries with a particularly high plant diversity and three countries with a particularly threatened plant diversity. The original survey wording was: "Please name three countries that

TABLE 1 | Characteristics of the pre-service biology[1] teacher sample from Germany (n = 868) and Costa Rica (n = 284).

Nationality	University	Total[2]	BS	AS	Females [%]
Germany	Berlin (Freie Universität)	6	3	3	100
	Berlin (Humboldt Universität)	26	13	12	69.2
	Bielefeld	54	5	49	77.8
	Braunschweig	27	27	0	88.9
	Bremen	26	19	6	73.1
	Dortmund	23	0	23	87.0
	Duisburg-Essen	21	0	21	76.2
	Erlangen-Nürnberg	59	31	28	74.6
	Halle-Wittenberg	21	9	12	71.4
	Hamburg	70	32	38	75.7
	Hannover	24	5	18	70.8
	Jena	56	53	3	75.0
	Karlsruhe[3]	32	1	31	84.4
	Köln	12	5	7	66.7
	Leipzig	26	0	26	65.4
	Marburg	72	48	24	70.8
	München	18	9	9	83.3
	Münster	38	14	24	71.1
	Oldenburg	39	23	16	76.9
	Osnabrück	105	48	57	78.1
	Potsdam	24	1	23	79.2
	Rostock	59	52	7	71.2
	Vechta	30	4	26	63.3
Costa Rica	Universidad Americana (UAM)[4]	16	10	3	37.5
	Universidad de Costa Rica (UCR)	60	20	40	51.7
	Universidad Estatal a Distancia (UNED)	41	5	34	61.0

(Continued)

TABLE 1 | Continued

Nationality	University	Total[2]	BS	AS	Females [%]
	Universidad Florencio del Castillo (UCA)[4]	72	35	27	51.4
	Universidad Nacional (UNA)	67	37	30	55.2
	Universidad de San José (USJ)[4]	28	21	6	75.0

BS, Beginning students (≤ 4 terms of study); AS, Advanced students (> 4 terms of study). [1]All German participants were pre-service biology teachers, whereas all the Costa Rican participants were pre-service natural science teachers (= biology, chemistry and physics). [2]Deviations in the total of students with BS and AS values can be attributed to the fact that not all students have indicated their terms of study. [3]University of Education (= "Pädagogische Hochschule"). [4]Private universities. The higher education system in Costa Rica is dominated by five public universities, of which only the Universidad de Costa Rica (UCR), Universidad Nacional de Costa Rica (UNA) and the Universidad Estatal a Distancia (UNED) offer natural sciences teacher education programs. In addition, there are more than 59 private universities with different quality and, in some cases, relatively high university fees. Of those private universities, only a few offer teacher education programs in the natural sciences (CONARE, 2015; DAAD, 2018). In Germany, teacher education is offered exclusively at state universities. In Germany there are a total of 87 public universities (including the seven Universities of Education in Baden-Württemberg; "Pädagogische Hochschule"), of which 51 offer biology teacher education programs (https://hochschulkompass.de).

you think have a particularly high diversity of plant species." and "Please name three countries where you think the diversity of plant species is particularly threatened."

Perceived Threat of Biodiversity

In order to evaluate student teachers' perception of threatened biodiversity on the national, transnational and global spatial levels, they were asked to estimate the percentage of threatened plant species in Germany, Costa Rica, and worldwide. Original survey wording in the German questionnaire was: "Please estimate what percentage of flowering plants are threatened in Germany, Costa Rica, and worldwide." In the Costa Rican version of the questionnaire, the question was phrased as: "Please estimate what percentage of flowering plants are threatened in Costa Rica, Germany, and worldwide." In both Germany and Costa Rica, the question was first asked with regards to the respondents' own country, followed by the other country and finally about the percentage of threatened plants in the world. For the answering of the question, there were ready-made spaces to enter the percentages (e.g., "Germany _____ %").

Analysis

Mental Map Production

Firstly, all mentioned country names of assumed high and/or threatened plant diversity were standardized, for example notions such as "United States," "United States of America," "US," or "USA" where all coded as "USA." Responses that could not clearly be assigned to a specific country were excluded from analysis (e.g., Andes, hot regions etc.). Hereafter, we formed a variable for each of the reported countries. The variables (= countries) were coded as "1" when a participant assumed a country to have a particularly high plant diversity, as "2" when a country was assumed to have a particularly threatened plant diversity, and as "3" when a country was considered to have a particularly high and threatened biodiversity – thus, resembling the concept of biodiversity hotspots. Frequencies of notions for each country and category were calculated using SPSS. Tabular frequency data of students' notions and the scientific data of the total number and the number of threatened plant species per country were exported to ArcGIS™ (GIS; Geographical Information Systems), a software infrastructure for the production of geographical information and maps. When exporting, the frequency data from SPSS is linked with the respective geo-referenced countries within an ArcGIS™ database, which can then be visualized via ArcMap™ (a module of the ArcGIS software) in a world map, complete with different shadings for countries that have a high or threatened biodiversity. Respective scientific data for total plant species counts per country were taken from Groombridge and Jenkins (2002) and for threatened plant species from IUCN (2011).

With the help of ArcMap™ composite political world maps of student teachers' worldviews on the distribution and threat of global plant diversity in comparison to the scientific views were created. For the map construction we overlaid the scientific views on the distribution and threat of global plant diversity with respective student teachers' views. The resulting map patterns are presented here to illustrate the special features of each sample and characteristics common to both (see **Figures 1**, **2**). In order to assess countries which were thought to have a particularly high and threatened plant diversity (= naive biodiversity hotspots) we created bubble charts (see **Figure 3**). The percentages of persons holding a naive biodiversity hotspot concept of a respective country are indicated by the size of the bubbles. All geo-spatial analysis, bubble charts and mental maps were created using ArcMap™. The programs GRASS (Geographical Resources Analysis Support System[1]) and QGIS[2] are free, readily available software on the Internet that have a similar functionality to ArcGIS™.

Statistical Analysis

National differences between student teachers' notions of countries with high and/or threatened plant diversity were analyzed by using chi²-tests. To test whether nationality was significantly related to student teachers' estimates of the percentages of threatened plant diversity on the national, transnational and global spatial level, we used an Analysis of Variance (One-way ANOVA).

RESULTS

Student Teachers' Mental Maps of Global Biodiversity

Special features and common characteristics of each subsample's composite mental maps on global plant diversity are shown in **Figures 1**, **2**.

[1]https://grass.osgeo.org

[2]https://qgis.org/de

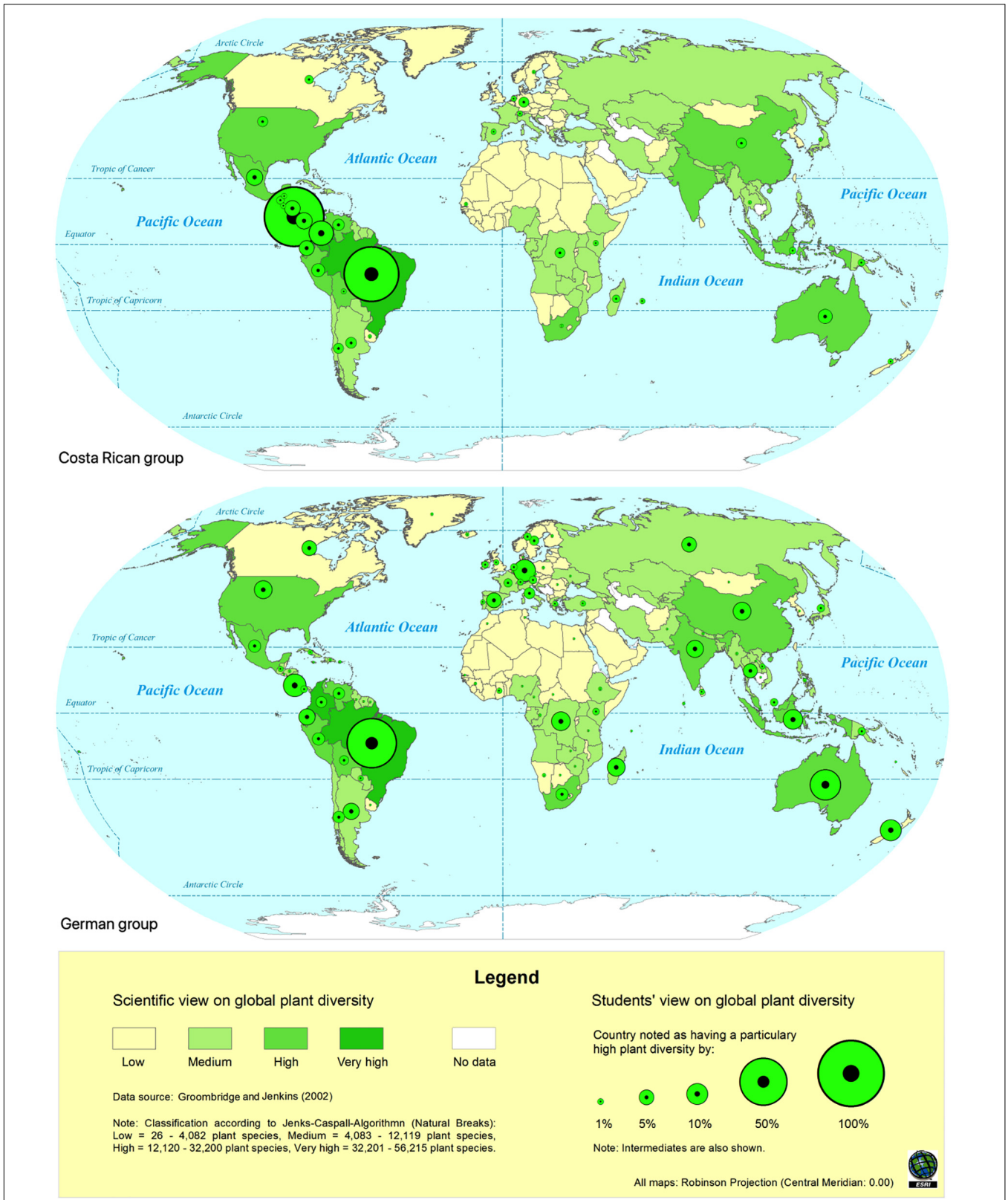

FIGURE 1 | Composite mental maps of countries assumed to have a high plant diversity of Costa Rican (top) and German (bottom) student biology teachers. Within each map the scientific view on global plant diversity (green shading) is overlaid with the respective student teachers' view (green circles).

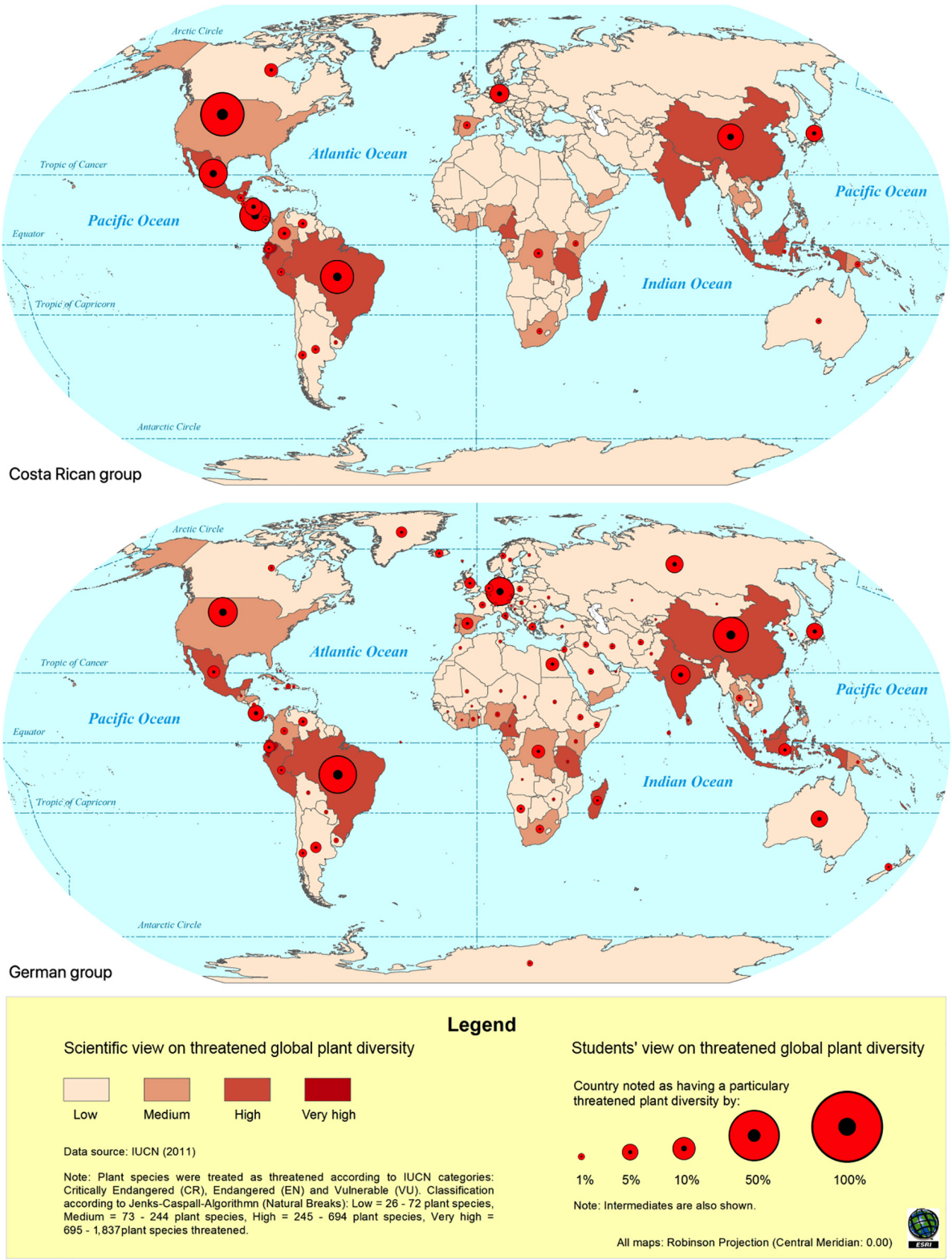

FIGURE 2 | Composite mental maps of countries assumed to have a threatened plant diversity of Costa Rican (top) and German (bottom) student biology teachers. Within each map the scientific view on threatened global plant diversity (red shading) is overlaid with the respective student teachers' view (red circles).

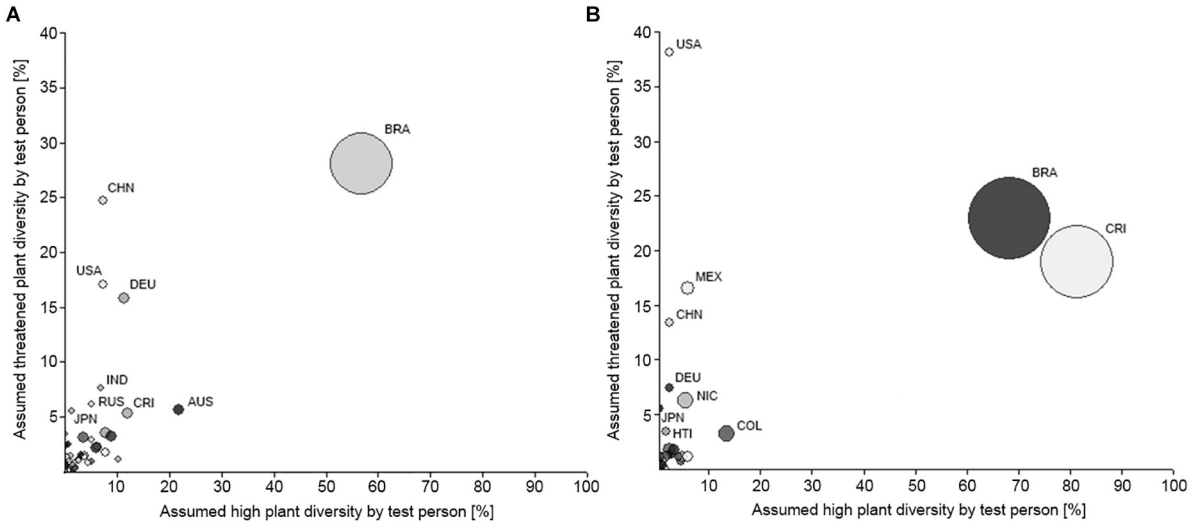

FIGURE 3 | Relationships between notions of countries with an assumed high and threatened biodiversity as mentioned by student teachers from Germany **(A)** and Costa Rica **(B)**. Bubble size indicates percentage of individuals naming a certain country as having a high and threatened biodiversity. AUS, Australia; BRA, Brazil; CHN, China; COL, Colombia; CRI, Costa Rica; DEU, Germany; HTI, Haiti; IND, India; JPN, Japan; NIC, Nicaragua; RUS, Russia; USA, United States.

Worldviews on Countries With High Plant Diversity

Common characteristics of student teachers' mental maps from both countries were: (1) the majority of student teachers in both countries mentioned Brazil as a country with particularly high plant diversity (Germany: 56.7% and Costa Rica: 68.3%), (2) most other countries were only mentioned by a small number of participants (except for Costa Rica in the Costa Rican sample, see below), and (3) students' views matched quite good with scientific data, except for some countries as mentioned in the German sample (e.g., Germany, New Zealand, and United States). However, some of the scientific top ten countries, such as South Africa and India, were not or only marginally considered to have high plant diversity. Special features of the Costa Rican sample were: (1) the vast majority (81.3%) of Costa Rican student teachers mentioned Costa Rica as a country with high plant diversity; (2) most Costa Rican students almost exclusively focused on Latin American countries as having high plant diversity, whereas other regions of the world, such as Africa and South-East Asia, were largely marginalized (**Figure 1**). Special features of the German sample were: (1) German students' notions were distributed more evenly across the globe including South- and Central America (e.g., Brazil and Costa Rica), Africa (e.g., Congo and Madagascar), and Asia (e.g., Indonesia and China), (2) German top ten country notions also included nations such as Germany and New Zealand that are described to have a rather low plant diversity from a scientific point of view. A detailed overview of the ten most frequently mentioned countries that have a high biodiversity can be found in **Table 2**.

Worldviews on Countries With Threatened Plant Diversity

Overall, there were more similarities between both subsamples concerning their views on countries with threatened plant diversity than for countries with high plant diversity (**Figure 2**). Common characteristics for our participants' views on countries with threatened plant diversity were: (1) the majority of student teachers from both countries mentioned Brazil as a country with particularly threatened plant diversity (Germany: 28.1% and Costa Rica: 22.9%), (2) industrialized or newly developed countries such as the United States, Germany, Japan, and China were considered as countries with a particularly threatened plant diversity by many students from both subsamples. Except for some countries such as Germany, Russia, Japan, and Canada the students' view matched quite well with scientific data. However, some of the scientific top ten countries of threatened plant species such as Malaysia, Indonesia and India were not or only marginally considered to have threatened plant diversity (**Figure 2**). Special features of the Costa Rican sample were: (1) the majority of Costa Rican students (38.1%) considered the United States as having a particularly threatened plant diversity (even more than Brazil), (2) Costa Rican students were mainly focused on Latin American countries as having a threatened plant diversity, except for some industrialized countries such as Germany, Japan and China. Special features of the German sample were: (1) German students' notions of countries with threatened were distributed more evenly across the globe. A detailed overview of the ten most frequently mentioned countries that have a threatened biodiversity can be found in **Table 3**.

Biodiversity Hotspots

Students' notions of countries with particularly high and threatened plant diversity on an individual level are shown in **Figure 3**.

As hypothesized, our results suggest that a naive biodiversity hotspot concept exists on an individual level in both samples.

TABLE 2 | Frequencies of student teachers' notions of countries holding high plant diversity.

German sample				Costa Rican sample			
Rank	**Country**	**Scientific rank[a]**	**Frequency [%][b]**	**Rank**	**Country**	**Scientific rank[a]**	**Frequency [%][b]**
1	Brazil	1	56.7**	1	Costa Rica	15	81.3***
2	Australia	13	21.8***	2	Brazil	1	68.3**
3	Costa Rica	15	12.1***	3	Colombia	2	13.4***
4	Germany	107	11.4***	4	Mexico	5	6.0***
5	New Zealand	112	10.2***	5	Panama	22	6.0***
6	Indonesia	4	8.9***	6	Nicaragua	32	5.6***
7	Congo (COD)	19	7.8***	7	Ecuador	9	4.9
8	Madagascar	23	7.7***	8	Australia	13	4.6***
9	China	3	7.3**	9	Peru	12	4.2
10	United States	84	7.3**	10	Venezuela	7	3.2

[a]*After Groombridge and Jenkins (2002),* [b]*Significance of Chi²-test between notions of the German and Costa Rican sample: **$p < 0.01$, and ***$p < 0.001$.*

TABLE 3 | Frequencies of student teachers' notions of countries holding threatened plant diversity.

German sample				Costa Rican sample			
Rank	**Country**	**Scientific rank[a]**	**Frequency [%][b]**	**Rank**	**Country**	**Scientific rank[a]**	**Frequency [%][b]**
1	Brazil	5	28.1	1	United States	14	38.1***
2	China	3	24.7***	2	Brazil	5	22.9
3	United States	14	17.1***	3	Costa Rica	28	19.0***
4	Germany	91	15.8***	4	Mexico	13	16.5***
5	India	7	7.6**	5	China	3	13.4***
6	Russia	94	6.2*	6	Germany	91	7.4***
7	Australia	9	5.7***	7	Nicaragua	55	6.3***
8	Japan	86	5.6	8	Japan	86	5.6
9	Costa Rica	28	5.3***	9	Haiti	65	5.3***
10	Congo (COD)	7	3.6**	10	Canada	158	3.5**

[a]*After IUCN (2011),* [b]*Significance of Chi²-test between notions of the German and Costa Rican sample: *$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$.*

Brazil is considered as a naive biodiversity hotspot by more than two in ten students from both subsamples. Additionally, nearly two in ten Costa Rican students also considered their home country a biodiversity hotspot. All other countries were mentioned to a far lesser extent, with Costa Rican students mainly focusing on Latin American countries, largely marginalizing other parts of the world. However, all mentioned "top-ten" biodiversity hotspot countries from both subsamples were in fact scientifically defined biodiversity hotspots (except for Germany in the German sample). A detailed overview of the ten most frequently mentioned countries that have a high *and* threatened biodiversity can be found in **Table 4**.

Perceived Threat of National, Transnational, and Global Biodiversity

Our results indicate that student science teachers have widely inaccurate ideas of the percentage of threatened plant species, when compared to scientific data. As hypothesized, students from both countries clearly showed a "spatial optimism bias" and an "overestimation bias" when estimating the percentage of threatened plant species in Germany, Costa Rica, and worldwide (**Figure 4**).

According to the current RL in Germany there are 0.5% of threatened plant species, in Costa Rica 1.0% and worldwide 4.5%, respectively (IUCN, 2011). Students from both countries largely overestimated[3] the percentage of threatened plant species on the national (Germany: 40 times and Costa Rica: 30 times), transnational (Germany: 30 times and Costa Rica: 80 times), and on the global level (Germany: 9 times and Costa Rica: 14 times). Additionally, the estimated percentage of threatened plant species increased with greater distance from the students' home country (**Figure 4**). Particularly for Germany the number of threatened plant species was strongly overestimated by both samples. German students estimated the percentage of threatened plant species more accurately than Costa Rican students for Germany ($F_{1,932} = 154.28$, $p < 0.001$) and worldwide ($F_{1,928} = 96.38$, $p < 0.001$). No difference was found in the accuracy of both samples estimates regarding the percentage of threatened plant

[3]Overestimation = median of estimates/actual percentage

TABLE 4 | Frequencies of student teachers' notions of countries holding high *and* threatened plant diversity (=biodiversity hotspots).

German sample			Costa Rican sample		
Rank	**Country**	**Frequency [%]**	**Rank**	**Country**	**Frequency [%]**
1	Brazil[a,b]	24.0	1	Brazil[a,b]	19.4
2	Australia[c]	2.6**	2	Costa Rica[f]	16.9***
3	Indonesia[d,e]	2.6*	3	Colombia[i,j]	2.1**
4	Costa Rica[f]	2.3***	4	Nicaragua[f]	2.1***
5	Mexico[f,g]	2.2**	5	Congo (COD)[h]	1.4*
6	Congo (COD)[h]	2.0*	6	Mexico[f,g]	1.4
7	Ecuador[i,j]	2.0	7	Ecuador[i,j]	0.7
8	Germany	2.0*	8	Guatemala[f]	0.7
9	China[k,l]	1.8	9	Panama[f]	0.7
10	United States[m]	1.7	10	Venezuela[j]	0.4

*Country is part of and/or hosts a scientifically defined biodiversity hotspot: [a]Atlantic Forest hotspot, [b]Cerrado hotspot, [c]Southwest Australia hotspot, [d]Sundaland hotspot, [e]Wallacea hotspots, [f]Mesoamerica hotspot, [g]Madrean Pine-Oak Woodlands hotspot, [h]Eastern Afromontane hotspot, [i]Tumbes-Chocó-Magdalena hotspot, [j]Tropical Andes hotspot, [k]Mountains of Southwest China hotspot, [l]Himalaya hotspot, [m]California Floristic Province hotspot (after Mittermeier et al., 2004). Significance of Chi²-test between notions of the German and Costa Rican sample: *$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$.*

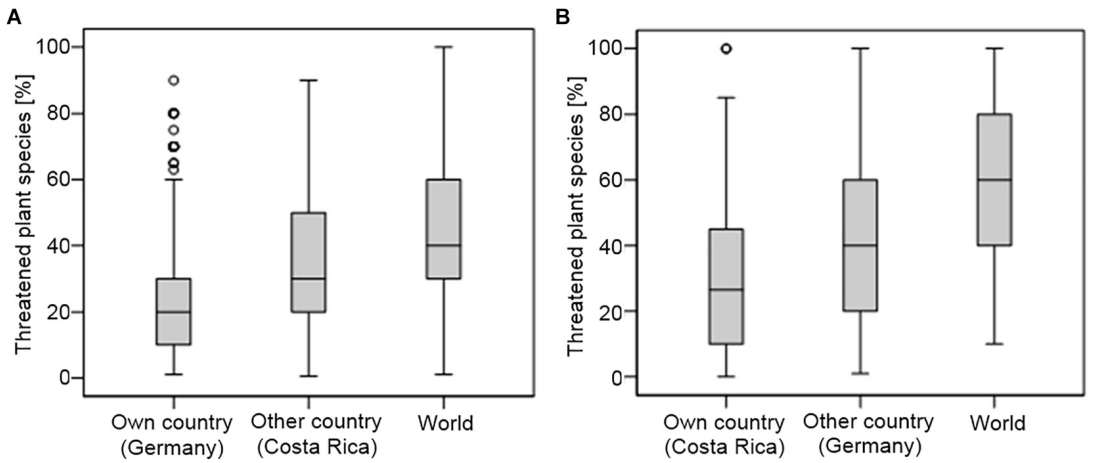

FIGURE 4 | Boxplots showing the estimated percentages of threatened plant species in Germany, Costa Rica and worldwide by student biology teachers from Germany **(A)** and Costa Rica **(B)**.

species in Costa Rica ($F_{1,927} = 2.49$, $p = 0.115$). A detailed overview of the estimated percentages of threatened plant species in Germany, Costa Rica and globally can be found in **Table 5**.

DISCUSSION AND EDUCATIONAL IMPLICATIONS

The main aim of the present study was to assess student teachers' worldviews on the global distribution and loss of biodiversity. Two research questions guided our study: (1) To what degree do biology teachers from an industrialized country and a biodiversity hotspot share a common view on Earth's biodiversity? (2) And in what ways do they differ? To address our research questions, we investigated the mental maps on the distribution and threat of global plant diversity and the perception of threatened plant species on the national, transnational and global levels of prospective biology teachers from Germany and Costa Rica.

Student Teachers' Mental Maps of High and Threatened Global Biodiversity

The most conspicuous common feature of the two subsamples' composite mental maps is a phenomenon which we summarize under the term "brazilisation" of global biodiversity. More than half of our participants from both countries first and foremost associated Brazil with a country of a particularly high or threatened plant diversity. In scientific terms, Brazil is in 1st place regarding the world's plant species richness (Groombridge and Jenkins, 2002) and in 5th place in terms of threatened plant species (IUCN, 2011). Thus, at first glance, our results seem very encouraging, as student teachers' perception of Brazil's biodiversity match quite well with the scientific view. However, we assume that this strong focus on Brazil might rather be

TABLE 5 | Estimated percentages of threatened plant species in Germany, Costa Rica, and worldwide by student biology teachers from Germany (D) and Costa Rica (CR) as compared to scientific data.

	Germany		Costa Rica		World	
Sample from	**D**	**CR**	**D**	**CR**	**D**	**CR**
Minimum	1	1	1	0	1	10
Maximum	90	100	90	100	100	100
Percentile 25	10	20	20	15	30	41
Median	20	40	30	30	40	60
Percentile 75	30	60	50	48	60	80
Actual percentage*	0.5		1.0		4.3	
Overestimation**	40.0	80.0	30.0	30.0	9.3	14.0

*All data in percent of total plant species of a country that are under threat [%]. *Threatened plant species counts taken from IUCN (2011): Germany = 0.5% (14 sp.), Costa Rica = 1.0% (116 sp.), worldwide = 4.3% (11,690 sp.). **Overestimation = median of estimate/actual percentage.*

based on lay people's associations than on a deep scientific understanding. In the following we will try to justify this critical assumption.

The Brazilian Amazon region represents more than 40% of the total tropical rainforests area of the world and Brazil alone accounts for about 30% of the loss of the world's tropical rainforests (Primack, 2010). The Earth Summit in Río de Janeiro in 1992 – and in particular the Amazon region in Brazil – gained a high media presence worldwide mainly focusing on the destruction of tropical rainforests and mass extinction of species (Väliverronen, 1998). Thus, the destruction of tropical rainforest has become a synonym for the rapid loss of species (Primack, 2010) and the latter has become a surrogate for global biodiversity loss (Haila and Kouki, 1994; Novacek, 2008). If we consider that children (Ballouard et al., 2011), the general public (Lindemann-Matthies and Bose, 2008) and even teachers (Cross, 1998; Michail et al., 2007) use the mass media as their major environmental information source, it is, thus, not surprising that prospective biology teachers' worldviews of biodiversity are biased toward Brazil. This is further supported by recent research in environmental psychology showing that adolescents' media exposure is closely associated with their biospheric value orientation and their environmental worldviews (Lee, 2011). In line with Michail et al. (2007) and Lee (2011) we assume that if teachers' worldviews about global biodiversity issues are almost exclusively shaped through the mass media, it seems very likely that they are mainly based on a lay than on a scientific understanding. In this context, it is also worth considering that in-service science teachers are possibly even more dependent on the media as a source of information, because they have not come to know biodiversity in their tertiary education (see Michail et al., 2007).

Geographical research already showed that world regions that we do not know very well seem to be represented in our mental maps by so called "landmark countries" (Saarinen and MacCabe, 1995; Pinheiro, 1998; Saarinen, 2005). For example, the geographically complex South West Pacific region is commonly represented by Australia "as the isolated 'church tower' of that region" (Pinheiro, 1998; p. 335). We assume that Brazil, within the mental maps of prospective biology teachers from both countries, might not only stand as a representative for the high and threatened biodiversity of the South American region, but rather functions as the "landmark country" for global biodiversity *per se*.

From an educational point of view this intuitive focus on Brazil – may it be based on lay or scientific knowledge – has its drawbacks. A strong and intuitive focus on one particular country of the world might hinder student teachers to develop a global perspective on the distribution and loss of biodiversity, which is considered an integral part of ESD (e.g., Scott and Gough, 2004; Bolscho and Hauenschild, 2006; Scheunpflug and Asbrand, 2006; Menzel and Bögeholz, 2008) as well as a formal requirement of the national secondary science curriculums of both countries (Ministerio de Educación Pública [MEP], 2003, 2005; Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland [KMK], 2004). Student teachers' worldviews and concepts – including their strong focus on Brazil – may be reflected in their future teaching practice (Cochran and Jones, 2003). In environmental education research it has already been shown that focusing too strong on selected flagship species such as the giant panda or the polar bear as biodiversity conservation tools to rise conservation awareness "detracts conservation efforts from other species and projects" (Ballouard et al., 2011; p. 6). Therefore, many authors demand that ESD "should encompass a wide diversity of species, notably by including less popular and neglected taxa" (p. 1) to develop positive attitudes toward global biodiversity (Ballouard et al., 2011; see also Balmford et al., 2002; Lindemann-Matthies, 2006). In the wake of this reasoning, we think that a mere restriction on the high and threatened biodiversity of a "flagship country" such as Brazil may not be the right way to promote a truly global perspective of biodiversity issues in pupils around the world.

Another common feature of the mental maps regarding threatened biodiversity is the predominant mentioning of industrialized countries such as United States, China, and Germany. From a scientific point of view, biodiversity is threatened most in tropical developing countries (Primack, 2010) and only China may be considered an industrialized country with a particularly threatened biodiversity (Mittermeier et al., 2004). This misconception of a particularly threatened biodiversity in industrialized countries is problematic as in most of the industrialized countries the loss of biodiversity is less urgent on a local scale than in developing countries (Mittermeier et al., 2004; Primack, 2010). Furthermore, based on this misconception, student teachers may conclude that industrialized countries make small efforts for biodiversity conservation and environmental protection. Thus, tertiary education programs should seize that industrialized countries also hold many species and ecosystems worth protecting, and that much of the biodiversity is actually protected. A concrete example to illustrate the biodiversity conservation efforts of industrialized countries in Europe may be the thematization of the European Habitats Directive on the conservation of natural habitats and of wild fauna and flora which forms the cornerstone of Europe's nature conservation policy.

Interestingly, similar misconceptions of a particularly low biodiversity in industrialized countries have been found in a sample of Chilean and German high school students (Menzel and Bögeholz, 2008). They showed a so-called "lack of space-concept," meaning that industrialized countries were thought to have extremely low biodiversity because of cramped cities and industries leaving no living space for animals and plants. In our sample this image might be so prominent that pre-service teachers even go a step further to ascribe industrialized countries a threatened biodiversity; possibly as a form of progression or superlative of an extremely low biodiversity. The meaning of and the differences between "extremely low" and "threatened" biodiversity seem to be mutually interdependent and even interchangeable. This equation of "extremely low" and "threatened" biodiversity might have merit in some cases, e.g., rare endemic island species (see Primack, 2010). However, at the country level this connection is not necessarily tenable. If a certain country holds a relatively small number of different species, this must not necessarily mean that these species are also threatened. Instead, it is even likely to be that many of those species will have a high number of individuals (Groombridge and Jenkins, 2002; Primack, 2010). We suggest that the just described misconception is essentially based on two fallacies: (1) a confusion of species richness and species abundance and (2) an insufficient differentiation between the different geographical scales of species diversity. Assuming that students confuse the low "number of different species in a given area" (= species richness) with a low "number of different individuals of a particular species in a given area" (= species abundance), it is reasonable that a low species diversity at the same time implicates its high threat. In general, species richness is differentiated along a gradient of the geographical scale of investigation from the habitat level (α-diversity), over the landscape level (γ-diversity) up to whole bio-geographical provinces (ε-diversity) (Magurran, 2004). We assume that student teachers in our sample possibly did not differentiate between these spatial levels. For example, if one assumes that the ε-diversity of a certain species is low, this does not necessarily mean that its species richness at the country level or below is also low. Teachers need a clear understanding of the similarities and differences between "species richness" and "species abundance" as they are the most widely used measures of species diversity (Magurran, 2004; Primack, 2010). A discussion and comparison of "common species" and "rare species" might promote a better understanding of both concepts: In general, rare species are characterized in that they have (1) small geographical ranges, (2) small population sizes, and (3) specialized habitat requirements (Harrison et al., 2008). Common species, such as the Dandelion (*Taraxacum officinale*), have broad geographical ranges, large populations and less specialized habitat requirements, and, thus, are less susceptible to extinctions than rare species are (Harrison et al., 2008; Primack, 2010). Nevertheless, a rare species may also have huge population sizes in only a very limited geographical range or a highly specialized habitat. For example, the Common Glasswort (*Salicornia europaea*) or the Sea Aster (*Aster tripolium*), both are halophytic plants of northern Europe that are found only in salt marshes and estuaries, yet within these habitats, both plants are quite common.

Apart from the above-mentioned similarities, a number of ethnocentric distortions merged between Costa Rican and German student teachers' composite mental maps. The majority of Costa Rican students almost exclusively focused on Latin American countries, especially on Costa Rica and adjacent countries, whereas other regions of the world such as Africa and Southeast Asia were largely marginalized. In contrast, German students' notions were distributed more evenly across the globe including many European countries – albeit with relatively low percentages.

The inclusion of many Latin American countries in the Costa Rican sample and the inclusion of many European countries in the German sample may be explained by the "factor of proximity" and "cultural factors" as coined by Saarinen (2005). He found that students sketch maps of the world – and thus their mental maps – are more likely to include countries that are immediately adjacent (= factor of proximity) and countries which are culturally similar or closer to one's home country (= cultural factor) (e.g., in terms of language, religion, and economy). It appears that these two factors identified by Saarinen (2005) also have an influence on our student teachers' mental maps of global biodiversity. For example, Costa Rican students completely ignored the Asian region, which might be related to both, the large geographical distance and cultural differences. In addition, students from both countries largely neglected Africa, which as well might be based on cultural differences. To achieve a purely scientific view of global biodiversity, tertiary teacher education programs should critically discuss the possible distortive influences of proximity and cultural factors on student teachers' biogeographic worldviews. Taking a psychological view, the distortions of the mental maps could also be interpreted in terms of the availability and representativeness heuristics (Kahneman and Tversky, 1972; Tversky and Kahneman, 1973), according to which individuals might mention some information more frequently because it is more readily *available* (the ease with which certain details can be brought to mind) and more *representative* in memory (people use categories to make estimates). Consistently, information about biodiversity might be more available and easier to categorize when it concerns one's own country and the surrounding countries.

To sum up, our study showed that German students have a more global perspective on biodiversity and its loss, whereas Costa Ricans students have a more localized view with a special focus on Latin American countries. This is in line with previous research indicating that people from developing countries are more concerned about local environmental problems, whereas people from industrialized countries are often more focused on global environmental problems (Dunlap and Mertig, 1995; Holl et al., 1999). We assume that this difference may also be related to differences in geographic literacy between Germans and Costa Ricans. We assume that Costa Rican student teachers are less geographic literate than German students (see RoperASW, 2002), and, therefore, share a more localized biogeographic worldview. We argue that proceeding from their more local view on biodiversity, Costa Rican teacher training should include

more global biodiversity issues, whereas German student teacher education should include more aspects of local biodiversity. As a starting point for participants in both countries, teacher educators may build up on German and Costa Rica students' perception of a particularly threatened biodiversity in their respective country. A central theme for discussion could also be the many differences regarding the causes and structures of threats affecting the local biodiversity between industrialized and developing countries (see Primack, 2010). The local biodiversity in Germany is threatened for other reasons than in Costa Rica. Consequently, it should also be discussed that industrialized and developing countries are faced with different challenges in terms of biodiversity conservation.

Apart from the above mentioned we found that most students from both countries hold a naive biodiversity hotspot concept: One in four German participants and one in five Costa Rican participants assumed Brazil to have a particularly high and threatened biodiversity. In addition, thereto, one in six Costa Ricans sees his home country as a biodiversity hotspot. Other countries are considered as biodiversity hotspots only by single persons. Thus, our assumption, that Costa Ricans will be more likely to hold a biodiversity hotspot concept is only partially confirmed. However, we suggest that this naive biodiversity hotspot concept provides a good starting point for integrating global biodiversity conservation issues into tertiary teacher education programs. Further, we assume that biodiversity hotspots as a teaching topic offer great learning opportunities to reflect on socio-economic, as well as on ecological considerations for conserving global biodiversity. As most of our participants mainly considered tropical regions as areas with high and at the same time threatened biodiversity, teacher education programs should consider that biodiversity hotspots also occur outside tropical regions such as the Mediterranean regions and even in temperate countries such as Japan or New Zealand (Mittermeier et al., 2004).

Perceived Threat of National, Transnational, and Global Biodiversity

In order to gain a deeper insight into student teachers' worldviews on global biodiversity we explored whether student teachers would show an overestimation bias and a spatial optimism bias concerning their perception of threatened plant species diversity on the national, transnational and global levels.

Overestimation Bias

According to the latest RL in Germany 0.5% of the plant species are threatened, in Costa Rica 1% and 4.3% worldwide, respectively (IUCN, 2011). As hypothesized, student teachers from both countries drastically overestimated the percentage of threatened plant species on all spatial levels, when compared to scientific data. In this our results are in line with those obtained by others scholars, who found that the general public tend to overestimate the overall number of national and global plant species (Lindemann-Matthies and Bose, 2008) as well as the total number of species on earth and species extinctions per year (Dunning, 1997). It is often argued that people have problems in comprehending the magnitude of large numbers and that "beyond a certain level, numbers become abstract and unrelated to our everyday experiences" (Gehrt, 1996, p. 900). In the present study we have deliberately avoided to assess large numbers and restricted the possible range of numbers from 0 to 100 by asking for percentages of threatened plants. Nevertheless, our results showed that even assessed percentages of threatened plant species are consistently overestimated. This might be due to the fact that an estimate of the percentage of threatened plant species entails a cognitive handling of large numbers such as the total number of plants and the total number of threatened plants, which have to be weighed against each other. An indicator that the task might have required a high level of cognitive performance – at least for the Costa Rican students – is the great number of students who did not answer the question: 42.2% of the Costa Rican students and 10.3% of the German participants. Lindemann-Matthies and Bose (2008) argue that peoples' responses to the ongoing loss of biodiversity and their support for conservation measures heavily depend on their conceptions of the numbers of species present and the ones being threatened or going extinct. In order to promote conservation attitudes and intentions among pupils and the wider community, quantitative data of certain species groups and their threat status have to be taught effectively in science classrooms. We think that this difficult task may not be achieved unless teachers are fully aware of the numerical scales involved, including the total numbers as well as the percentages of threatened species of certain taxonomic groups on the national and global level. In this context, Dunning (1997) already gave some practical suggestions on how to make large number relevant to students (e.g., through the use of more graphical conceptualizations of the dimensions of biodiversity loss). Some authors have already shown that the current global human population and its annual growth are also drastically overestimated by most people (Meffe, 1994; Dunning, 1997). As human overpopulation is one of the greatest threats to biodiversity (Millennium Ecosystem Assessment [MEA], 2005), we follow Gehrt's (1996) suggestion that biodiversity relevance should always accompany figures of human population growth and vice versa.

Spatial Optimism Bias

In our study student biology teachers from both countries showed a strong "spatial optimism bias," meaning that the assumed percentage of threatened plant species increased from the national, over the transnational up to the global spatial level. In this study, we demonstrated for the first time that the "spatial optimism bias" applies to concrete transnational assessments. Thus, we could show that the "spatial optimism bias" not only occurs when assessing environmental problems on different geographical scales (e.g., from the local to the global) but also in concrete situation when it comes to evaluate environmental problems in one's home country in comparison to another country. Our results suggest that in most cases one's home country will be evaluated better concerning its status of biodiversity then those of other countries, no matter if one lives in a biodiversity hotspot or an industrialized country. From a global perspective, this extended view of the spatial optimism bias has immense educational shortfalls, for example if the majority

of science teachers around the world may think that their local biodiversity is in good conditions in comparison to that of other countries, they might not feel a special need to address local biodiversity issues in classroom and outdoor activities. However, first hand nature experiences with local flora and fauna are seen as a crucial prerequisite for the development of environmental knowledge and values in pupils (Bögeholz, 2006).

However, it should be considered that the students were first asked about their own country, followed by the other country in the study, before they were finally asked about the percentage of threatened plant species globally. A different arrangement of the items might have led to different results, even if this can be assumed to be relatively unlikely (cf. Dunning, 1997; Lindemann-Matthies and Bose, 2008). Nevertheless, a randomization of the items in the questionnaire would certainly have been a viable alternative. Due to the special sample used, it should be noted that the results of the present study cannot be easily transferred for use in studies pertaining to students in other fields of study, or the general population.

Furthermore, it should be noted that we did not consider in this study whether socio-economic features of both student teacher samples (e.g., housing, family incomes, types of employment during the university course) could have an impact on their mental maps of global biodiversity. This question in relation to the socio-economic status of the students may be deeply approached in future studies.

ETHICS STATEMENT

The study was carried out in accordance with the Declaration of Helsinki and APA's Ethical Principles of Psychologists and Code of Conduct (American Psychological Association, 2016; Nijhawan et al., 2013). Anonymity was guaranteed and the participation was on a voluntary basis. Thus, all participants had the chance to decline to participate and to withdraw from the research at any time. Informed written consent of the participants was implied through survey completion. Additionally, all participants were introduced to the aim of the study. As our investigation was conducted by an anonymous questionnaire in an educational setting in the presence of the respective university professor, our research involved no risk to our subjects. Moreover, our research will not adversely affect the rights and welfare of our subjects, had no medical background and assessed no sensitive personal data. In consequence, an ethics approval was not required as per institutional (Universität Osnabrück, 2017) and national guidelines (German Research Foundation, DFG, 2018).

AUTHOR CONTRIBUTIONS

Both authors made substantial contributions to the conception and design of the work as well as for the analysis and interpretation of data.

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