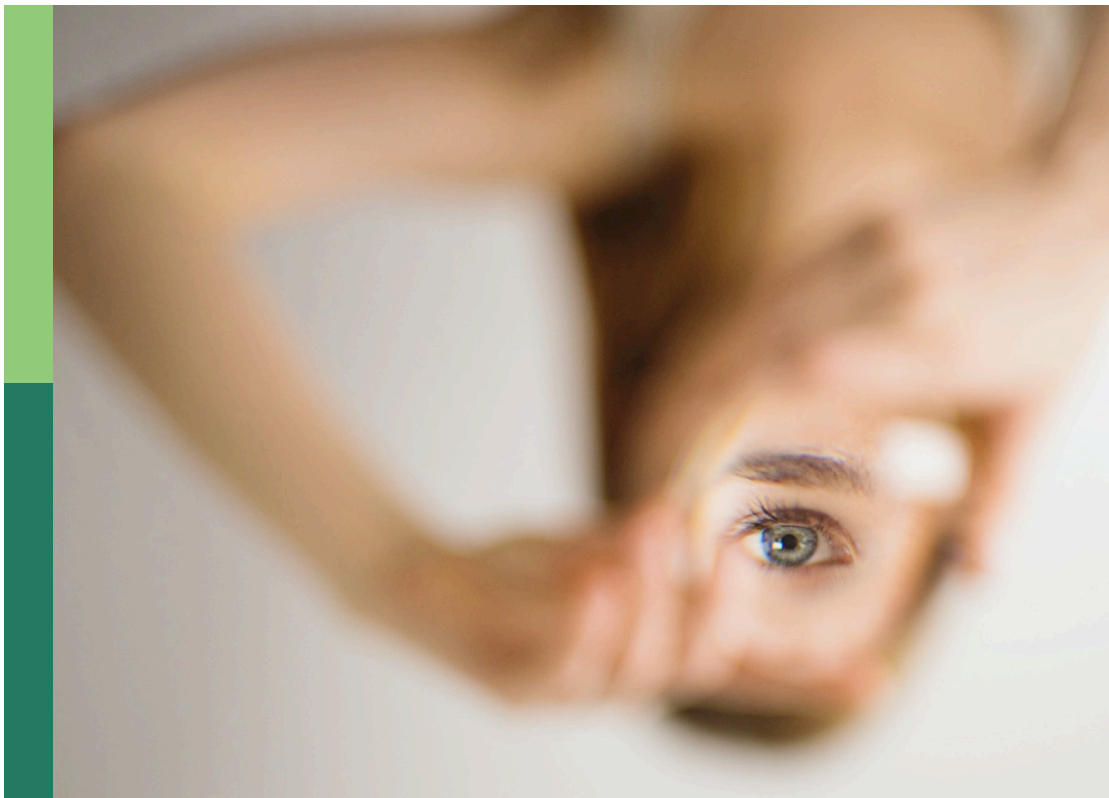
frontiers | Research Topics

# Insights in Environmental psychology 2021

**Edited by**
Giuseppe Carrus, Massimiliano Scopelliti, Ferdinando Fornara and Juan I. Aragones

**Published in**
Frontiers in Psychology



ISSN 1664-8714
ISBN 978-2-8325-3547-9
DOI 10.3389/978-2-8325-3547-9

## About Frontiers

Frontiers is more than just an open access publisher of scholarly articles: it is a pioneering approach to the world of academia, radically improving the way scholarly research is managed. The grand vision of Frontiers is a world where all people have an equal opportunity to seek, share and generate knowledge. Frontiers provides immediate and permanent online open access to all its publications, but this alone is not enough to realize our grand goals.

## Frontiers journal series

The Frontiers journal series is a multi-tier and interdisciplinary set of open-access, online journals, promising a paradigm shift from the current review, selection and dissemination processes in academic publishing. All Frontiers journals are driven by researchers for researchers; therefore, they constitute a service to the scholarly community. At the same time, the *Frontiers journal series* operates on a revolutionary invention, the tiered publishing system, initially addressing specific communities of scholars, and gradually climbing up to broader public understanding, thus serving the interests of the lay society, too.

## Dedication to quality

Each Frontiers article is a landmark of the highest quality, thanks to genuinely collaborative interactions between authors and review editors, who include some of the world's best academicians. Research must be certified by peers before entering a stream of knowledge that may eventually reach the public - and shape society; therefore, Frontiers only applies the most rigorous and unbiased reviews. Frontiers revolutionizes research publishing by freely delivering the most outstanding research, evaluated with no bias from both the academic and social point of view. By applying the most advanced information technologies, Frontiers is catapulting scholarly publishing into a new generation.

## What are Frontiers Research Topics?

Frontiers Research Topics are very popular trademarks of the *Frontiers journals series*: they are collections of at least ten articles, all centered on a particular subject. With their unique mix of varied contributions from Original Research to Review Articles, Frontiers Research Topics unify the most influential researchers, the latest key findings and historical advances in a hot research area.

Find out more on how to host your own Frontiers Research Topic or contribute to one as an author by contacting the Frontiers editorial office: frontiersin.org/about/contact

# Insights in: Environmental psychology 2021

**Topic editors**

Giuseppe Carrus — Roma Tre University, Italy
Massimiliano Scopelliti — Libera Università Maria SS. Assunta, Italy
Ferdinando Fornara — University of Cagliari, Italy
Juan I. Aragones — Complutense University of Madrid, Spain

**Citation**

Carrus, G., Scopelliti, M., Fornara, F., Aragones, J. I., eds. (2023). *Insights in: Environmental psychology 2021*. Lausanne: Frontiers Media SA.
doi: 10.3389/978-2-8325-3547-9

# Table of contents

frontiers in Psychology

ORIGINAL RESEARCH
published: 22 February 2022
doi: 10.3389/fpsyg.2022.794816

# Effect of Materialism on Pro-environmental Behavior Among Youth in China: The Role of Nature Connectedness

*Jing Wang and Yongquan Huo**

*School of Psychology, Shaanxi Normal University, Xi'an, China*

We designed three studies to explore the effect of materialistic values on pro-environmental behavior among youth and the mediated role of nature connectedness between materialistic values and pro-environmental behavior. Through a self-report questionnaire survey (Study 1) and an experimental manipulation of materialistic values (Study 2), we found that materialistic values negatively predicted pro-environmental behavior, and that nature connectedness played a mediating role. Further, we used natural contact strategies to control the level of nature connectedness, and found that the negative impact of high materialistic values on pro-environment behavior decreased with the increase of nature connectedness, further supporting the mediating role of nature connectedness (Study 3). These results may contribute to the design of strategies that effectively mitigate the negative effects of materialistic values on pro-environmental behavior.

**Keywords: materialistic values, pro-environmental behavior, nature connectedness, nature contact, mediation model**

OPEN ACCESS

***Edited by:***
*Ferdinando Fornara, University of Cagliari, Italy*

***Reviewed by:***
*Angela Castrechini, University of Barcelona, Spain*
*Muhammad Rehan Masoom, United International University, Bangladesh*

****Correspondence:***
*Yongquan Huo*
*hyq@snnu.edu.cn*

***Specialty section:***
*This article was submitted to Environmental Psychology, a section of the journal Frontiers in Psychology*

***Received:*** *14 October 2021*
***Accepted:*** *26 January 2022*
***Published:*** *22 February 2022*

***Citation:***
*Wang J and Huo Y (2022) Effect of Materialism on Pro-environmental Behavior Among Youth in China: The Role of Nature Connectedness. Front. Psychol. 13:794816. doi: 10.3389/fpsyg.2022.794816*

## INTRODUCTION

In recent years, a variety of environmental problems have posed threats to environmental sustainability, including global warming, air pollution, water shortages, noise pollution, and the loss of biodiversity, many of which are caused by human activities and behavior (Vlek and Steg, 2010). Therefore, increasingly more attention has been paid to research on environmental protection behavior and its influencing factors in different fields (Rosa and Collado, 2019). Hines et al. (1987) suggested that such action to avoid or solve various environmental problems, known as pro-environmental behavior, is a conscious behavior based on personal responsibility and values. Recent research has found a close relationship between individual values and behaviors toward the environment (Hurst et al., 2013). Among the many factors that influence pro-environmental behavior, the important role of materialistic values has attracted attention in academic circles (Furchheim et al., 2020). Recent studies have shown that materialism is popular among Chinese consumers, especially young consumers (Ma et al., 2020). However, there is little research on the relationship between specific values and environment-friendly behaviors, especially in Eastern cultures such as China. Thus, it is important to gain a deeper understanding of the role of materialistic values in pro-environmental behavior among young consumers in the context of China, a developing Asian country where only modest research efforts have been made toward exploring this important topic.

## MATERIALISTIC VALUES AND PRO-ENVIRONMENTAL BEHAVIOR

Since China's reform and opening up, the urban economy has substantially developed, and the nation's urbanization process has advanced to gradually enter a "new normal" phase. In this process, China's population and industries continue to inundate its cities, and environmental pollution has become a critical problem (Hao et al., 2020). Materialistic values involves the increasing emphasis on material wealth as the center of life, source of happiness, and criterion for success (Richins and Dawson, 1992). In general, materialism is usually positively correlated with selfishness, self-centeredness, and extrinsic motivation (Shrum et al., 2013), and individuals with materialistic tendencies seem to pay more attention to externally visible characteristics and appearance than to social relationships. In particular, materialistic values can affect the development of society through their effects on individuals. According to the theory of value conflict, people's various values are not completely isolated, but coexist in an interrelated hierarchical structure (Schwartz, 1994). On these grounds, if individuals hold two competing or opposing values at the same time, they will experience a conflict of values. Specifically, concern for the health of our planet is reflected in self-transcendental values, which tends to be universalist and collectivist, while materialistic values are the opposite of these two values. There is evidence that a conflict between materialistic and green value profiles can arise in consumers (Furchheim et al., 2020), and it is illustrated that materialism is accompanied by less concern for ecological sustainability. Numerous studies have also found a significant negative correlation between materialism and pro-environmental behavior (see Hurst et al., 2013; Kasser, 2016). Increasingly, research in countries, such as Canada, Italy, and Sweden further supports this finding (Hirsh and Dolderman, 2007; Hultman et al., 2015; Lu et al., 2016). According to the above theory and the negative effects of material values, we hypothesize that: higher levels of materialistic value are associated with lower levels of pro-environmental behavior (H1).

## THE ROLE OF NATURE CONNECTEDNESS

Nature connectedness is a psychological connection to nature reflecting one's relationship with the natural environment (Mayer and Frantz, 2004; Tam, 2013). It means that the individual endows nature with human characteristics, perceiving nature as a feeling, thinking, and living object just like humans. Relevant studies show that materialism has been associated with lower quality relationships with friends and romantic partners (Kasser and Ryan, 2001). An individual's materialistic tendency may lead to higher indifference, lower empathy, and less attention to others' pain (Kasser, 2016). In addition, the interpersonal relationship (e.g., peers, parents, or teachers) can be extended to non-interpersonal relationships (e.g., the natural environment itself), in which individuals can undertake various commitments (Davis et al., 2009). A recent study showed that higher materialism was associated with a lower level of attachment to the places and people one lives in contact with, which was a stable predictor of one's level of pro-environmental behavior (Scannell and Gifford, 2013). These studies suggest that people with high materialistic values have lower levels of empathy and attachment to nature; that is, they have a weaker sense of connection with nature, and may thus further show a lower level of pro-environmental behavior.

In environmental psychology, the sense of nature connection may be a way to environmental sustainability (Zelenski and Nisbet, 2014). Individuals' sense of nature connection may motivate them to participate in pro-environmental behavior (Mayer and Frantz, 2004). Conversely, a lack of connection with nature has been blamed for individuals' indifference toward environmental degradation and protection (Pyle, 2003; Soga and Gaston, 2016). Roszak (1992), an American ecological psychologist, proposed the "ecological subconscious" concept in his book *The Voice of the Earth*. He believed that there is an innate and evolving emotional connection between humans and the environment. If the emotional connection is suppressed, individuals will not have a high sense of identity to fully correspond to the ecological environment, let alone treat themselves and nature equally. This will be detrimental to the development of an ecological self-concept and cognition as well as pro-environmental behavior. Studies have also shown that emotional attitudes toward nature can play a key driving role in individuals' actual behavior toward the environment (Pinho et al., 2014; Whitburn et al., 2020). Based on the above literature, it can be seen that there is a close relationship between materialistic values, pro-environmental behavior, and nature connectedness (Aruta, 2021). Specifically, activating individual materialistic values can lead to a decrease in the level of nature connectedness and a decrease in the level of pro-environment behavior, while the nature connectedness can affect the level of pro-environment behavior. Our research hypothesis was as follows: the mediating effect of nature connectedness on the relationship between materialistic values and pro-environmental behavior (H2).

## NATURAL CONTACT PARADIGM AND NATURE CONNECTEDNESS

Nowadays, young people clearly encounter an extraordinary array of vicarious images of nature. Young people's experience of nature, broadly speaking, can be classified in three ways: direct, indirect, and what may be called "vicarious" or "symbolic" experience (Kellert, 2002). For the majority of people today, outdoor nature experiences, while vanishing, can be replaced with virtual alternatives (Clements, 2004; Ballouard et al., 2011). These vicarious images often occur in modern society through relatively innovative communication technologies like mobile phones, television, film, or computers (Kellert, 2002). The environmental connectedness perspective also posits that direct encounters with generalized or non-specific "nature" lead to environmental connectedness (Kellert, 2002; Beery and Wolf-Watz, 2014). There is evidence that the longer the contact time with nature, the stronger the sense of connection with nature (Kals et al., 1999; Chawla, 2006). In addition, some studies have

shown that after viewing pictures or videos of nature, known as the nature exposure paradigm, individuals scored higher on nature connectedness (Weinstein et al., 2009; Zelenski et al., 2015; Soga et al., 2016). Importantly, there is evidence that four laboratory studies (where participants reported their wishes after having been exposed to a particular scene or object) showing that individuals focused on their internal aspirations more than on external ones when they were exposed to nature stimuli (Weinstein et al., 2009). It may be that when people are guided to focus on intrinsic and self-transcendent goals, they move away from materialistic values. Taken together, we hypothesized the following: enhancing the nature connectedness through natural contact paradigm could mitigate the impact of high materialism on pro-environment behavior (H3).

# THE PRESENT STUDY

To extend the former research, three main points have been improved in this study. First, at present, the evidence that high materialistic values are predictive of lower pro-environmental behavior among youth and young adults is scant and relatively weak especially in a Chinese cultural context (Gu et al., 2020). Most such research is cross-sectional. Moreover, such research has not examined the underlying psychological mechanisms between materialistic values and pro-environment behavior. Third, Kasser (2016) suggests that while acknowledging that everyone has materialistic values or goals, proposed ways to reduce the damage of materialism to other valuable life goals. As for how to promote the possibility of pro-environment behavior of people with materialistic values, this is also a problem worthy of attention and discussion.

Accordingly, considering the limitations of previous studies, we conducted a questionnaire survey (Study 1) and an experimental study (Study 2) to examine the causal relationship between materialism and pro-environmental behavior, and to verify the intermediary role of nature connectedness in the relationship. Further, to thoroughly examine whether the effects of high levels of materialism on pro-environment behavior can be mitigated, Study 3 used the natural contact paradigm to manipulate the level of nature connectedness to further test the role of the nature connectedness in the relationship between high materialistic values and pro-environmental behavior.

# STUDY 1

## Participants and Procedure

A power analysis using G*Power software (Faul et al., 2009) analysis suggested that to obtain a medium power test ($r = 0.30$, $\alpha = 0.05$, $1\text{-}\beta = 0.80$), 82 participants were needed. Considering that questionnaires attrition rate may be low, we recruited 305 students from two local universities in Xi'an, China, to complete a questionnaire, and 277 questionnaires were collected (recovery rate = 90.8%). Participants (119 women) were between 18 and 24 years of age ($M_{age} = 20.85$ years, $SD = 1.53$). Participants were informed about the nature of their participation in the study and provided their verbally consent to participate. After completing the questionnaire, each participant was given a pen in appreciation.

## Measures

### Trait Materialistic Values

The revised Chinese version of the Material Values Scale (MVS; Li and Guo, 2009), originally developed by Richins and Dawson (1992), was used to measure trait materialism. The structure of the revised scale is similar to that of the original scale; however, five items were removed due to cultural differences and translation problems (Li and Guo, 2009). This is a reliable and valid measurement for assessing trait materialism in Chinese populations (Li et al., 2018) and includes 13 items rated on a five-point Likert scale (1 = "strongly disagree," 5 = "strongly agree"). The reliability of the scale in the present study was Cronbach's $\alpha = 0.78$.

### Pro-environmental Behavior

We used the self-report Pro-environmental Behavior Scale (PBS), revised by Liu and Wu (2013) for Chinese college students in reference to past research (Kaiser et al., 2007; Gong, 2008). This scale consists of 12 items, and participants rate each item from one to five according to their actual behaviors. The total score ranges from 12 to 60. The PBS includes items such as "I am actively involved in activities organized by the school or the environmental protection society" and "When no one is in the room, I will turn off the lights when I leave the room." Higher scores on the PBS indicate higher pro-environmental behavior. In previous studies, the reliability and validity of the questionnaire were good, and the Cronbach α coefficient was above 0.78 (Zong and Wang, 2017). In the present study, Cronbach's α for the PBS was 0.81.

### Nature Connectedness

We used the Connectedness to Nature Scale (CNS) developed by Mayer and Frantz (2004) and revised by Li and Wu (2016). Participants rate their agreement with 14 items using a five-point scale (1 = "strongly disagree," 5 = "strongly agree"); items 4, 12, and 14 are reverse-scored. The scale is unidimensional, and higher total scores indicate higher emotional connection and a closer relationship with nature. The CNS has been found to be reliable across time and is widely used (Diebels and Leary, 2019). The reliability of the scale in our study was Cronbach's $\alpha = 0.78$.

## Results and Discussion

### Common Method Biases

According to the suggestion of Podsakoff et al. (2003), the Harman single-factor test used to test common method deviation. That is, an unrotated principal component factor analysis is performed on all variables simultaneously. If multiple factors are obtained and the variation explained by the first factor does not exceed 40%, the common method variation problem is not serious. The results revealed 11 eigenvalues >1 without rotation, and the mutation rate interpretation of the first factor was 15.94%, which was less than the critical value of 40%. This indicated that the common method deviation in this

study was not problematic, and subsequent data analysis could be carried out.

### Descriptive Statistics and Correlations

We computed Pearson's correlation coefficients to explore the relationships among the study variables (see **Table 1** for the descriptive statistics and correlations). The results showed that materialistic values had a significant negative correlation with pro-environmental behavior. Nature connectedness showed a significant negative correlation with materialistic values and a significant positive correlation with pro-environmental behavior.

### Mediation Analysis: The Role of Nature Connectedness

We examined the mediating role of nature connectedness in the association between materialistic values and pro-environmental behavior by employing the PROCESS 3.0 (Hayes, 2013) macro (Model 4, 5,000 bootstrap samples) of SPSS. Materialistic values was the independent variable (X), pro-environmental behavior was the dependent variable (Y), and nature connectedness was the mediating variable (M). The results are shown in **Figure 1**.

**TABLE 1 |** Descriptive statistics and correlation coefficients for materialistic values, nature connectedness, and pro-environmental behavior.

| | *M* | *SD* | 1 | 2 | 3 |
|---|---|---|---|---|---|
| 1. Materialistic values | 2.56 | 0.58 | – | | |
| 2. Nature connectedness | 3.89 | 0.57 | −0.29** | – | |
| 3. Pro-environmental behavior | 3.52 | 0.60 | −0.12* | 0.28** | – |

*Sample size = 277; *p < 0.05; **p < 0.01.*

In the direct path (c), materialistic values negatively predicted pro-environmental behavior. In the indirect path, materialistic values negatively predicted nature connectedness (a), while nature connectedness positively predicted pro-environmental behavior (b). The mediating effect value of nature connectedness between materialistic values and pro-environmental behavior was -0.08, 95% confidence interval (CI) [-0.1405, -0.0349], and this range did not include zero. The ratio of indirect to direct effect of materialistic values on pro-environmental behavior was 39%. Therefore, the mediating mechanism of nature connectedness had statistical significance in the relationship between materialistic values and pro-environmental behavior.

In summary, we used a cross-sectional questionnaire to explore the relationship between materialistic values and pro-environmental behavior, and the mediating role of nature connectedness. Results showed that the level of pro-environmental behavior of participants with high materialistic values was lower compared with participants with low materialistic values. Low pro-environmental behavior was often accompanied by a high level of materialistic tendencies and low levels of nature connectedness. This result provides support for our hypothesis but does not explain the causal relationships. Hence, Study 2 was performed to further explore the relationships among the three variables through experimental manipulation of materialism.

## STUDY 2

### Participants

To obtain a medium power test (effect size = 0.55 in a *t*-test analysis), a G*power analysis suggested a total sample size of 106 participants would be needed to obtain a power

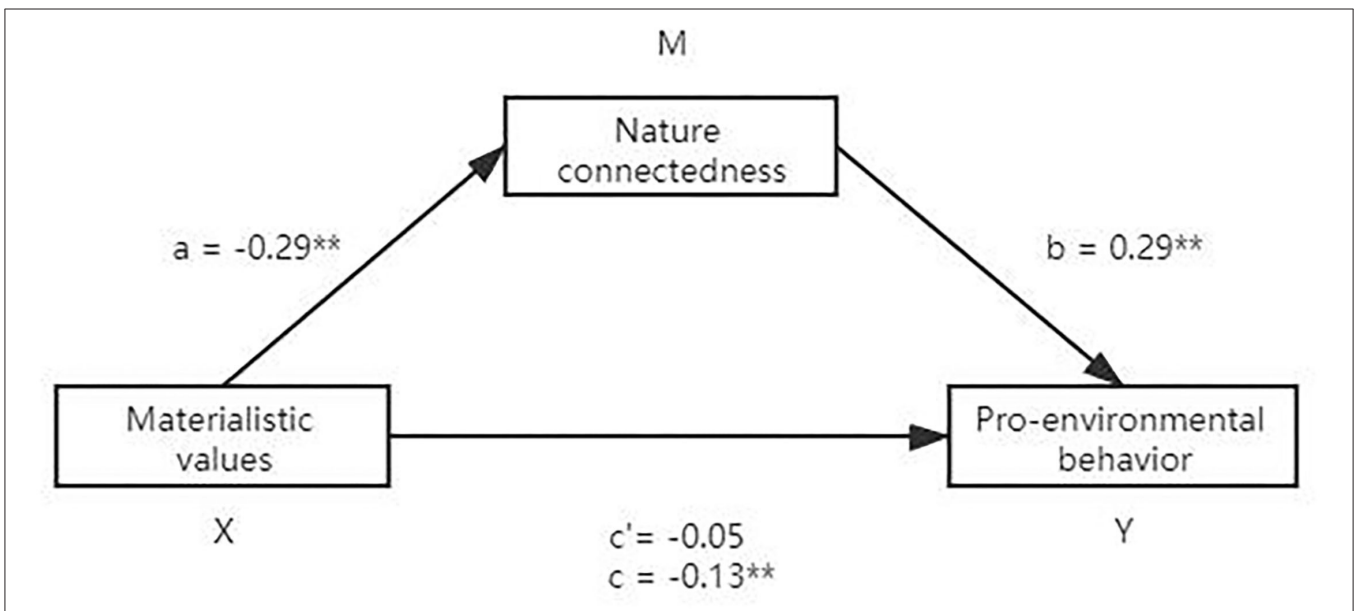



**FIGURE 1 |** Mediating effect of nature-connectedness on the relationship between materialistic values and pro-environmental behavior.

of 0.80 (Faul et al., 2009). Therefore, we recruited 140 college students from two local universities in Xi'an, China; data from 3 participants were removed because they did not complete the experiment as required. Thus, 137 participants (68 women) aged between 18 and 24 years ($M_{age}$ = 18.88 years, $SD$ = 1.07) completed the experiment. Participants provided their informed consent to participate.

## Stimulus, Materials, and Procedure

### Materialistic Values Manipulation

We referred to the activation theory of materialistic values and previous research (Bauer et al., 2012; Caruso et al., 2013) and selected cues reflecting materialism in daily life such as cars, brand-name cosmetics, jewelry, and luxury goods (30 pictures from an Internet gallery). We also selected 30 geometric pictures (including planar, three-dimensional regular or irregular) to be used in the neutral control group in the same way, according to Berry et al. (2014) study. These images were randomly presented to the experimental and control groups, respectively (rendering time: 30,000 ms; interval: 5,000 ms).

### State Materialistic Values Scale

We modified the Chinese version of the MVS (Li and Guo, 2009) used in Study 1 to develop a state materialism scale by adding "At the moment," so that items referred to the participants' current state of mind (e.g., "At the moment, I think I will feel happier if I can afford to buy more things"). The scoring criteria were the same as in the original scale. The reliability of this revised scale in our study was Cronbach's $\alpha = 0.73$.

### State Connectedness to Nature Scale

The state CNS version contained 13 of the 14 items in the trait CNS version (Study 1) simply reworded. The state CNS was well-correlated with the trait CNS ($r > 0.6$) and has been successfully used to measure connectedness to nature due to experimental manipulations in previous studies (Frantz et al., 2005). For example, the item, "I often feel a sense of oneness with the natural world around me" was rephrased as "At this moment I feel a sense of oneness with the natural world around me." One item from the original scale was deleted because it could not be reworded. Items were rated on a five-point Likert scale (1 = "strongly disagree," 5 = "strongly agree"). The reliability of this scale in our study was Cronbach's $\alpha = 0.76$.

### Pro-environmental Behavior Scenario Simulation Task

We used a pro-environmental behavior scenario simulation task. The level of pro-environmental behavior was measured by assessing simulated donations to an environmentally friendly organization (Ku and Zaroff, 2014; Zaval et al., 2015), and participants received the following information. "Our research group is cooperating with the environmental protection organization of our school *Friends of Green* to carry out the environmental protection activity of urban garbage reduction. This activity aims to explore new models of waste disposal and provides support for relevant policy formulation and public knowledge popularization. Many a little makes a mickle. You can choose to convert this gift into 10 RMB. We hope you can take some money from this experiment remuneration to help our environmental protection activities. If the fee is divided into 10 parts, from 0 to 10, how many parts of the community chest would you donate to help the environmental campaign?"

## Procedure

After the participants entered the laboratory, we asked them to sign an informed consent form, and explained to them that the experimental procedure was divided into three parts. Then, the participants were each randomly allocated to one of two conditions: materialism condition ($n = 69$) and neutral priming condition ($n = 68$). Initially, participants completed a photo categorization game (priming task). The priming group was shown materialism-inducing material, and the control group was shown the geometric material. Immediately afterwards, they were asked to complete the measures of state materialism and state nature connectedness. Next, participants were asked to complete the pro-environmental behavior scenario simulation task and a demographic questionnaire. Participants were informed that the survey was anonymous and confidential and were asked to answer truthfully. After the experiment, each participant was debriefed to determine their awareness of the study hypotheses, and no one was able to identify the study's true purpose. Participants were given a notebook as a token of appreciation.

## Results and Discussion

### Materialistic Values Manipulation Check

We compared the state materialistic values scores of the priming group with the control group to check the manipulation of materialism. The analysis revealed that the state materialism values scores in the priming group ($M = 3.52$, $SD = 0.46$) were significantly higher than in the control group ($M = 2.84$, $SD = 0.46$), $t(68) = -8.64$, $p < 0.001$, which suggests that the manipulation of state materialism was successful.

### Pro-environmental Behavior

We compared the money donated to the environmental organization the number between the materialism priming group and control group to test the influence of materialistic values on pro-environmental behavior. The results showed a significant difference in the scores of the two groups. Participants in the materialism priming group ($M = 5.62$, $SD = 2.21$) chose to donate significantly fewer money for environmentally friendly activity than those in the control group ($M = 8.21$, $SD = 1.53$), $t(68) = 7.94$, $p < 0.001$. In addition, The indices indicated that participants who had temporarily enhanced materialism in the laboratory showed lower levels of pro-environmental behavior.

### Mediation Analysis: The Role of Nature Connectedness

The correlations between the study variables are shown in **Table 2**. There were significant correlations between materialistic values, nature connectedness, and pro-environmental behavior, which provided a basis for testing the mediating effect.

Next, we used the PROCESS macro of SPSS 23.0 (Model 4, 5,000 bootstrap samples) to estimate the mediating effect of

**TABLE 2 |** Descriptive statistics and intercorrelations between variables in Study 2.

| | *M* | *SD* | 1 | 2 | 3 |
|---|---|---|---|---|---|
| 1. Materialistic values | 3.18 | 0.57 | – | | |
| 2. Nature connectedness | 2.84 | 0.50 | −0.47** | – | |
| 3. Pro-environmental behavior | 6.91 | 2.30 | −0.39** | 0.42** | – |

**$p < 0.01$.

nature connectedness on the relationship between materialistic values and pro-environmental behavior. Results revealed that the materialistic values negatively predicted nature connectedness ($\beta = -0.41, p < 0.001$), which in turn negatively predicted the score for number of green products purchased ($\beta = -1.01, p < 0.005$). The residual direct effect was also significant ($\beta = -1.01, p < 0.005$). The total effect of materialism on the score for number of green products purchased was significant (total effect = −1.58, 95% CI = [-2.21, -0.95]). After nature connectedness was entered into the equation, the indirect negative effect of materialism on the pro-environmental behavior remained significant (indirect effect = −0.57, 95% CI = [-1.01, -0.20]). The results supported the role of nature connectedness as a partial mediator.

The results from Study 2 conceptually replicated Study 1 (by manipulating the individual relative level of materialistic tendency) and provided support for the hypothesis. As a special case of pro-social behavior, pro-environmental behavior has a high degree of social desirability. According to a meta-analysis performed Kormos and Gifford (2014), self-reported pro-environmental behavior can only explain 21% of the variance in actual behavior. Therefore, to improve the ecological validity of the research, this study adopted a simulation of giving money to environmental groups. We found that participants with higher materialism tended to show lower levels of pro-environmental behavior due to their lower nature connectedness. If nature connectedness is an intervention strategy with negative effects on materialism, it should increase the level of pro-environmental behavior among highly materialistic individuals. Therefore, in Study 3, we explored whether the activation of nature connectedness could enhance the pro-environmental behavior of high-materialism participants.

# STUDY 3

## Participants

Referring to the sample size of study 2 using G*power analysis and considering the needs of this study, we recruited 420 college students from two local universities in Xi'an, China, who had not participated in the previous experiment, then completed the MVS questionnaire. Data from 17 participants were excluded due to incomplete information (recovery rate = 95.95%). Total MVS scores were ranked from low to high. The highest 27% were selected as the high-materialism group. Thus, the participants were 109 college students between 18 and 27 years of age (58 women; $M_{age} = 19.38$ years, $SD = 1.70$). Participants provided their informed consent to participate.

## Stimulus, Materials, and Procedure

### State Materialistic Values Scale

The measure of trait MVS was the same as in Study 1, and Cronbach's α was 0.86.

### State Connectedness to Nature Scale

The measure of state CNS was the same as in Study 2, and Cronbach's α was 0.78.

### Natural Contact Paradigm

Referring to a prior study using nature-contact materials (Mayer et al., 2009), we selected 5 × 3-min videos from network documentaries of Chinese nature scenes. We asked five doctoral students in psychology to establish corresponding scores for these clips using the "structural evaluation of the environment" method (Ulrich et al., 1991) and different dimensions (complexity, structure, concerns, and scene depth). After extensive deliberation, we selected the video with high scores in all aspects as the material for the nature group. The control group procedure was consistent with the method in Study 2; as such, we selected videos of geometric shapes ∼3 min in length.

### Pro-environmental Behavior Scenario Simulation Task

We added a score on willingness to donate time to environmental activities from study 2. After completing the money donation option, participants were given the following message: "If you divide your leisure time into 10 parts, from 0 to 10, how much time do you have for environmental activities?"

## Procedure

As in Study 2, after providing informed consent, participants were randomly divided into two groups: nature exposure ($n = 55$) and neutral control ($n = 54$). First, participants were required to watch videos with nature content or geometric figures, depending on their group assignment, and then complete the state CNS and a demographic questionnaire. Following this, participants were asked to complete the second task: making a donation of money and time to the environmental organization. We assured them that the survey was anonymous and confidential, and asked them to answer truthfully. After the experiment, each participant was debriefed to determine their awareness of the study hypotheses, and no one was able to identify the study's true purpose. Participants were given a notebook in appreciation.

## Results and Discussion

### Nature Connectedness

To test the level of nature connectedness between the nature exposure and neutral control, we used *T*-test to compared the sense of nature connectedness in the two groups.

The analysis revealed that the mean state CNS score in the nature exposure group ($M = 3.91$, $SD = 0.43$) was significantly higher compared to the control group ($M = 3.41$, $SD = 0.53$), [$t(95) = 5.43$, $p < 0.001$]. These results suggest that natural contact intervention strategies can effectively enhance the sense of natural connection inhibited by high materialistic values.

**TABLE 3 |** Descriptive statistics and intercorrelations between variables in Study 3.

| | *M* | *SD* | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|
| 1. Materialistic values | 4.09 | 0.28 | – | | | |
| 2. Nature connectedness | 3.66 | 0.54 | −0.24* | – | | |
| 3. Money donated to environmental organization | 6.04 | 2.53 | −0.21* | 0.22* | – | |
| 4. Time donated to environmental organization | 5.53 | 2.65 | −0.17 | 0.21* | 0.45** | – |

*$p < 0.05$; **$p < 0.01$.

### Descriptive Statistics and Correlations

Descriptive statistics were used for participants' general characteristics with high materialistic values and descriptive statistics of the measurement variables (see **Table 3**). The results showed that materialistic values had a significant negative correlation with nature connectedness and money donated to environmental organization, except time donated to environmental organization. Nature connectedness showed a significant positive correlation with money donated to environmental organization and time donated to environmental organization. Meanwhile, there is a strong positive relationship between the money donated to environmental organization and time donated to environmental organization.

### Comparison of Pro-environmental Behavior at Different Levels of Nature Exposure

To assess the effect of the nature contact intervention on pro-environmental behavior among individuals with high materialistic tendencies, a *t*-test was conducted to compare the money and time donated to the environmental organization between the nature exposure and control groups. The results showed a significant difference between the two groups (**Table 4**); specifically, participants in the nature exposure group willing to donate more money to the environmental organization and spend more time in environmental activities than those in the control group.

Therefore, we believe that the natural contact paradigm can effectively enhance the emotional relationship of individuals with materialistic values to the environment. Nature contact paradigm could enhance pro-environmental behavior for individuals with high materialistic tendencies in a short period of time. The negative effect of high materialistic tendencies on pro-environmental behavior may decrease or disappear with increased contact with nature, leading to an increase in nature connectedness. Therefore, the covariant relationship between materialistic values, nature connectedness, and pro-environmental behavior was further verified.

## GENERAL DISCUSSION

We designed three studies to investigate the influence of materialism on pro-environmental behavior and the underlying psychological mechanisms. Studies supported our prediction that individuals with higher materialism tendencies would have a lower level of pro-environmental behavior, and that nature connectedness would play an intermediary role in this relationship. Moreover, study 3 also demonstrated natural contact paradigm can effectively enhance the sense of nature connection and the level of pro-environmental behavior among those with high materialism.

### Relationship Between Materialism and Pro-environmental Behavior

Study 1 and 2 both showed that materialistic values negatively predicted pro-environment behavior. Compared with participants withe low levels of materialistic values, those with high levels of materialistic values reported fewer pro-environmental behaviors. These results were consistent with previous studies. For example, researches in different areas have shown that college students with high materialism are less likely to consider environmental protection to be a goal for their future behavior (Hirsh and Dolderman, 2007; Hultman et al., 2015; Lu et al., 2016). China has developed a largely materialistic culture, marked by the pursuit of pretention, identity, and status. Thus, there is a need to examine the relationship between individual materialistic tendencies and pro-environmental behavior in the context of the local culture in China.

### Psychological Mechanisms of How Materialism Influences Pro-environmental Behavior

In a previous study by Soga and Gaston (2016), the results showed that the individual's development in industrial social environments was highly separated from nature, and the loss of direct or indirect nature experience may reduce individuals' positive emotions toward nature and willingness to protect it. Recently, Whitburn et al. (2020) found that indicators related to nature connectedness were significantly positively correlated with pro-environmental attitudes and behavior. These studies confirm the important role of connection to nature in environmental sustainability (Zelenski and Nisbet, 2014). Consistent with these previous studies, our findings showed that the negative effect of high materialism on pro-environmental behavior may be due to the suppression of nature bonding emotions.

It is not sufficient to only demonstrate the mediating role of nature connectedness, because we could merely speculate that high materialists exhibit lower pro-environmental behavior due to the inhibition of their nature connectedness. To address this issue, we directly verified the mitigating effect in Study 3. Individual contact with nature is regarded as a key factor in cultivating a good relationship with nature (Chawla, 2006). Although there is a difference between actual and virtual experiences of nature, studies have often shown that nature simulation can replace actual nature (Kellert, 2002; Beery and Wolf-Watz, 2014). The frequency of viewing nature-themed videos and books was found to be positively correlated with children's emotional attitudes toward local biodiversity, promoting a stronger sense of connection between people and

**TABLE 4 |** Comparison of pro-environmental behavior at different levels of nature exposure.

| Group | *n* | Money donated to environmental organization | | | | Time donated to environmental organization | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *M* | *SD* | *t* | *p* | *M* | *SD* | *t* | *p* |
| Nature exposure group | 55 | 7.27 | 2.30 | 5.91 | 0.000 | 6.36 | 2.72 | 3.47 | 0.001 |
| Control group | 54 | 4.78 | 2.12 | | | 4.69 | 2.30 | | |

nature (Soga et al., 2016). Our research also confirmed this result. In addition, we found that improving one's connection to nature was a successful pathway to mitigating the negative effects of high levels of materialism. Our results are consistent with Weinstein et al. (2009), individuals of high materialistic values with higher levels of affiliation with nature report greater engagement in ecological behavior, and willingness to display pro-environmental behavior.

The present study contributes to the literature in several ways. First, it extends our understanding of the relationship between materialistic values and pro-environmental behavior. Previous studies (Wierzbicki and Zawadzka, 2016) have focused only slightly on the relevant psychological mechanisms, which was not conducive to explaining the underlying causes of materialism's influence on pro-environmental behavior. Therefore, our research provided the initial evidence on the intermediary role of nature connectedness in the relationship between materialism and pro-environmental behavior. Individuals with materialistic goals, such as pursuing status and financial success, tend to be more prone to conspicuous consumption and accumulation of high-status commodities (Liao and Wang, 2009). This suggests that, to an extent, an individual's materialism-based dreams have a greater negative impact on the environment. This new finding not only helps construct new models for this relationship but also contributes to developing new approaches to intervene in it.

The findings of our research also have significant practical implications. Studies have shown that enhancing individuals' sense of nature connectedness can affect the relationship between materialism and environmentally friendly behavior, which could play an important role in further improving environmentally friendly activities. This is conducive to helping individuals find a balance between the great enrichment of material wealth and the sustainable development of the ecological environment, thus reducing the social risks for the benefit of future generations. Specifically, whether it is the government's social governance or enterprises' product promotion, indirect or direct nature contact in various forms can be increased, so as to promote a sense of connection with nature to the greatest extent and thereby increase environmentally friendly behavior.

## LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

Limitations to this research need to be addressed by future studies. First, this research only selected college students as participants, which limits the generalizability of our results. Moreover, the display of materialism across different life stages is not completely consistent (Jaspers and Pieters, 2016). Therefore, future research should test our hypotheses with a broader range of participants of all ages from the general population. Second, our studies only examined the mediating role of nature connection. However, the relationship between materialism and pro-environmental behavior is complex and diverse (Kollmuss and Agyeman, 2002). To clarify the action mechanism between these constructs and identify the strongest influences, other variables can be studied in depth in the future to promote pro-environmental behavior and improve environmental quality. Third, the present study demonstrated that the sense of nature connectedness enhanced environmental behavior in individuals with high materialistic tendencies in a short time, but other long-term effective means of weakening this relationship should be explored.

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Experimental Research Ethics Review Committee, School of Psychology, Shaanxi Normal University. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

JW: conceptualization, software, and writing—original draft. YH: supervision and validation. Both authors contributed to the article and approved the submitted version.

## FUNDING

This work was supported by the Fundamental Research Funds for the Central Universities (grant number 2019TS139).

## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.794816/full#supplementary-material

## REFERENCES


Aruta, J. J. B. R. (2021). Connectedness to nature encourages, but materialism hinders, ecological behavior in the Philippines: The higher order and second-order factors of environmental attitudes as viable mediating pathways. *Ecopsychology* 13, 114–122. doi: 10.1089/eco.2020.0053

Ballouard, J. M., Brischoux, F., and Bonnet, X. (2011). Children prioritize virtual exotic biodiversity over local biodiversity. *PLoS ONE* 6, e23152. doi: 10.1371/journal.pone.0023152

Bauer, M. A., Wilkie, J. E., Kim, J. K., and Bodenhausen, G. V. (2012). Cuing consumerism: Situational materialism undermines personal and social well-being. *Psychol. Sci.* 23, 517–523. doi: 10.1177/0956797611429579

Beery, T. H., and Wolf-Watz, D. (2014). Nature to place: Rethinking the environmental connectedness perspective. *J. Environ. Psychol.* 40, 198–205. doi: 10.1016/j.jenvp.2014.06.006

Berry, M. S., Sweeney, M. M., Morath, J., Odum, A. L., and Jordan, K. E. (2014). The nature of impulsivity: Visual exposure to natural environments decreases impulsive decision-making in a delay discounting task. *PLoS ONE* 9, e97915. doi: 10.1371/journal.pone.0097915

Caruso, E. M., Vohs, K. D., Baxter, B., and Waytz, A. (2013). Mere exposure to money increases endorsement of free-market systems and social inequality. *J. Experi. Psychol.* 142:301. doi: 10.1037/a0029288

Chawla, L. (2006). Learning to love the natural world enough to protect it. *Barn* 2, 57–78.

Clements, R. (2004). An investigation of the status of outdoor play. *Contemp. Issues Early Childhood* 5, 68–80. doi: 10.2304/ciec.2004.5.1.10

Davis, J. L., Green, J. D., and Reed, A. (2009). Interdependence with the environment: Commitment, interconnectedness, and environmental behavior. *J. Environ. Psychol.* 29, 173–180. doi: 10.1016/j.jenvp.2008.11.001

Diebels, K. J., and Leary, M. R. (2019). The psychological implications of believing that everything is one. *J. Posit. Psychol.* 14, 463–473. doi: 10.1080/17439760.2018.1484939

Faul, F., Erdfelder, E., Buchner, A., and Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behav. Res. Methods* 41, 1149–1160. doi: 10.3758/BRM.41.4.1149

Frantz, C., Mayer, F. S., Norton, C., and Rock, M. (2005). There is no "I" in nature: The influence of self-awareness on connectedness to nature. *J. Environ. Psychol.* 25, 427–436. doi: 10.1016/j.jenvp.2005.10.002

Furchheim, P., Martin, C., and Morhart, F. (2020). Being green in a materialistic world: Consequences for subjective well-being. *Psychol. Market.* 37, 114–130. doi: 10.1016/j.jenvp.2012.08.002

Gong, W. J. (2008). A gender comparison on the environment-friendly behaviors of contemporary urban residents. *J. China University Geosci.* 6, 37–42. doi: 10.16493/j.cnki.42-1627/c.2008.06.009

Gu, D., Gao, S., Wang, R., Jiang, J., and Xu, Y. (2020). The negative associations between materialism and pro-environmental attitudes and behaviors: individual and regional evidence from China. *Environ. Behav.* 52, 611–638. doi: 10.1177/0013916518811902

Hao, Y., Zheng, S., Zhao, M., Wu, H., Guo, Y., and Li, Y. (2020). Reexamining the relationships among urbanization, industrial structure, and environmental pollution in China—New evidence using the dynamic threshold panel model. *Energy Rep.* 6, 28–39. doi: 10.1016/j.egyr.2019.11.029

Hayes, A. F. (2013). *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*. New York, NY: Guilford Press.

Hines, J. M., Hungerford, H. R., and Tomera, A. N. (1987). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *J. Environ. Educ.* 18, 1–8. doi: 10.1080/00958964.1987.9943482

Hirsh, J. B., and Dolderman, D. (2007). Personality predictors of consumerism and environmentalism: A preliminary study. *Pers. Individ. Dif.* 43, 1583–1593. doi: 10.1016/j.paid.2007.04.015

Hultman, M., Kazeminia, A., and Ghasemi, V. (2015). Intention to visit and willingness to pay premium for ecotourism: The impact of attitude, materialism, and motivation. *J. Bus. Res.* 68, 1854–1861. doi: 10.1016/j.jbusres.2015.01.013

Hurst, M., Dittmar, H., Bond, R., and Kasser, T. (2013). The relationship between materialistic values and environmental attitudes and behaviors: A meta-analysis. *J. Environ. Psychol.* 36, 257–269. doi: 10.1016/j.jenvp.2013.09.003

Jaspers, E. D., and Pieters, R. G. (2016). Materialism across the life span: An age-period-cohort analysis. *J. Personal. Soc. Psychol.* 111, 451–473. doi: 10.1037/pspp0000092

Kaiser, F. G., Oerke, B., and Bogner, F. X. (2007). Behavior-based environmental attitude: Development of an instrument for adolescents. *J. Environ. Psychol.* 27, 242–251. doi: 10.1016/j.jenvp.2007.06.004

Kals, E., Schumacher, D., and Montada, L. (1999). Emotional affinity toward nature as a motivational basis to protect nature. *Environ. Behav.* 31, 178–202. doi: 10.1177/00139169921972056

Kasser, T. (2016). Materialistic values and goals. *Annu. Rev. Psychol.* 67, 489–514. doi: 10.1146/annurev-psych-122414-033344

Kasser, T., and Ryan, R. M. (2001). "Be careful what you wish for: Optimal functioning and the relative attainment of intrinsic and extrinsic goals. Life goals and well-being," in *Life Goals and Well-Being: Towards a Positive Psychology of Human Striving*, eds P. Schmuck and K. M. Sheldon (Kirkland: Hogrefe & Huber Publishers).

Kellert, S. R. (2002). "Experiencing nature: Affective, cognitive, and evaluative development in children," in *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations*, eds P. H. Kahn and S. R. Kellert (Massachusetts: MIT Press).

Kollmuss, A., and Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ. Educ. Res.* 8, 239–260. doi: 10.1080/13504620220145401

Kormos, C., and Gifford, R. (2014). The validity of self-report measures of environmental behavior: A meta-analytic review. *J. Environ. Psychol.* 40, 359–371. doi: 10.1016/j.jenvp.2014.09.003

Ku, L., and Zaroff, C. (2014). How far is your money from your mouth? The effects of intrinsic relative to extrinsic values on willingness to pay and protect the environment. *J. Environ. Psychol.* 40, 472–483. doi: 10.1016/j.jenvp.2014.10.008

Li, J., and Guo, Y. Y. (2009). Revision of material value scale in Chinese college students. *Stud. Psychol. Behav.* 7, 280–283.

Li, J., Lu, M., Xia, T., and Guo, Y. (2018). Materialism as compensation for self-esteem among lower-class students. *Pers. Individ. Dif.* 131, 191–196. doi: 10.1016/j.paid.2018.04.038

Li, N., and Wu, J. P. (2016). Revise of the connectedness to nature scale and its reliability and validity. *China J. Health Psychol.* 9, 1347–1350. doi: 10.13342/j.cnki.cjhp.2016.09.018

Liao, J., and Wang, L. (2009). Face as a mediator of the relationship between material value and brand consciousness. *Psychol. Market.* 26, 987–1001. doi: 10.1002/mar.20309

Liu, X. W., and Wu, J. P. (2013). Environmental values and pro-environmental behaviors of college students: Mediating role of environmental concern. *Stud. Psychol. Behav.* 11, 780–785.

Lu, A. C. C., Gursoy, D., and Del Chiappa, G. (2016). The influence of materialism on ecotourism attitudes and behaviors. *J. Travel Res.* 55, 176–189. doi: 10.1177/0047287514541005

Ma, M. N., Shi, D. D., and Chen, L. Y. (2020). The influence of materialism on contemporary teenagers and the countermeasures. *Educ. Teach. Forum* 8, 92–94.

Mayer, F. S., and Frantz, C. M. (2004). The connectedness to nature scale: a measure of individuals' feeling in community with nature. *J. Environ. Psychol.* 24, 503–515. doi: 10.1016/j.jenvp.2004.10.001

Mayer, F. S., Frantz, C. M., Bruehlman-Senecal, E., and Dolliver, K. (2009). Why is nature beneficial? The role of connectedness to nature. *Environ. Behav.* 41, 607–643. doi: 10.1177/0013916508319745

Pinho, J. R., Grilo, C., Boone, R. B., Galvin, K. A., and Snodgrass, J. G. (2014). Influence of aesthetic appreciation of wildlife species on attitudes towards their conservation in Kenyan agropastoralist communities. *PLoS ONE* 9, e88842. doi: 10.1371/journal.pone.0088842

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., and Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *J. Appl. Psychol.* 88, 879–903. doi: 10.1037/0021-9010.88.5.879

Pyle, R. M. (2003). Nature matrix: Reconnecting people and nature. *Oryx* 37, 206–214.doi: 10.1017/S0030605303000383

Richins, M. L., and Dawson, S. (1992). A consumer values orientation for materialism and its measurement: Scale development and validation. *J. Consumer Res.* 19, 303–316. doi: 10.1086/209304

Rosa, C. D., and Collado, S. (2019). Experiences in nature and environmental attitudes and behaviors: Setting the ground for future research. *Front. Psychol.* 10, 763. doi: 10.3389/fpsyg.2019.00763

Roszak, T. (1992). *The Voice of the Earth*. New York, NY: Simon & Schuster.

Scannell, L., and Gifford, R. (2013). Personally relevant climate change: The role of place attachment and local versus global message framing in engagement. *Environ. Behav.* 45, 60–85. doi: 10.1177/0013916511421196

Schwartz, S. H. (1994). Are there universal aspects in the structure and contents of human values? *J. Soc. Issues* 50, 19–45.

Shrum, L. J., Wong, N., Arif, F., Chugani, S. K., Gunz, A., Lowrey, T. M., et al. (2013). Reconceptualizing materialism as identity goal pursuits: Functions, processes, and consequences. *J. Bus. Res.* 66, 1179–1185. doi: 10.1016/j.jbusres.2012.08.010

Soga, M., Gaston, K., Yamaura, Y., Kurisu, K., and Hanaki, K. (2016). Both direct and vicarious experiences of nature affect children's willingness to conserve biodiversity. *Int. J. Environ. Res. Public Health* 13:529. doi: 10.3390/ijerph13060529

Soga, M., and Gaston, K. J. (2016). Extinction of experience: The loss of human–nature interactions. *Front. Ecol. Environ.* 14, 94–101. doi: 10.1002/fee.1225

Tam, K.-P. (2013). Concepts and measures related to connection to nature: Similarities and differences. *J. Environ. Psychol.* 34, 64–78. doi: 10.1016/j.jenvp.2013.01.004

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., and Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *J. Environ. Psychol.* 11, 201–230. doi: 10.1016/S0272-4944(05)80184-7

Vlek, C., and Steg, L. (2010). Human behavior and environmental sustainability: Problems, driving forces, and research topics. *J. Soc. Issues* 63, 1–19. doi: 10.1111/j.1540-4560.2007.00493.x

Weinstein, N., Przybylski, A. K., and Ryan, R. M. (2009). Can nature make us more caring? Effects of immersion in nature on intrinsic aspirations and generosity. *Personal. Soc. Psychol. Bull.* 35, 1315–1329. doi: 10.1177/0146167209341649

Whitburn, J., Linklater, W., and Abrahamse, W. (2020). Meta-analysis of human connection to nature and environmental behavior. *Conserv. Biol.* 34, 180–193. doi: 10.1111/cobi.13381

Wierzbicki, J., and Zawadzka, A. M. (2016). The effects of the activation of money and credit card vs. that of activation of spirituality – which one prompts pro-social behaviours? *Curr. Psychol.* 35, 344–353. doi: 10.1007/s12144-014-9299-1

Zaval, L., Markowitz, E. M., and Weber, E. U. (2015). How will I be remembered? Conserving the environment for the sake of one's legacy. *Psychol. Sci.* 26, 231–236. doi: 10.1177/0956797614561266

Zelenski, J. M., Dopko, R. L., and Capaldi, C. A. (2015). Cooperation is in our nature: Nature exposure may promote cooperative and environmentally sustainable behavior. *J. Environ. Psychol.* 42, 24–31. doi: 10.1016/j.jenvp.2015.01.005

Zelenski, J. M., and Nisbet, E. K. (2014). Happiness and feeling connected: The distinct role of nature relatedness. *Environ. Behav.* 46, 3–23. doi: 10.1177/0013916512451901

Zong, Y., and Wang, G. X. (2017). Anthropomorphism of nature and pro-environmental behaviors of college students: the mediating effect of empathy with nature. *Psychology* 5, 654–664. doi: 10.16842/j.cnki.issn2095-5588.2017.11.003

**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Publisher's Note:** All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

frontiers | Frontiers in Psychology

BRIEF RESEARCH REPORT
published: 29 April 2022
doi: 10.3389/fpsyg.2022.856063

# Optimistic Environmental Messaging Increases State Optimism and *in vivo* Pro-environmental Behavior

*Megan MacKinnon, Adam C. Davis and Steven Arnocky**

*Human Evolution Laboratory, Department of Psychology, Nipissing University, North Bay, ON, Canada*

Despite recent empirical interest, the links between optimism and pessimism with pro-environmental behavior (PEB) remain equivocal. This research is characterized by a reliance on cross-sectional data, a focus on trait-level at the neglect of state-level optimism–pessimism, and assessments of retrospective self-reported ecological behavior that are subject to response bias. To attend to these gaps, 140 North American adults ($M_{age}$ = 34; $SD$ = 11.60; 44% female) were experimentally primed with bogus optimistic or pessimistic environmental news articles, and then asked to report their levels of state optimism–pessimism, intentions to purchase green products, *in vivo* PEB (donating to WWF and providing contact information to join an environmental organization), and support for geoengineering technologies. Results confirmed that optimistic (versus pessimistic) environmental messaging enhanced the expression of state optimism, which then contributed to PEB and support for geoengineering. These results have important implications for the framing of environmental messaging intended to promote ecologically conscious behavior.

**Keywords: pro-environmental behavior, pessimism, optimism, priming experiment, conservation behavior, *in vivo* environmental action**

OPEN ACCESS

***Edited by:***
*Paola Passafaro,*
*Sapienza University of Rome, Italy*

***Reviewed by:***
*Haywantee Ramkissoon,*
*University of Derby,*
*United Kingdom*
*Diana Gregory-Smith,*
*Newcastle University,*
*United Kingdom*

***Correspondence:**
*Steven Arnocky*
*stevena@nipissingu.ca*

***Specialty section:***
*This article was submitted to Environmental Psychology, a section of the journal Frontiers in Psychology*

***Received:*** *16 January 2022*
***Accepted:*** *28 March 2022*
***Published:*** *29 April 2022*

***Citation:***
*MacKinnon M, Davis AC and Arnocky S (2022) Optimistic Environmental Messaging Increases State Optimism and in vivo Pro-environmental Behavior. Front. Psychol. 13:856063. doi: 10.3389/fpsyg.2022.856063*

## INTRODUCTION

Many people across the globe are concerned about the threat posed by climate change, which may evoke feelings of uncertainty, anxiety, and hopelessness (Landry et al., 2018; Clayton, 2020). Expressing concern and feeling hopeful about the future may motivate pro-environmental behavior (PEB) and engender trust that one's actions can ameliorate pressing ecological dilemmas (Ojala, 2012, 2015). Conversely, hope may be underpinned by "wishful thinking" and denialism, leading to complacency and inaction (Ojala, 2012). Furthermore, negative emotionality (e.g., fear) may be important in being able to identify climate change as a threat and encourage conservation behavior (Kleres and Wettergren, 2017). Indeed, being able to acknowledge environmental dissolution and wanting to avoid negative future outcomes might motivate compensatory PEB (i.e., the constructive pessimism hypothesis; Kaida and Kaida, 2016a). Nonetheless, like the emotion of hope, heightened optimism (i.e., expressing positive future expectancies) may inspire people to take charge and engage in conservation behavior (Kaida and Kaida, 2017, 2019; McAfee et al., 2019). Accordingly, ambiguity remains surrounding the relative roles of optimism and pessimism in predicting PEB. This literature is further limited by a reliance on cross-sectional data and retrospective indices of environmental behavior.

This precludes an assessment of the causal relations among variables and leaves unanswered the question of whether optimism is truly complicit in promoting conservation behavior. The objective of the current research was to address these gaps by (1) using an experimental approach by exposing participants to either optimistic or pessimistic environmental messaging, (2) examining the effects of such exposure on state optimism, and (3) examining the mediating role of state optimism induction on *in vivo* group differences in environmental attitudes and behavior. Based on recent literature reviews (McAfee et al., 2019), we anticipated that optimistic (but not pessimistic) messaging would predict a suite of *in vivo* pro-environmental attitudes and behaviors, and that induced state optimism would mediate these links.

## Optimism, Pessimism, and Environmental Action

Since the late 1960s, the proportion of negative environmental news articles in the media has increased, while the amount of positive environmental news has decreased (McAfee et al., 2019). It is important to discuss and draw attention to evidence of growing environmental degradation, but media coverage of the environment has an evident negativity bias: coverage of environmental threats and the failure of conservation efforts receives significant attention, whereas ecological recovery and successful conservation is largely ignored (Ader, 1995; Hart and Feldman, 2014; McAfee et al., 2019). Despite the prevalence of environmental messaging in the media, there is limited empirical work on the topic of how pessimistic and optimistic environmental messaging may influence viewers' attitudes, values, and behavior toward the environment (Morris et al., 2020). There is also a shortage of research considering individual differences in optimism and pessimism in relation to PEB (Kaida and Kaida, 2019). Most of the previous research on the topic inside and outside of environmental psychology involves examining the links between related constructs, such as subjective wellbeing, in relation to PEB.

In a recent meta-analysis of 78 published studies, Zawadzki et al. (2020) found a small positive correlation between different kinds of PEB and various indicators of subjective wellbeing. In the 10% ($n = 7$) of studies that involved an experimental design, evidence suggested that positive affective states could be both an antecedent, as well as an outcome, of PEB (van der Linden, 2018). It was also uncertain whether expectations of future wellbeing and satisfaction could similarly promote, or be promoted by, PEB. In their work, Kaida and Kaida (2016a,b) found that PEB positively predicted *current* subjective wellbeing, but that *future* subjective wellbeing negatively predicted PEB. These authors reasoned that negative future expectancies might stimulate action to attenuate anxiety (so-called "constructive pessimism"), which explains why those with lower future subjective wellbeing might engage in more self-reported PEB. In contrast, Kaida and Kaida (2017) found that trait pessimism (related to lower future subjective wellbeing) shared a small negative relation with switching off the lights when not in use, whereas optimism was unrelated to this behavior. In a follow-up study, different kinds of PEB (e.g., reusing bags for grocery shopping) shared small positive relations with optimism and were either unrelated or weakly negatively related to pessimism (Kaida and Kaida, 2017). In a recent longitudinal study, Kaida and Kaida (2019) found that optimism both positively predicted and was predicted by PEB, but that the former pathway (optimism ➔ PEB) was stronger than the latter (PEB ➔ optimism). Within time, pessimism was weakly related to PEB in a negative direction. In contrast, Morris et al. (2020) found that experimentally priming pessimistic messaging about climate change increased risk perception and enhanced outcome efficacy—measured with the item "*I believe my actions have an influence on climate change*"—which was mediated by heightened emotional arousal. However, neither retrospective nor actual PEB were assessed in this study.

There is also indirect evidence supporting links between optimism-related constructs and PEB. For instance, those higher in place attachment may be happier and more optimistic (e.g., Brehm et al., 2004). Individuals high in ecological place attachment (e.g., to a national park) experience greater subjective wellbeing and are more likely to engage in PEB to protect that ecological resource (Ramkissoon et al., 2018). This research also indicates that intentions to engage in conservation behavior may be driven by certain factors encompassed within place attachment, such as place affect (e.g., feeling emotionally connected to a national park; Ramkissoon et al., 2013; Ramkissoon and Mavondo, 2014). This sense of place attachment may also be cultivated in one's household during periods of place confinement, such as the during the COVID-19 pandemic, through engaging in household PEB (e.g., conserving water when washing one's hands) which could heighten people's sense of happiness and wellbeing (Ramkissoon, 2020).

Most previous research on indicators of subjective wellbeing and optimism–pessimism in relation to PEB has (1) been cross-sectional or correlational across a few longitudinal timepoints, precluding an understanding of the causal links between variables, (2) is characterized by mixed findings (e.g., Kaida and Kaida, 2016a,b, 2017, 2019), and (3) has relied on self-reported measures of retrospective conservation behavior that are subject to response bias (see Dupuis and Arnocky, 2012). To ascertain "true" causal associations and actual engagement in PEB, an experimental approach is needed with *in vivo* assessments of behavioral engagement. Previous research has explored *in vivo* measures of environmental donating and joining an environmental organization as behavioral indices of pro-environmental action, finding that learned helplessness predicted lower likelihood of engaging in these actions (Landry et al. 2018). Given that optimism is often considered in opposition to helplessness (Seligman, 2000), we anticipate that these variables will be positively associated with induced optimism. Similarly, green purchasing has previously been associated with optimism, but not pessimism (Sadiq et al., 2020). Geoengineering represents a collection of technologies intended to abate climate change that people appear to express support of and optimism toward (Rehman et al., 2021). In previous work, Landry et al. (2018) found a positive relation between support for geoengineering and environmental concern. Nonetheless, technologies designed

to mitigate climate change may discourage people from engaging in everyday "green" behavior (Murtagh et al., 2015; Mittiga, 2019). It is currently unclear how attitudes toward geoengineering may be influenced by optimistic and pessimistic environmental messaging, state optimism–pessimism, and whether these attitudes may subsequently predict *in vivo* PEB. Given ambiguity surrounding how geoengineering support relates with other measures of pro-environmental attitudes and behavior (Arnocky et al., 2020), and whether optimism around the effectiveness of these technologies or pessimism about any other less risky solutions being viable (i.e., a "last resort hypothesis") would drive support for geoengineering, we included it in an exploratory manner along with other measures of individual pro-environmental actions.

There has also been a preoccupation with trait-level (i.e., enduring) at the relative neglect of state-level (i.e., temporary) optimism–pessimism; the latter of which may be particularly important when considering the influence of environmental messaging about climate change (see Morris et al., 2020).

There is also ambiguity revolving around whether trust, hope, and optimism toward science and technology to solve environmental dilemmas detracts from (Dunlap et al., 2000), or encourages pro-environmental attitudes and action (Ojala, 2012, 2015).

# PRESENT STUDY

Although challenging to advance a directional hypothesis, previous research suggests that optimistic environmental messaging likely increases state-level optimism, which may then encourage PEB (McAfee et al., 2019). The goal of the present research was to experimentally examine the effects of exposure to optimistic versus pessimistic environmental messaging upon state optimism and a diverse set of *in vivo* pro-environmental attitudes and behaviors, including green purchasing intentions, donating study earnings to an environmental organization, joining an environmental activism group, and support for geoengineering technologies. Specifically, we hypothesized:

*H1*: Exposure to optimistic (versus pessimistic) environmental messaging will predict greater state optimism.

*H2*: State optimism will predict each of the four pro-environmental outcome measures and will mediate links between condition and these outcomes.

# MATERIALS AND METHODS

## Participants and Procedure

We aimed to expose participants to optimistic or pessimistic passages modified from real digital print media sources, and subsequently assess state optimism followed by measures of pro-environmental attitudes and behavior. Sample size was determined for the path analysis model based upon previous simulation studies which indicate that simple structural equation models, which path analysis falls under the umbrella of, with reliable measures, good fit indices, and limited missing data will converge with sample sizes around 100 (Iacobucci, 2010). For data that are approximately normally distributed with a small number of variables, a participant to parameter ratio of 5:1 is adequate (Bentler and Chou, 1987). With 19 parameters in the current study, a sample size of $N = 95$ would be sufficient. Previous work also indicates that to maintain adequate power ($\geq 0.80$) to detect a medium correlational effect ($r = 0.30$) *via* path analysis requires a sample size of $N \sim 80$ (Miles, 2003). Accordingly, 152 North American participants were recruited *via* Amazon's Mechanical Turk (MTurk) and completed all tasks on Qualtrics. Participants with duplicate IP addresses, who failed to complete the experiment, failed the attention checks ("*If you are paying attention to this survey, please select 'disagree'*"; "*What do you think this article was about?*"), or did not provide a unique survey code were removed from the analytic sample. The final sample size was 140 ($M_{age} = 34$, $SD = 11.60$, range = 19–69; 44% female). Participants were primarily Caucasian (87%), Black (10%), Latin American (2%), and South Asian (1%). Participants were renumerated $1.00 USD. This research received approval by the Nipissing University Research Ethics Board (protocol #102658).

## Measures

### Experimental Priming Tasks

Participants were randomly assigned to one of two conditions: environmental optimism or environmental pessimism using bogus magazine articles adapted from real news (see **Supplemental Material** file for articles). In the optimism condition, the article explained reasons to be optimistic for the future of the environment (e.g., conservation efforts are saving many endangered species). In the pessimism condition, the article pertained to the inevitability of environmental degradation (e.g., at this point, our window for action has closed; there is nothing we can do to stop it). Participants were required to briefly explain the contents of the article that they had read as an attention check.

### State Optimism

The 7-item State Optimism Measure (SOM; Millstein et al., 2019) was used to assess state optimism (e.g., "*The future is looking bright for me*"). Items were measured with a 5-point Likert-type scale ranging from 1 (*Strongly disagree*) to 5 (*Strongly agree*) and averaged to create a mean scale score with higher scores reflecting greater state optimism ($\alpha = 0.93$).

### Intended Green Purchasing

Intended green purchasing behavior was measured using the Green Purchasing Behavior Scale (Lee, 2009), which was modified slightly to address intended green purchasing behavior (e.g., "*I intend to buy organic products*"; $\alpha = 90$). Participants responded

to seven items using a 5-point Likert-type scale ranging from 1 (*Strongly disagree*) to 5 (*Strongly agree*).

### *In vivo* Pro-environmental Behavior

Participants were given the option to keep their earnings from the survey or donate to the World Wildlife Fund (WWF), a prevalent environmental organization (coded: 0 = keep money, 1 = donate money). They were then asked if they wanted to join a bogus environmental group by providing their email (coded: 0 = no email, 1 = email provided). Donators comprised 11% ($n = 17$), and email joiners comprised 43% ($n = 65$) of the total sample. See **Supplemental Material** for wording of questions.

### Geoengineering

Following Pidgeon et al. (2012), participants were asked to report their support of geoengineering defined as "*The use of large-scale engineering projects designed specifically to comebat global climate change*." Participants used a 5-point Likert-type scale to record their responses, ranging from 1 (*Strongly oppose*) to *5* (*Strongly support*).

## Analytic Approach

Path analysis *via* AMOS (version 27) was used to explore whether priming environmentally related optimism (versus pessimism) would increase state optimism (Hypothesis 1), which in turn would predict an increase in green purchasing intent, willingness to donate earnings from the study to an environmental group, and willingness to join an environmental activism group, as well as support for geoengineering (Hypothesis 2), while controlling for sex (male/female) and age (**Figure 1**). Path analysis allowed us to simultaneously test predictions for each dependent variable while controlling for their shared variance. Model fit was assessed using the chi-square test of significance ($\chi^2$), comparative fit index (CFI), normed fit index (NFI), and the root mean square error of approximation (RMSEA; Kline, 2016). CFI and NFI values >0.90, RMSEA values <0.08, and a non-significant $\chi^2$ indicate adequate model fit (Hooper et al., 2008). Indirect (mediation) effects were examined using 2000 bootstrap samples and bias-corrected 95% confidence intervals. Missing data were estimated using the AMOS regression imputation (Collier, 2020).

## RESULTS

We first examined covariates and intercorrelations among dependent variables. Green purchasing correlated with joining the environmental group, $r = 0.18$, $SE = 0.03$, $p = 0.03$, and was modestly correlated with donating to the WWF, $r = 0.15$, $SE = 0.02$, $p = 0.08$. However, donating and joining the environmental group were unrelated to one another, $r = -0.05$, $SE = 0.01$, $p = 0.56$. Geoengineering support correlated positively with donating, $r = 0.30$, $SE = 0.03$, $p < 0.001$, and with green purchasing intent, $r = 0.49$, $SE = 0.04$, $p < 0.001$, but not with joining the environmental group, $r = 0.07$, $SE = 0.02$, $p = 0.40$. Sex was modestly related to green purchasing, $b = 0.20$, $\beta = 0.13$, $SE = 0.13$, $p = 0.10$,

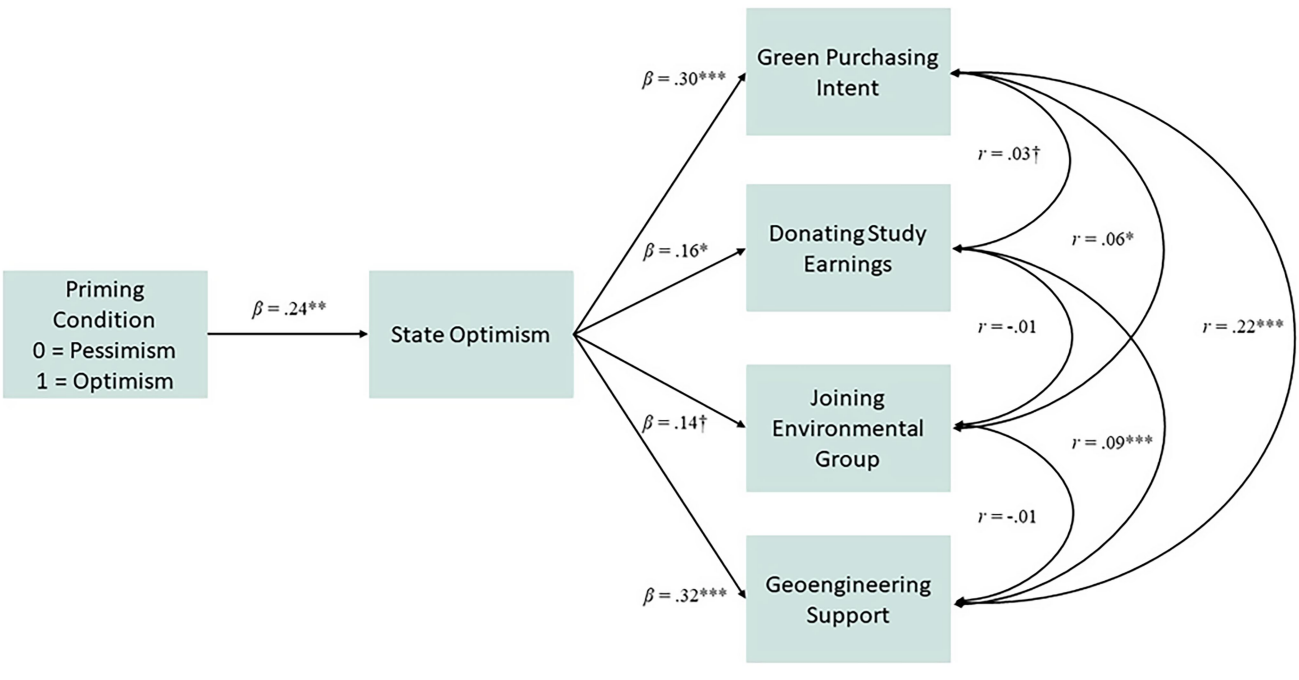



**FIGURE 1** | Results of an observed variable path model analysis for examining the indirect effect of induced optimism on pro-environmental behavior, green purchasing intent, and support for geoengineering. Note that links between demographic control variables sex and age and the dependent variables are not depicted. †=$p < 0.10$, *=$p < 0.05$, **=$p < 0.01$, and ***=$p < 0.001$.

and joining the environmental group, $b = 0.14$, $\beta = 0.14$, $SE = 0.08$, $p = 0.08$, such that women were more likely than men to endorse both. However, sex was unrelated to donating, $b = 0.01$, $\beta = 0.01$, $SE = 0.05$, $p = 0.93$, and geoengineering support, $b = -0.07$, $\beta = -0.05$, $SE = 0.10$, $p = 0.52$. Younger participants were more likely to join the environmental group, $b = -0.01$, $\beta = 0.26$, $SE = 0.03$, $p = 0.001$, and to support geoengineering, $b = -0.01$, $\beta = -0.15$, $SE = 0.004$, $p = 0.05$, but not to donate, $b = -0.03$, $\beta = 0.12$, $SE = 0.02$, $p = 0.14$, or intend to purchase green products, $b = 0.01$, $\beta = 0.07$, $SE = 0.01$, $p = 0.39$.

Next, we examined whether the priming manipulation had the desired effects on state optimism. Results showed that reading the optimistic climate article (versus the pessimistic article) positively predicted subsequent state optimism, $b = 0.42$, $\beta = 0.24$, $SE = 0.14$, $p = 0.004$. In turn, state optimism positively predicted green purchasing intent, $b = 0.27$, $\beta = 0.30$, $SE = 07$, $p < 0.0001$, donating one's earnings from the study to the WWF, $b = 0.06$, $\beta = 0.16$, $SE = 0.03$, $p = 0.05$, support for geoengineering, $b = 0.24$, $\beta = 0.32$, $SE = 0.06$ $p < 0.001$, and modestly predicted joining the environmental activism group, $b = 0.08$, $\beta = 0.14$, $SE = 0.08$, $p = 0.09$. Examination of the indirect effects showed that induced state optimism significantly mediated the links between the priming task and green purchasing intent, $b = 0.11$, $\beta = 0.07$, $SE = 0.05$, $p = 0.004$, LLCI = 0.03 ULCI = 0.25, donating, $b = 0.02$, $\beta = 0.04$, $SE = 0.01$, $p = 0.008$, LLCI = 0.01 ULCI = 0.06, geoengineering, $b = 0.10$, $\beta = 0.08$, $SE = 0.05$, $p = 0.004$, LLCI = 0.03 ULCI = 0.20, and joining the environmental group, $b = 0.03$, $\beta = 0.03$, $SE = 0.02$, $p = 0.042$, LLCI = 0.008 ULCI = 0.25. The model fit the data well, $\chi^2 = 4.71$ ($df = 9$, $p = 0.52$), RMSEA = 0.00 (95% CI = 0.00–0.05), CFI = 1.00, NFI = 0.96.

## DISCUSSION

Optimism can imbue people with hope, self-efficacy, and the capacity to persist and achieve goals when faced with challenges and uncertainty (Carver et al., 2010). Optimists are also approach-oriented and possess a greater capacity to tackle stressful life events (Nes and Segerstrom, 2006). Given that environmental dilemmas are complex and difficult to predict (discussed in Davis and Stroink, 2016), and sometimes evoke feelings of anxiety and stress (Clayton, 2020), optimism might encourage taking action to benefit the environment. Optimism is also entwined with positive emotionality and life satisfaction (i.e., subjective wellbeing), which seems to promote, and be a consequence of, engaging in pro-environmental behavior (PEB; see Zawadzki et al., 2020 for meta-analysis). Nonetheless, evidence has been mixed regarding whether trait optimism or closely related constructs, such as hope and future subjective wellbeing, are reliably associated with greater PEB (Ojala, 2012, 2015; Kaida and Kaida, 2016a,b, 2017). Similar mixed findings have been reported for the relations among support for geoengineering technologies, optimism, and engagement in conservation behavior (Murtagh et al., 2015; Rehman et al., 2021). Most of the research on the associations between subjective wellbeing, optimism–pessimism, and PEB has been cross-sectional, precluding an examination of "true" causal mechanisms. This is particularly important given some evidence that, like subjective wellbeing, optimism might be an antecedent and/or an outcome of PEB (Kaida and Kaida, 2019). Moreover, trait-level as opposed to state-level optimism–pessimism has received more attention in the literature, and more research involving an assessment of optimism–pessimism specifically toward environmental dilemmas is needed (Morris et al., 2020).

To attend to these gaps, we tested whether priming environmentally related optimism (versus pessimism) would increase state optimism (Hypothesis 1) to consequently predict intentions to purchase "green" products, as well as willingness to donate to the World Wildlife Fund (WWF) and join an environmental organization (Hypothesis 2). Controlling for participant sex and age, in line with some previous research (e.g., Kaida and Kaida, 2017, 2019), we found support for the idea that priming people to feel hopeful about the future of the environment heightened their optimism, which promoted intentions to make green purchases and donate to the WWF. This is in contrast to findings by Morris et al. (2020), where pessimistic affective messaging revolving around beekeeping and climate change increased risk perceptions and greater outcome efficacy (believing that one had the power to influence climate change). However, neither retrospective nor actual PEB were examined in their study.

Some have posited a reliance on science and technology to solve environmental ills is problematic and may breed complacency and inaction regarding conservation behavior (Dunlap et al., 2000; Murtagh et al., 2015; Mittiga, 2019). Nonetheless, support for geoengineering technologies to abate climate change has been linked with expressing concern for the environment (Landry et al., 2018), and people seem to express optimism toward to efficacy of geoengineering interventions to mitigate environmental dilemmas (Rehman et al., 2021). We found that optimistic environmental messaging promoted support for geoengineering *via* heightened state optimism (Hypothesis 2).

### Limitations

The current study has several noteworthy strengths, such as the use of an experimental design with *in vivo* assessments of PEB (e.g., donation behavior). Nonetheless, there are important limitations to consider. The *in vivo* measures of donating behavior and committing to join a naturalist organization were uncorrelated with one another, which may signal issues with convergent validity. MTurk workers could also be much less inclined to donate their study earnings in comparison to other community-level populations and undergraduate students, and perhaps this is a problematic means of assessing *in vivo* PEB in this population. Furthermore, evidence suggests that optimism may be both an antecedent and an outcome of PEB (Kaida and Kaida, 2019); however, we were unable to assess the latter causal pathway (i.e., PEB ➔ state optimism). Therefore, in future experimental work, it would be fruitful for researchers to examine whether *in vivo* PEB can also enhance state optimism. Moreover, we decided to focus on state optimism–pessimism to address important causal issues lacking in extant research, yet it may be prudent to control for trait-level dispositions to ascertain the unique contributions of state-level influences more confidently (see Kluemper et al., 2009). Future researchers might consider the

potential moderating role of environmental concern to the relationship between optimism induction and PEB. Rafiq et al. (2022) recently found that environmental concern moderated the relationship between dispositional optimism and eco-friendly tourist behavior, such that those high in concern and high in optimism were most eco-friendly in their tourism actions. Perhaps trait environmental concern would similarly interact with induced state optimism in predicting a wider range of pro-environmental actions. It is also possible that optimism priming could induce group differences in environmental concern, which might then mediate links between optimism priming and PEB. Finally, our experimental design relied on examining between-group differences. It would also be interesting to expose participants to both optimistic and pessimistic messaging using a within-subject design to better target intra-individual changes in the effects of optimism and pessimism on environmentalism.

## CONCLUSION

Gathering insight into the downstream influences of optimistic and pessimistic environmental messaging on actual green behavior and support for techno-centric solutions to environmental dilemmas, such as geoengineering, is paramount (Morris et al., 2020). Our findings suggest that optimistic environmental messaging heightens one's sense of optimism temporarily, which then promotes behaving in an ecologically conscious way, as well as being aware and supportive of climate abating technologies. These results coincide with some research (e.g., Kaida and Kaida, 2017), but contrast others (e.g., Morris et al., 2020). The current study attends to several shortcomings of previous work in that it was an experiment where both state optimism and *in vivo* PEB were assessed to provide a more valid test of causality. Our findings indicate that optimistic messaging enhanced state optimism and behaving in ways that will benefit the environment. However, our findings also highlight a problem raised by others, in that optimistic environmental messaging has been declining since the early 1970s (McAfee et al., 2019). Together, these findings highlight a troubling contradiction: Although climate change is a progressively worsening global issue that must be covered diligently and accurately in the popular press, it is simultaneously important to increase focus and coverage on positive steps being taken toward bettering our climate. Indeed, others have highlighted the fact that some meaningful advancements in habitat and species conservation and rehabilitation, reducing commercial fishing impacts, and the scope of legislative environmental protection have been made (McAfee et al., 2019) alongside a global greening phenomenon (Piao et al., 2020), and yet receive little relative media attention (Ridley, 2020). Ultimately, our findings suggest that this could negatively impact individuals' environmental engagement.

## DATA AVAILABILITY STATEMENT

The dataset presented in this study can be found in an online repository on the Open Science Framework: https://osf.io/gqv94/.

## ETHICS STATEMENT

The study involving human participants was reviewed and approved by the Nipissing University Research Ethics Board. The participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

MM collected the data, performed data analysis, and helped to prepare the manuscript. AD co-wrote the manuscript. SA designed the study and led the revision of the manuscript. All authors contributed to the article and approved the submitted version.

## FUNDING

Funding for this research provided by a Social Sciences and Humanities Research Council of Canada (SSHRC) Institutional Research Grant (file # 102093) awarded to SA.

## ACKNOWLEDGMENTS

AD is supported by a Social Sciences and Humanities Research Council (SSHRC) Postdoctoral Fellowship.

## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.856063/full#supplementary-material

## REFERENCES

Ader, C. R. (1995). A longitudinal study of agenda setting for the issue of environmental pollution. *Journalism Mass Commun. Q.* 72, 300–311. doi: 10.1177/107769909507200204

Arnocky, S., Desrochers, J., and Locke, A. (2020). Entitlement predicts lower pro-environmental attitudes and behavior in young adults. *Ecopsychology* 12, 292–300. doi: 10.1089/eco.2019.0078

Bentler, P. M., and Chou, C. P. (1987). Practical issues in structural modeling. *Sociol. Methods Res.* 16, 78–117. doi: 10.1177/0049124187016001004

Brehm, J. M., Eisenhauer, B. W., and Krannich, R. S. (2004). Dimensions of community attachment and their relationship to well-being in the amenity-rich rural west. *Rural. Sociol.* 69, 405–429. doi: 10.1526/0036011041730545

Carver, C. S., Scheier, M. F., and Segerstrom, S. C. (2010). Optimism. *Clin. Psychol. Rev.* 30, 879–889. doi: 10.1016/j.cpr.2010.01.006

Clayton, S. (2020). Climate anxiety: psychological responses to climate change. *J. Anxiety Disord.* 74:102263. doi: 10.1016/j.janxdis.2020.102263

Collier, J. E. (2020). *Applied Structural Equation Modeling Using AMOS: Basic to Advanced Techniques*. Milton Park: Routledge.

Davis, A. C., and Stroink, M. L. (2016). The relationship between systems thinking and the new ecological paradigm. *Syst. Res. Behav. Sci.* 33, 575–586. doi: 10.1002/sres.2371

Dunlap, R. E. V. L., Liere, K. V., Mertig, A., and Jones, R. E. (2000). Measuring endorsement of the new ecological paradigm: a revised NEP scale. *J. Soc. Issues* 56, 425–442. doi: 10.1111/0022-4537.00176

Dupuis, D. R., and Arnocky, S. (2012). Decoupling and contextualizing self-sacrifice and intentions to act for the benefit of the environment. *Anal. Soc. Issues Public Policy* 12, 225–229. doi: 10.1111/j.1530-2415.2012.01283.x

Hart, P. S., and Feldman, L. (2014). Threat without efficacy? Climate change on US network news. *Sci. Commun.* 36, 325–351. doi: 10.1177/1075547013520239

Hooper, D., Coughlan, J., and Mullen, M. R. (2008). Structural equation modelling: guidelines for determining model fit. *Electron. J. Bus. Res.* 6, 53–59. doi: 10.21427/D7CF7R

Iacobucci, D. (2010). Structural equations modeling: fit indices, sample size, and advanced topics. *J. Consum. Psychol.* 20, 90–98. doi: 10.1016/j.jcps.2009.09.003

Kaida, N., and Kaida, K. (2016a). Facilitating pro-environmental behavior: the role of pessimism and anthropocentric environmental values. *Soc. Indic. Res.* 126, 1243–1260. doi: 10.1007/s11205-015-0943-4

Kaida, N., and Kaida, K. (2016b). Pro-environmental behavior correlates with present and future subjective well-being. *Environ. Dev. Sustain.* 18, 111–127. doi: 10.1007/s10668-015-9629-y

Kaida, K., and Kaida, N. (2017). Wake up for the environment: an association between sleepiness and pro-environmental behavior. *Pers. Individ. Differ.* 104, 12–17. doi: 10.1016/j.paid.2016.07.014

Kaida, N., and Kaida, K. (2019). Positive associations of optimism–pessimism orientation with pro-environmental behavior and subjective well-being: a longitudinal study on quality of life and everyday behavior. *Qual. Life Res.* 28, 3323–3332. doi: 10.1007/s11136-019-02273-y

Kleres, J., and Wettergren, Å. (2017). Fear, hope, anger, and guilt in climate activism. *Soc. Mov. Stud.* 16, 507–519. doi: 10.1080/14742837.2017.1344546

Kline, R. B. (2016). *Principles and Practice of Structural Equation Modeling, 4th Edn*. New York City: Guilford Publications.

Kluemper, D. H., Little, L. M., and DeGroot, T. (2009). State or trait: effects of state optimism on job-related outcomes. *J. Organ. Behav.* 30, 209–231. doi: 10.1002/job.591

Landry, N., Gifford, R., Milfont, T. L., Weeks, A., and Arnocky, S. (2018). Learned helplessness moderates the relationship between environmental concern and behavior. *J. Environ. Psychol.* 55, 18–22. doi: 10.1016/j.jenvp.2017.12.003

Lee, K. (2009). Gender differences in Hong Kong adolescent consumers' green purchasing behavior. *J. Consum. Mark.* 26, 87–96. doi: 10.1108/07363760910940456

McAfee, D., Doubleday, Z. A., Geiger, N., and Connell, S. D. (2019). Everyone loves a success story: optimism inspires conservation engagement. *Bioscience* 69, 274–281. doi: 10.1093/biosci/biz019

Miles, J. (2003). A framework for power analysis using a structural equation modelling procedure. *BMC Med. Res. Methodol.* 3:27. doi: 10.1186/1471-2288-3-27

Millstein, R. A., Chung, W.-J., Hoeppner, B. B., Boehm, J. K., Legler, S. R., Mastromauro, C. A., et al. (2019). Development of the State Optimism Measure. *Gen. Hosp. Psychiatry*, 58, 83–93.

Mittiga, R. (2019). What's the problem with geo-engineering? *Soc. Theory Prac.* 45, 471–499. doi: 10.5840/soctheorpract201992768

Morris, B. S., Chrysochou, P., Karg, S. T., and Mitkidis, P. (2020). Optimistic vs. pessimistic endings in climate change appeals. *Humanit. Soc. Sci. Commun.* 7, 1–8. doi: 10.1057/s41599-020-00574-z

Murtagh, N., Gatersleben, B., Cowen, L., and Uzzell, D. (2015). Does perception of automation undermine pro-environmental behaviour? Findings from three everyday settings. *J. Environ. Psychol.* 42, 139–148. doi: 10.1016/j.jenvp.2015.04.002

Nes, L. S., and Segerstrom, S. C. (2006). Dispositional optimism and coping: a meta-analytic review. *Personal. Soc. Psychol. Rev.* 10, 235–251. doi: 10.1207/s15327957pspr1003_3

Ojala, M. (2012). Hope and climate change: the importance of hope for environmental engagement among young people. *Environ. Educ. Res.* 18, 625–642. doi: 10.1080/13504622.2011.637157

Ojala, M. (2015). Hope in the face of climate change: associations with environmental engagement and student perceptions of teachers' emotion communication style and future orientation. *J. Environ. Educ.* 46, 133–148. doi: 10.1080/00958964.2015.1021662

Piao, S., Wang, X., Park, T., Chen, C., Lian, X. U., He, Y., et al. (2020). Characteristics, drivers and feedbacks of global greening. *Nat. Rev. Earth Environ.* 1, 14–27. doi: 10.1038/s43017-019-0001-x

Pidgeon, N., Corner, A., Parkhill, K., Spence, A., Butler, C., and Poortinga, W. (2012). Exploring early public responses to geoengineering. *Philos. Trans. Royal Soc. A: Math., Phys. Eng. Sci.* 370, 4176–4196. doi: 10.1098/rsta.2012.0099

Rafiq, F., Chishty, S. K., and Adil, M. (2022). Explanatory or dispositional optimism: which trait predicts eco-friendly tourist behavior? *Sustainability* 14:2994. doi: 10.3390/su14052994

Ramkissoon, H. (2020). COVID-19 place confinement, pro-social, pro-environmental behaviors, and residents' wellbeing: a new conceptual framework. *Front. Psychol.* 11:2248. doi: 10.3389/fpsyg.2020.02248

Ramkissoon, H., and Mavondo, F. (2014). Proenvironmental behavior: the link between place attachment and place satisfaction. *Tour. Anal.* 19, 673–688. doi: 10.3727/108354214X14146846679286

Ramkissoon, H., Mavondo, F., and Uysal, M. (2018). Social involvement and park citizenship as moderators for quality-of-life in a national park. *J. Sustain. Tour.* 26, 341–361. doi: 10.1080/09669582.2017.1354866

Ramkissoon, H., Smith, L. D. G., and Weiler, B. (2013). Testing the dimensionality of place attachment and its relationships with place satisfaction and pro-environmental behaviours: a structural equation modelling approach. *Tour. Manag.* 36, 552–566. doi: 10.1016/j.tourman.2012.09.003

Rehman, T., Bandh, S., Peerzada, M., Bashir, S., and Hoang, A. (2021). Knowledge, perception and attitude in relation to climate change: a cross-sectional survey. *Sustain. Earth.* 16:266. doi: 10.21203/rs.3.rs-433071/v1

Ridley, M. (2020). Against environmental pessimism. Rational Optimist. https://www.rationaloptimist.com/blog/against-environmental-pessimism/ (Accessed March 25, 2022).

Sadiq, M., Paul, J., and Bharti, K. (2020). Dispositional traits and organic food consumption. *J. Clean. Prod.* 266:121961. doi: 10.1016/j.jclepro.2020.121961

Seligman, M. E. (2000). Optimism, pessimism, and mortality. *Mayo Clin. Proc.* 75, 133–134. doi: 10.4065/75.2.133

van der Linden, S. (2018). Warm glow is associated with low-but not high-cost sustainable behaviour. *Nat. Sustain.* 1, 28–30. doi: 10.1038/s41893-017-0001-0

Zawadzki, S. J., Steg, L., and Bouman, T. (2020). Meta-analytic evidence for a robust and positive association between individuals' pro-environmental behaviors and their subjective wellbeing. *Environ. Res. Lett.* 15:123007. doi: 10.1088/1748-9326/abc4ae

**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Publisher's Note:** All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

frontiers | Frontiers in Psychology

ORIGINAL RESEARCH
published: 31 May 2022
doi: 10.3389/fpsyg.2022.870555

# Assessing Socioeconomic Risks of Climate Change on Tenant Farmers in Pakistan

*Muhammad Tariq Yousafzai[1†], Tariq Shah[2†], Salim Khan[3], Sana Ullah[4], Muhammad Nawaz[5], Heesup Han[6*], Antonio Ariza-Montes[7], Horacio Molina-Sánchez[8] and Alejandro Vega-Muñoz[9]*

[1]Centre for Management and Commerce (CMC), University of Swat, Swat, Pakistan, [2]Department of Economics and Development Studies, University of Swat, Swat, Pakistan, [3]Riphah School of Leadership, Faculty of Management Science (FMS), Riphah International University, Chakdara, Pakistan, [4]Department of Environmental and Conservation Sciences, University of Swat, Swat, Pakistan, [5]Institute of Business Studies, Kohat University of Science and Technology, Kohat, Pakistan, [6]College of Hospitality and Tourism Management, Sejong University, Seoul, South Korea, [7]Social Matters Research Group, Universidad Loyola Andalucía, Córdoba, Spain, [8]Department of Financial Economics and Accounting, Universidad Loyola Andalucía, Córdoba, Spain, [9]Public Policy Observatory, Universidad Autónoma de Chile, Santiago, Chile

OPEN ACCESS

**Edited by:**
*Shah Ashfaq Ahmad, Hohai University, China*

**Reviewed by:**
*Sajjad Ali, Jiangsu University, China*
*Ayat Ullah, Leibniz Center for Agricultural Landscape Research (ZALF), Germany*
*Takaaki Nihei, Tokyo Metropolitan University, Japan*

***Correspondence:**
*Heesup Han*
*heesup.han@gmail.com*

*[†]These authors have contributed equally to this work and share first authorship*

**Specialty section:**
*This article was submitted to Environmental Psychology, a section of the journal Frontiers in Psychology*

**Received:** *07 February 2022*
**Accepted:** *05 May 2022*
**Published:** *31 May 2022*

**Citation:**
*Yousafzai MT, Shah T, Khan S, Ullah S, Nawaz M, Han H, Ariza-Montes A, Molina-Sánchez H and Vega-Muñoz A (2022) Assessing Socioeconomic Risks of Climate Change on Tenant Farmers in Pakistan. Front. Psychol. 13:870555. doi: 10.3389/fpsyg.2022.870555*

The study uses a transformative worldview to give voice to an economically marginalized group of tenant farmers vulnerable to climate changes due to their calamity prone geographical location. Drawing on anthropogenic global warming (AGW) theory lens, we examine the impact of manmade actions on climate change in District "Swat" and "Malakand" of Khyber Pakhtunkhwa (KPK) province, Pakistan using a sequential mixed methods research design. Through this research design, the results of quantitative survey were complemented with a qualitative analysis of in-depth interviews. In first phase, we conducted a survey of 200 tenant farmers, followed by second wave of data collection involving 12 open-ended in-depth interviews (IDIs). The both qualitative and quantitative results suggest that farmers in both districts are affected by climate change although their crop yield had progressively increased signaling better coping and survival skills than other parts of country. Majority of respondents believed that climate change is something beyond their control in disagreement with AGW theory. Major economic losses were specifically, due to sudden alterations in weather patterns, such as floods, and hailstorms that reduce productivity as well as results in food waste with no avenues available to reclaim the energy laden in organic food waste. Besides, a productivity loss was attributed to outdated farming, lack of awareness regarding sharecropping and crop loan insurance practices. The study concludes that farmers are most vulnerable to climate change in socioeconomic terms as such changes impact their income sources; This inwardly compels cash strapped tenant farmers to delve in practice of informal credit with substantive risks attached which further deteriorates their livelihoods. The study offers understanding of how low-literate and economically marginalized indigenous tenant farmers cope to climate change and offers policy recommendations to advocate for the rights to earn sustainable livelihoods in the face of grand climate challenge.

**Keywords: anthropogenic global warming, climate change, economic risks, tenant farmers, sustainable development**

## INTRODUCTION

The developing countries are most vulnerable to climate change due to huge exposure and lack of awareness regarding impending threats (Ali et al., 2017; Rauf et al., 2018). Zhao et al. (2017) proclaims that global food security is disturbed due to altering rainfall spells and sudden rise in temperature in form of heat waves. Similarly, a study by Clapp (2017) asserts that food production at local level leads to food security indigenously. As a counter measure strategy to climate change, businesses now embrace the concept of Triple bottom line (TBL), which does not solely focus on profit dimension of performance. The TBL argues for a balanced approach to sustainable development by emphasizing social, economic, and environmental dimension of anthropogenic activities (Sun and Ertz, 2021). From a sustainable world perspective, some serious consideration is required to offset the effects of the grand challenge of climate change, which has the potential to act as an obstacle in attainment of sustainability (Sörqvist, 2016).

Due to direct interface of environmental conservation and agriculture, special attention is required to comply with quantifiable actions, policies, and programs as envisioned in sustainable development goals SDGs. On one hand, agriculture is a primal source of livelihoods of people in agri-based economies like Pakistan. On the other hand, this sector is most vulnerable to food insecurity threats due to climate changes (Dhimal et al., 2021). In Pakistan, a major stratum of the population, almost 42% is occupationally, related to agriculture that belongs mostly to rural localities (Shah et al., 2021). Pakistan is included in the list of top ten most vulnerable countries to climate change and was ranked among the three worst affected countries worldwide due to climate change (Kreft et al., 2013; Yousafzai et al., 2020). The reasons for such vulnerability are mainly attributed to arid and semi-arid climatic conditions and geographical dimensions. In comparison with humid regions, the impact of rise in temperature is more visible in arid and semi-arid regions (Huang et al., 2016). A rise in precipitation pattern has been witnessed ever since, the inception of new millennium, with an average value of rain recorded at 40% in South East, 20% in North, and 10% in central parts of Pakistan (Gitay et al., 2002). Since, the start of this century, Pakistan has confronted recurrent natural disasters. A destructive flood in 2012 adversely affected more than three million people including District Swat and Malakand in Khyber Pakhtunkhwa (KPK) province in Pakistan. As a result, thousands of hectares of agricultural land and more than four hundred lives were lost (Blunden and Arndt, 2012). Hence, in the backdrop of universal agreement on value of human life (Parncutt, 2019) the world needs studies on marginalized communities to mitigate their suffering by raising the voices of economically oppressed and environmentally threatened people. With this study, we aim to assess the socioeconomic risks of climate change on tenant farmers in Khyber Pakhtunkhwa and to assess their awareness levels to climate change from AGW theory lens.

It is common in academic discourse, that climate change affects farmer's productivity on various dimensions, which inwardly cascades socioeconomic challenges as it affects their income. More specifically, such climatic variability affect the economically marginalized farmers more due to their limited skills sets and lack of adaptive capacities (Ofoegbu et al., 2017). The economic vulnerabilities of farmers in district Malakand and district Swat are important to study because such tenant farming practices differ from those of landholder farmers. Their informal contract arrangements are agreed prior to harvest seasons, which keeps farmers at a disadvantage in the absence of crop insurance schemes. Consequently, the tenant farmers are more vulnerable to climate changes due to the absence of credit support from Government and any other forms of support, such as crop insurance schemes Kabeer et al. (2010). Their socioeconomic conditions hinge upon a variety of factors beyond their locus of control that includes precipitation patterns, temperature, floods, and dry spells (Fahad et al., 2020). These climatic changes have become more challenging for the tenant farmers in both districts due to low awareness levels of tenants, which warrant the investigation of studies, such as this one to support the downtrodden tenant farmers in improving their climate resilience as significance of study. This will also help mitigate the socioeconomic shocks experienced by tenant farmers in target area including some districts of Malakand prone to tenant-landlord conflicts by informing policymakers to tailor effective programs interventions.

Assessing the socioeconomic impact of climate risks is important globally, due to its transboundary effects, which a challenge is for future generation of scientists. Parncutt (2019) contends that globally, climate change has become a serious threat to activities in the many sectors. Some of the neighboring countries in Asia, such as China, Nepal, and India, have successfully enhanced technical capabilities to counter climate change and thus reduced the negative effects of such changes on agricultural operations (Shabbir et al., 2019). These improvements are not without externalities due on bordering countries due to the transboundary movement emanating from burning of post-harvest residue in Indian to Lahore city of Pakistan. The situation was so alarming in certain areas of Lahore district due to smog that a lockdown was imposed as part of climate emergency response [Correspondent, 2021 (TNI, 2021 the news international)]. In this context, the government of Pakistan is also focusing on climate change and has made a Climate change (CC) policy to adhere the ideals of climate justice. Manifestations emanating from such a policy are evident from initiation of a "Billion Tree Tsunami Afforestation Project" which will also help improve local community needs in a sustainable manner (Kamal et al., 2019; Ullah et al., 2022). The Climate change policy of Pakistan aims to address a whole set of possible changes of adaptation and mitigation by serving as a focal document for related plans, projects, and programs for effective implementation. Unfortunately, Pakistan is one of the countries, which are strapped, in terms technical and financial support to deal with climate change. According to Global Climate risk index (2020), Pakistan is constantly ranked among top most vulnerable countries to catastrophes and adverse effects of climate change (Eckstein et al., 2019). Moreover, Khyber Pakhtunkhwa (KPK) province in Pakistan has suffered widely due to recurrent natural calamities, such as massive

floods of 2010 and 2011, which swept away fertile soil and farmlands of locals (Ullah et al., 2019). It is clear that geographical location contributes to prevalence of such recurrent occurrence of catastrophes, such as heat waves, sudden rise in temperatures, and drastic changes in weather patterns in Pakistan (Yousafzai et al., 2020). In the backdrop of preceding decisions, it becomes imperative to search for better solutions to instill climate resilience and adaptation in local communities through improving the socioeconomic conditions of land less or land strapped tenant farmers. Hence, it is utmost necessary to adopt such countermeasure strategies to cope with this grand challenge and achieve SDGs oriented targets in true letter and spirit (Ahmed et al., 2020).

This study is conducted in district Malakand and District Swat, located in the north west of KPK province. Swat valley and adjoining Malakand districts are blessed with vast mountainous area with rivers flowing downstream lowlands of Khyber Pakhtunkhwa. This also makes both the districts prone to climate changes induced by floods (Saqib et al., 2018). Farming is one of the leading occupations for majority of population besides their own business, such as small enterprises like commodity shops; vegetable trading, fuel wood trading, and other trades associated with agriculture, such as seeds and fertilizer are common in study areas. A considerable portion of subsistence farmers have small land holding with tenant status and average land per tenant is estimated to be less than national averages. These people also lack access to formal sources of credit due to lack of collateral and livelihood assets (Saqib et al., 2018). Most common crops of the area are wheat, rice, sunflower, and maize. Different types of vegetable like potato, onion, tomato, okra and peas are also grown regularly. In fruits, peach, plum, apple, persimmon, and loquat are common.

Majority of the studies conducted on the impact of climate on farmer's livelihoods had used either a quantitative or qualitative research designs. This study is unique in a sense that it amalgamates both qualitative and quantitative approaches in a mixed methods research design in a rural setting of Pakistan as well as considers exclusively tenant farmers in land strapped regions of Swat Valley and protected areas of Malakand district in KPK, Pakistan. The study is important from a policy perspective as it informs the changes that had taken place in past two decades and contributes to original information available for future researchers in the areas of District Swat and Malakand in KPK. The aim of this research is to identify the overall impact of climate change on socioeconomics condition of the tenant farmers in Malakand and Swat district of Khyber Pakhtunkhwa province (KPK), Pakistan. The main objectives of this research are to:

a. To assess the awareness level of the tenant farmers regarding climate changes.
b. To determine concurrent changes due to climate change observed by such farmers in their areas.
c. To investigates the adoptive strategies to mitigate the effect of climate change.
d. Construct a policy guideline for policymakers and related stakeholders for overall improvement (**Figure 1**).

## MATERIALS AND METHODS

According to Creswell and Creswell (2017) mixed methods are useful to understand complex problems, especially when there are contradictions between positivist (quantitative) and constructivist (qualitative) findings. We used a sequential mixed methods research design to achieve a more synergistic data collection and analysis across two stages of data collection to give voice to marginalized group of tenant farmers affected by climate change (Wisdom and Creswell, 2013). The study was conducted in two districts of Swat and Malakand in Khyber Pakhtunkhwa (KPK) which, were prone to natural calamities as evident from recurrent pattern of floods, hailstorms, strong winds, and dry spells. KPK is a topographically a diverse province in Pakistan. It has a versatile weather and a unique topography. Its climate varies from the dry and hot rocky zones in south to the cool and lavish green forests in the north. It has twenty-five (25) districts in total (Babar et al., 2015). For the study, a representative sample of 200 tenant farmers was selected through use of multistage sampling technique in both districts Swat and Malakand during initial survey phase followed up by twelve in-depth interviews during inductive second phase. In the former phase, a comprehensively structured questionnaire was used to collect information from farmers and in later phase, an interview protocol was used to collect information from participants. General demographic characteristics and data regarding the socioeconomic status of the respondents as well as details about climate change from farmers' perspective. Special focus was made to analyze the changes in the cropping pattern due to climatic change.

The research onion was used to situate the research by depicting various layers encompassing worldviews, strategy of inquiry, and data collection approaches and procedures (Saunders, 2011). This study used a sequential mixed method research choice with a transformative worldview to raise voice for the economically disadvantaged tenant farmers who are involved in farming where nature of contracts is informal and verbally agreed prior several months in advance to harvest season. The nature of data collected across both quantitative and qualitative stages of sequential mixed methods can be termed longitudinal as it involves data collected over a span of two stages.

In the first phase, our research positionality was inclined toward a positivist worldview. In the second phase of inductive nature we used a social constructivist worldview with a qualitative analysis of 12 interviews from same set of respondents to offer a longitudinal stance of data collection although many other delimitations also favored collection of such information. In the first phase, we used Krejcie and Morgan methods table (Morgan, 1970) to determine adequacy of sample size. In the second phase, we used a purposive sampling procedure for recruitments of participants of study and used data saturation concept when new insights ceases to emerge from further data collection as indication of interview adequacy with 12 in-depth interviews (Creswell and Creswell, 2017). In order to maintain trustworthiness of data collected through interviews, we used member checks, peer debriefing, and follow-up interviews in

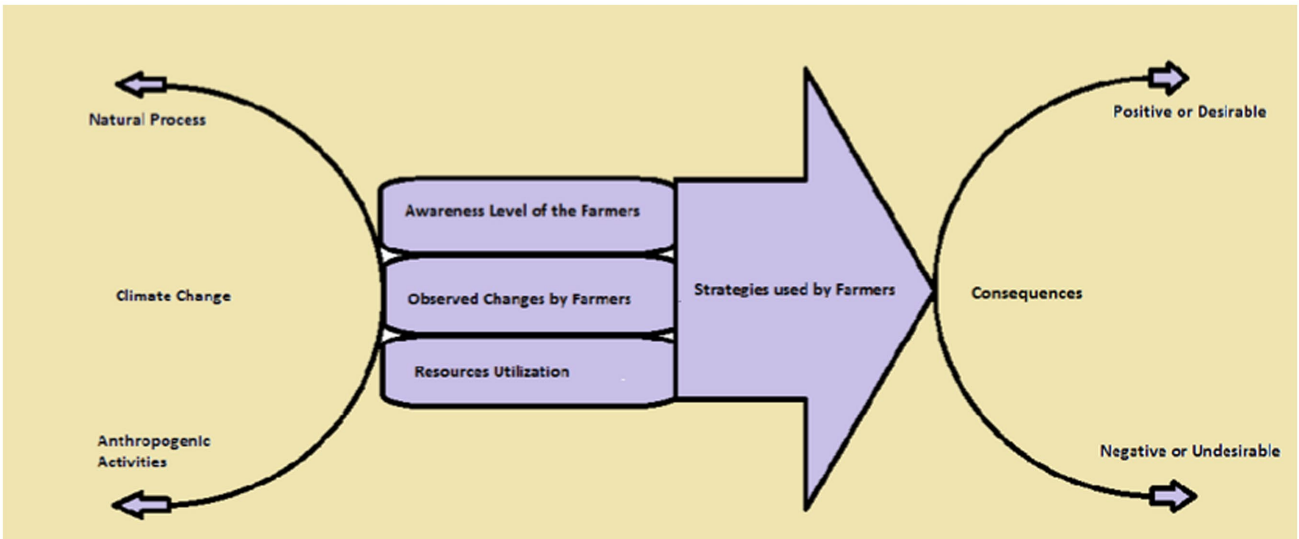



**FIGURE 1** | Conceptual framework of the study.

qualitative part of study. In both phases of data collection, the investigator assured the participants regarding the privacy of their information. In the second phase of qualitative data as per the ideals of ethics, we used aliases to maintain privacy of participants (Iqbal et al., 2018).

Pakistan's province Khyber Pakhtunkhwa (KPK), formerly named North West Frontier Province (NWFP), is the area designated for this study as shown in **Figure 2**. Specifically, the two districts of District Swat and District Malakand as evident from **Figure 2** used for this study. The KPK province has a versatile weather and a unique topography. Its climate varieties from the dry and hot rocky zones in south to the cool and lavish green forests in the north. It has twenty-five (25) districts in total in KPK (Babar et al., 2015). Maximum temperature of the northern region is also showing an increasing trend in case of Kharif as well as rabi seasons. The Kharif cropping season trend line shows a 0.7°C increase, whereas Rabi crop is showing a 2.5°C increase in Rabi season over the past 30 years. The overall increase in maximum temperature can be one of the factor causing increased rains, melting of snows, and glaciers that results in unalarmed floods in the lower part of KPK but the crop productivity trend in both the season is positive and favorable (Babar et al., 2015). Mean temperature trend of the northern region is almost stationary for the Kharif crop, whereas it is showing a sharply increasing trend in case of Rabi cropping season. An increase of 1°C is observed in the Rabi mean temperature. The increase in temperature is having a favorable impact on vegetation growth that has been positively affecting Rabi crops.

## RESULTS AND DISCUSSION

This section will focus to illustrate the views and finding of the respondents in both the phases of mixed methods research study. In the first part, we discuss the results from survey followed by a qualitative analysis of in-depth interviews (IDIs). The context of the study is incorporated with relevant literature, which supports or opposes the finding of this study offering insights into how climate changes impacts socioeconomic conditions of tenant farmers in the study area. Farming is one of the prime occupations, which are generally affected by climate change (Rosenzweig et al., 2014). It is obvious from **Table 1** that majority of the respondents in first phase of data collection were uneducated comprising almost 60% of the participants. Another study was conducted by Ali et al. (2017) which reveals 51% of the respondents as educated, while 49% were uneducated in their study in the northern areas of Malakand division comprising both Swat and Malakand Districts. A recurrent theme, which manifests during the thematic analysis of the data collected from IDIs, reflects that there is higher level of unemployment in Pakistan. Most people associated with farming are tenants who do not have their own land in study area. Hence, these economically marginalized people prefer farming or other informal apprenticeships instead of formal education. Moreover, their women also support farming activities in the confines of their four walls and their education level is even lower due to lack of financial support and access. However, as part of this study no women were interviewed due to cultural barriers of a conservative society.

Most of people think that climate change is involuntary natural process beyond their locus of control. Fatalism and Passive resignation to events are common in farming communities of Muslim faith oriented countries like Pakistan (Mahmood et al., 2020). Some of the respondents also believe that climate change occurs with anthropogenic activities. **Table 1** part 2 indicates information in response to knowledge of climate change, which reveals that majority of the respondents possess knowledge about climate change but this knowledge is not conceptually clear due to weak educational backgrounds.

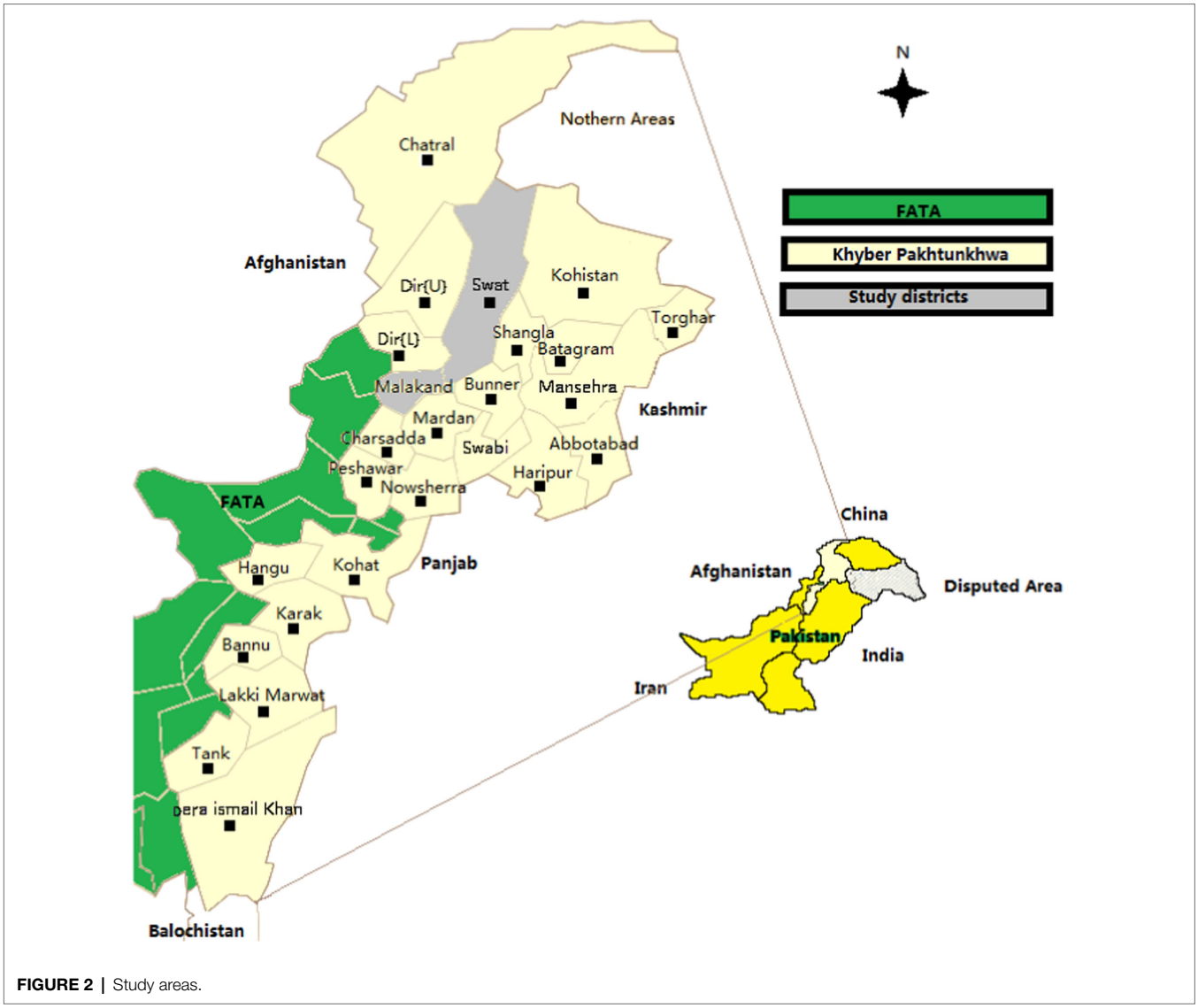



**FIGURE 2** | Study areas.

The finding by Maponya et al. (2013) suggested that about 63.3% people have received information regarding climate in South Africa. While, only 36.7% people did not receive any information in Mpumalanga Province, South Africa. These facts are also supported by the work of Maryam et al. (2014) who proclaim that in upper Swat region of Pakistan, people are well aware of their surroundings and have felt the changes in climate. They further argued that 94.8% of respondents observed changes in the climate and only a dismal 5.3% did not observed such changes. However, a recurrent theme, which manifests itself during qualitative thematic analysis reveals that majority of people are aware of the climate change but hitherto unable to comprehend the impact of such changes in totality. Due to their low-literacy levels, such people are skeptical of the Governmental narrative on climate change. They attribute the changes to a variety of factors beyond their control where human contribution is minimal in disagreement to anthropogenic global warming viewpoint.

The ensuing **Table 1** part 3 express that majority of the respondents 91% observed a long-term shift in rise of the average temperatures in the study areas of District Malakand and Swat spanning more than 100 kilometers. In some regions, rising temperature would improve some crops, such as rice, for example, in Mediterranean areas, where cool weather usually leads low crop production (Nakagawa et al., 2003). But the negative effects associated with temperature increments heavily outweigh the positive ones (Shah et al., 2011). The findings of Moretti et al. (2010) indicate that extreme temperatures will impact fruit quality, such as fruit firmness, sugar, and antioxidant compounds. On similar lines, a recurrent pattern which emerges from qualitative thematic analysis of data collected from IDIs suggest that a rise in temperature-related events has been observed in both district Malakand and Swat which has adversely impacted the productivity of tenant farmers due to weather extremes. The spot rise in temperature is due to fact that combined area of both districts contains both upstream and downstream areas, which are far a

**TABLE 1** | Impact of climate change on socioeconomic conditions of farmers.

| 1. Status | District name | | Total | Percentage |
|---|---|---|---|---|
| | Swat | Malakand | | |
| Educated | 51 | 29 | 80 | 40 |
| Uneducated | 49 | 71 | 120 | 60 |
| Total | 100 | 100 | 200 | 100 |
| **2. Knowledge regarding Change** | **District name** | | **Total** | **Percentage** |
| | **Swat** | **Malakand** | | |
| No | 14 | 42 | 56 | 28 |
| Yes | 84 | 58 | 144 | 72 |
| Total | 100 | 100 | 200 | 100 |
| **3. Long-term shifts in temperature** | **District name** | | **Total** | **Percentage** |
| | **Swat** | **Malakand** | | |
| No | 18 | 0 | 18 | 9 |
| Yes | 182 | 100 | 182 | 91 |
| Total | 100 | 100 | 200 | 100 |
| **4. Cool/warm** | **District name** | | **Total** | **Percentage** |
| | **Swat** | **Malakand** | | |
| Cool | 16 | 1 | 17 | 8.5 |
| Warm | 84 | 99 | 183 | 91.5 |
| Total | 100 | 100 | 200 | 100 |
| **5. Long-term shifts in precipitation** | **District name** | | **Total** | **Percentage** |
| | **Swat** | **Malakand** | | |
| No | 10 | 0 | 10 | 5 |
| Yes | 90 | 100 | 190 | 95 |
| Total | 100 | 100 | 200 | 100 |
| **6. Drier/wetter** | **District name** | | **Total** | **Percentage** |
| | **Swat** | **Malakand** | | |
| Drier | 84 | 99 | 183 | 91.5 |
| Wetter | 16 | 1 | 17 | 8.5 |
| Total | 100 | 100 | 200 | 100 |
| **7. Long-term shifts in drought** | **District name** | | **Total** | **Percentage** |
| | **Swat** | **Malakand** | | |
| No | 10 | 2 | 12 | 6 |
| Yes | 90 | 98 | 188 | 94 |
| Total | 100 | 100 | 200 | 100 |

part in terms of distance. Moreover, based on inputs from qualitative data, it is suggested that temperature rise has caused many people from other parts of country to migrate to upper areas of Swat and Malakand which had further reduced the land availability for farmers, which cascades negative vibes on their livelihoods due to limited land.

Information in **Table 1** part 4 indicates that 91.5% of the respondents perceived warmer weather condition in their localities. Only a dismal 8.5% of the respondents, observed cooler weather condition in their areas mainly due to the vast distances between two districts as well as their upstream and downstream locations. Likewise, analysis of in-depth interviews (IDIs) reveals that the intensity of cold was high in 2020 and 2021 during the Corona pandemic mainly due to restriction in human activities. This is presumably attributed to reduction in emission levels due to lockdowns observed in past 2 years. Moreover, the qualitative interviews suggest that mountains have received greater level of snow in both District Swat and Malakand during the pandemic years (2020–2021). The general observation also supports this fact as the mountains in past 2 years had become greener due to excessive rain spells and snow received in the area. The analysis goes in agreement with notion of anthropogenic global warming, which entails that mainly human activities contribute to global warming and climate change (Fielding and Hornsey, 2016). However, there is a higher level of ambiguity relating to the fact that in the past cyclical rises and downturns were also experienced by the residents of the district Malakand and Swat.

There is a time in-variant relationship between precipitation and crop yield in the context of climate change (Feng et al., 2021). Among certain other consequences of climate change, precipitation pattern is crucial, which increases the probability of impacting farmers' socioeconomic conditions. Erratic changes in precipitation pattern contribute to lower yields with a corresponding rise in temperatures or fall in temperatures (Bloomfield et al., 2006; Lobell and Burke, 2008; Robinson and Katherine, 2010). Information in **Table 1** part 5 indicates that 95% of the respondents observed long-term shift in precipitation pattern in their localities. While, only 5% did not observe any changes in precipitation patterns mainly due to lower recall and recognition of such changes. Due to the shift in precipitation patterns as evident from **Table 1**, 91.5% of the respondents think that on aggregate weather condition is going drier. While, only 5.5% of them consider that weather condition on aggregate is moving toward wetter conditions with the passage of time in the target areas of study. This inwardly, shows that generally there is little water available for irrigation especially in downstream areas. However, a recurrent pattern, which emerges from qualitative analysis of in-depth interviews, entails that in the past three years (2019–2021), recursive rise has been experienced in precipitation amounts in district Malakand and Swat. A recurrent pattern from qualitative thematic analysis of in-depth interviews suggests that higher precipitation helps improve local crops but the accompanying hailstorms and strong winds generally mar farmers' productivity of tomato, peach, and apples in district Swat and Malakand causes huge amount of food losses from orchard farms.

In the same vein, information presented in **Table 2** part 1 shows the results of the measures of farmers for mitigating the impact of climate change. The information received in response to question revealed that 16.5% of respondents used alternate planting dates to reduce climate change impact. These results are in conformity with the findings of Lasco et al. (2014) who reported from a study conducted in Tanzania that farmer used planting date variation practice to adapt to challenges of climate change. Another finding reveals that 60% of the respondents used different crop varieties for adjustment of their fields to climate changes. The switching of crop varieties, that is, sowing one crop variety instead of other is the emerging response to climate change in the study areas. In a study by Komba and Muchapondwa (2012), it was reported that some farmers try to adapt climate change by planting drought-resistant crops in Tanzania. Similarly, using Avena (Indigo) species as a fodder crop which was lately replaced by a dominant stable crop (barley) performed as a means of adaptation to climate change (Menon et al., 2007). It was further reported by 8 and 15.5% farmers, respectively, that techniques, such as additional irrigation and crop rotation, are used as countermeasures for adjusting to climate

change. To assure harvest in the face of climate change, farmers adapt cropping systems and management measures, for instance, by implementing different crop rotations, crop sowing dates, irrigation, and tillage methods (Kaukoranta and Hakala, 2008; Fleming and Vanclay, 2010; Daccache et al., 2012). Farmers are also likely to choose new, climatically suited crops or cultivations that are better adapted to warm and dry conditions, such as low delta crops (Bloomfield et al., 2006; Tokatlidis, 2013). Extreme weather events in the future will probably set yield at higher risks, which may lead to an increase in pesticide usage and fertilizer input (Baessler and Klotz, 2006; Lososová et al., 2006). On the contrary, the empirical evidence generated from in-depth interviews reveals that farmers use indigenous knowledge including the fog formation months, local calendars of farming months as well as the behavior of insects and animals to determine changes in weather triggered by climate change.

Climate change is predicted to result in a higher frequency of extreme weather events, such as heavy storms, summer droughts, and extreme cold spells (Jentsch et al., 2009; Coumou and Rahmstorf, 2012). **Table 2** section 2 indicates various sources that farmer use for predicting the future weather condition. It was found that 48.5% of the respondents relied on weather experts/meteorologists. Similarly, 22% of the farmers reported that they use their past experience. Out of the total sampled farmers, 12% of respondents used television and radio for weather prediction. Among the sampled farmers, only 7% reported the use of Internet for weather prediction. While 11.5% farmers reported that they use other sources for weather prediction in their area. Dessai and Hulme (2004) also reported that the costs of climate changes are differentiated by various types of risk. For instance, some risk is associated to the rate and magnitude of climate change, whereas some is associated to biological response of agricultural products and how the community responds. Climate change also influences weeds indirectly, by enforcing adaptations of farming methods, such as crop choice, sowing time, harvesting date, and other agronomical practices to these alterations (Fleming and Vanclay, 2010). The empirical evidence generated from interviews (IDIs) reveal a recurrent pattern whereof the farmers council (community level) and ongoing observation and discussions were used in coping up the climatic changes triggered by extreme weather events. Besides, use of Internet was more pronounced among young tenant farmers than others, although the overall theme reveals a mixed approach to information used for weather prediction.

Prediction of climate change risks for farmers' livelihoods is crucial because it directly impacts farmers' livelihoods. According to García-Martínez et al. (2016), almost 85% of small-scale farms are subsistence oriented and produces primarily for on-farm consumption, while only 15% farms are market-oriented with commercial objectives. Therefore, tenant farmers mainly seek family welfare (including education) and vulnerability reduction by applying low-cost coping strategies to climate change. It is expected that there will be decline in crop yield up to 30% by the mid of 21st century in certain regions (Rotz et al., 2016). As evident from **Table 2** part 4 majority of (61.5%) respondents' increased their crops yield, while 29.5 respondents witnessed a decline in yield of their crops due to climate change. This result goes in agreement with experienced a decline (White, 2012; Rotz et al., 2016). Our findings also showed that 48% of the farmers reported that there is an improvement in the crop quality due to climate change as the used of imported seeds has been in vogue recently. On the contrary, 34% of the farmers reported that crop quality has deteriorated due to changes in the climate. These results support the findings of Moretti et al. (2010) who reported that extreme temperatures will impact fruit quality, such as fruit firmness and sugar as well as antioxidant compounds. As evident from **Table 2** part 4, 18% of the respondents did not observe any change on their crops quality. It was further observed that 36.5% of the tenant farmers disclosed that crop growth has been enhanced due to climate changes, especially due to the rise in rain spells. While, 51.5% of the farmers reported a decrease in the crop growths due to climate changes. In the same way, majority of respondents, that is, 87.5 and 89% reported increase in the crop disease and crop water requirement respectively, due to climate change while 8.5 and 9% of the respondents account decrease in the

**TABLE 2** | Countermeasures to climate changes adopted by farmers.

| **1. Adjustment of farmers to climate change** | **District name** | | **Total** | **Percentage** |
|---|---|---|---|---|
| | **Swat** | **Malakand** | | |
| Changing planting dates | 10 | 23 | 33 | 16.5 |
| Using different crop varieties | 55 | 65 | 120 | 60 |
| Adding irrigation | 11 | 5 | 16 | 8 |
| Crop rotation | 24 | 7 | 31 | 15.5 |
| Total | 100 | 100 | 200 | 100 |
| **2. Source of weather predict for next season** | **District name** | | **Total** | **Percentage** |
| | **Swat** | **Malakand** | | |
| Use past season weather | 34 | 10 | 44 | 22 |
| Expert opinion | 36 | 61 | 97 | 48.5 |
| TV/ radio | 19 | 5 | 24 | 12 |
| Internet | 10 | 4 | 14 | 7 |
| Others | 1 | 20 | 21 | 11.5 |
| Total | 100 | 100 | 200 | 100 |
| **3. Predict risk due to climate change** | **District name** | | **Total** | **Percentage** |
| | **Swat** | **Malakand** | | |
| Drought | 62 | 61 | 123 | 61.5 |
| Cyclone | 2 | 3 | 5 | 2.5 |
| Floods | 12 | 24 | 36 | 18 |
| Storms | 9 | 2 | 10 | 5 |
| Heavy rain | 15 | 8 | 23 | 11.5 |
| Others | 0 | 2 | 2 | 1 |
| Total | 100 | 100 | 200 | 100 |
| **4. Impact of climate change on** | **Increases (%)** | **Decreased (%)** | **No change (%)** | **Do not know (%)** |
| Crop Yield | 61.5 | 29.5 | 8.5 | 0.5 |
| crop quality | 48 | 34 | 18 | - |
| crop growth | 36.5 | 51.5 | 11.5 | 0.5 |
| crop disease | 87.5 | 8.5 | 4 | - |
| crop water requirement | 89 | 9 | 2 | - |

crop disease and crop water requirements, respectively, due to climate change. The empirical evidence generated from IDIs in qualitative data analysis complements the findings of preceding survey although the crop yield has been improved but not quality. The introduction of hybrid seeds has practically eradicated the natural taste crops and fruits as well reports of lower nutritional value have been observed in District Swat and Malakand.

Agricultural risks have been part of life since the beginning of the evolution of the human race. Valdés et al. (1986) indicated that risk and uncertainty pose a serious impediment to agriculture development. Such risks inwardly translate into socioeconomic risks as income of tenant farmers is disturbed due to them. Crop diversification, share cropping, and sharing food during times of scarcity are all part of risk management strategies. Information in **Table 3** part 1 shows some of the risk related to farming in the study areas. A reasonable portion 42.5% of the farmers indicates that production risk is one of the leading risk in their regular farming which affects their income and hence their socioeconomic conditions. Similarly, a majority of 44.5% of the respondents depict price of their agricultural product is the prime risk in their areas as sudden fall and rise in market prices cascades economic losses and gains beyond their control. The prices of agricultural commodities are instable and subsequently changes from very low to very high in the study areas due to poor enforcement of laws and informal nature of market dynamics. Agricultural producers including tenant farmers have little or no control over the market forces that drive commodity prices. Information in the same table part 2 illustrates information of the respondents regarding the consequences or major losses due to climate changes. It is evident from the table data that majority of the respondents 45% express that drought or extended dry spells is one of the foremost losses to climate change in the areas especially for rainfed farms. On a global scale, this risk is much greater than that of cyclones, floods and storms experience in target areas of study. However, on a regional rather than global scale, there are areas where the risk of flooding exceeds that of drought. Similarly, losses of agricultural production reported by 34% of the respondents in the study areas. The theme which emerged from the qualitative analysis of in-depth interviews, confirms the preceding findings as tenant farmers experience adverse risks due to unfriendly weather changes due to which many of the orchard farmers experience bankruptcy. In socioeconomic terms unfortunately for tenant farmers, failing to fulfill obligations to land owners also results in social stigma. According to Lead Pakistan Under Play (2019) article the almost 25–30 percent of people in Malakand and Swat districts are by the use of Under Play to meet the demands of debtors. Under this scheme, the lender give items to borrowers at a higher cruel price while the borrower sells it on market price to extend financial life line up till next harvest season. The emergent themes from qualitative analysis confirm that majority of tenant farmers also delve in "underplay or Neta Watta" which refers to gamblers like risk taking in order to fulfill their unmet financial obligations to land lords and family needs.

**TABLE 3 |** Information of the farmers regarding Agricultural risk and major losses due to climate change.

| Agricultural risk in study area | District name | | Total | Percentage |
|---|---|---|---|---|
| | Swat | Malakand | | |
| Production risk | 69 | 16 | 85 | 42.5 |
| Price/market risk | 29 | 60 | 89 | 44.5 |
| Financial risk | 2 | 23 | 25 | 12.5 |
| Others | 0 | 1 | 1 | 0.5 |
| Total | 100 | 100 | 200 | 100 |
| **Major losses due to climate change in study area** | **District name** | | **Total** | **Percentage** |
| | **Swat** | **Malakand** | | |
| Heavy rainfall (floods) | 15 | 11 | 26 | 13 |
| Drought | 51 | 39 | 90 | 45 |
| Rising temperature | 3 | 1 | 4 | 2 |
| Loss of Agric. production | 26 | 42 | 68 | 34 |
| Others | 5 | 7 | 12 | 6 |
| Total | 100 | 100 | 200 | 100 |

Information in **Table 4** indicated the overall impact of climate change on some of the growing crops and orchards. It is evidence from the table that majority of the growing plants, crops, medicinal plant, and wild life including birds are adversely affected from climatic changes. Majority of the respondents confirm that the quantity of such plants, crops and wild life had decreased with the increase in climatic changes. Information in the given data further demonstrates strategies to mitigate the effect of climate change in their areas. Similarly majority of the respondents 72% and 75.5 highly desired that increase in the farmers knowledge and the provision of proper training for adoptive capacity, respectively, mitigate the effect of climate change in the study area. In the same vein, 66% of the farmers reveal that Advancement weather forecasting system will help to mitigate the effect of climate change. Moreover, 64% of the respondents highly desired that the provision agricultural finance would obviously mitigate the effect of climate change in the study area. Some of the respondents 29.5% desired that reduces the use of fertilizer will mitigate the impact of climate change.

Common views regarding climate change have their socioeconomic roots, which are specific to geographical locations, such as urban and rural localities (Weckroth and Ala-Mantila, 2022). The study has unveiled a variety of findings in rural areas of district Swat and Malakand. The study unveils that tenant farmers are affected in socioeconomic terms by the changes triggered due to climate change. In particular the under play mechanism used as a short-term fix causes severe issue for tenant farmers, especially in instances wherein they are unable to meet their agreed upon financial obligations to farmers. This has wide range of socioeconomic impact on farmers and their families. The study proposes better tenant farm owner contracts to safeguard the interests of economically marginalized tenant farmers in district Swat and Malakand. The farmers in target area although are disadvantaged due to lack of land provision but at the same time had witnessed a rise in production of yield although such rise in not proportionate to fulfill

**TABLE 4** | Impact of climate change on indigenous yield and mitigating strategies by the farmers.

| Impact of climate change on: | Increases (%) | Decreased (%) | No change (%) | Do not know (%) |
|---|---|---|---|---|
| Medicinal Plants | 5.5 | 88 | 5 | 1.5 |
| Birds and wildlife | 5 | 83 | 10.5 | 1.5 |
| Pears trees | 3.5 | 83 | 12.5 | 1 |
| Apple trees | 29 | 61 | 9 | 1 |
| Wheat | 38 | 53 | 9 | 0 |
| Maize | 15.5 | 75 | 9.5 | 0 |
| Walnut trees | 3 | 51 | 21 | 25 |
| Honeybee colony | 22.5 | 74 | 3.5 | 22.5 |
| **Strategies to mitigate the effect of climate change** | **Not desired (%)** | **Less desired (%)** | **Somewhat desired (%)** | **Highly desired (%)** |
| Reduce the use of artificial fertilizer | 27 | 11.5 | 32 | 29.5 |
| Enhance the knowledge of farmers | 1.5 | 2.5 | 24 | 72 |
| Create fund research activity | 2.5 | 9 | 31 | 56.5 |
| Introduce crop insurance policy | 15.5 | 6 | 19.5 | 59 |
| Strengthen through agricultural finance | 3 | 6 | 27 | 64 |
| Advancement weather forecasting system | 4.5 | 10.5 | 24 | 66 |
| Provision of Training for adoptive capacity | 4 | 4 | 16.5 | 75.5 |

their socioeconomic needs. The farmers use a variety of indigenous countermeasures, such as crop managing by crop sowing dates, use of hybrid seeds but not without associated tradeoffs. It has been reported that hybrid seeds had altered the original taste of fruits and crops. A similar study was conducted by Maryam et al. (2014) in Swat District only by using a positivist's world view to report that a whopping majority of people were aware of the perils of climate change on their livelihoods. Likewise, a study conducted by Maponya et al. (2013) in South Africa goes in agreement with our findings wherein 65% of people were aware of the dangers of climate change. Another study was conducted by Lasco et al. (2014) in Tanzania whose result goes in agreement with findings of this study in regard to socioeconomic impact of climate change of livelihoods. Likewise, Komba and Muchapondwa (2012) conducted a study to assess the climate adaptation of small farmers in Tanzania wherein farmers utilize drought-resistant crops to cope up with threats of climate changes on livelihoods. Against general perception, the current study reported that due to climate change actually the yield of crops had improved. A similar study was conducted by Moretti et al. (2010) using a positivist ontology to report that farmers experienced a rise in productivity due to climate-related associated awareness which goes in agreement with findings of this study in district Swat and Malakand of Khyber Pakhtunkhwa province in Pakistan. In addition to these, it has been learnt that farmers in this part of the world use indigenous farming knowledge (spoken) which is unwritten to cope up with climate changes in order to adjust their farming practices to sustain their livelihoods. No study is complete in all aspects and that is why we would like to mention the limitations of the study. The biggest limitation pertains to the inclusion of female participants across both phases of data collection which was not possible due to a variety of reasons including cultural barriers of honor and purdah. Future studies can use the findings of the study with a larger sample to further validate the findings of the study in order to mitigate the socioeconomic impact of climate changes tenant farmers in district Swat and Malakand.

## CONCLUSION

Assessing the socioeconomic risks of climate change on tenant farmers in Pakistan with a longitudinal research design offers important insights regarding coping mechanism of tenant farmers in a flood calamity prone study areas. Detailed information from this research indicates that a tenant farmer was collected to implement adaptive techniques in order to cope with the impact of climate change at farm levels. Findings of the current research study have yielded valuable insights on the level of awareness and strategies used by the farmers for mitigating the impact of the climate change. A key finding pertains to the fact that actually farmers yield had progressively gone up amidst the grand climate risks as indigenous farmers had become more alert to new changes than ever. However, the overall average growth is much less than when compared to global standards. The study highlights that farmers in both districts are affected by climate change due to sudden onset of recurrent natural calamities in the form of cyclones, floods, droughts, hailstorms, and pesticide resistance but overall survival skills and coping strategies had been improved with passage of time. The overall economic losses in study areas are mostly attributed to use of outdated farming practices and lack of awareness regarding climate change due to belief that anthropogenic activities contribute little to climate changes. The study concludes that climate change triggers multiple threats to vulnerable farmers to climate change in socioeconomic terms as they struggle to cope with climate changes, yet they also utilize countermeasures, such as crop rotation, fertilizer change, and sowing date changes to offset the climatic changes. Finally, the study contributes to raise voice for land strapped tenant farmers using a transformative worldview, as these people had been involved in tenant farming for generations despite no or little support from the government. The study recommends introduction of better land distribution legislation and schemes, such as crop sharing and crop insurance to mitigate

the effects of climate changes on economically marginalized farmers in district Swat and Malakand.

The study recommends provision of climate resilience training for tenant farmers who had time and again experienced climate volatilities be it nature or otherwise. Then there is also a need for stable agricultural commodity prices monitoring in the market. Other than this, farmers needs to be incentivized and encouraged to improve their knowledge of climate changes by way of training sessions for farmers. Finally, better land distribution legislation and safety schemes, such as crop loan insurance (takaful) in Khyber Pakhtunkhwa, Pakistan.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Higher Education Commission, Islamabad, Pakistan (No:21–1,509/SRGP/R&D/HEC/2017). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

## AUTHOR CONTRIBUTIONS

MY, TS, SK, SU, MN, HH, AZ-M, HM-S, and AV-M contributed to conceptualization, formal analysis, investigation, methodology, and writing and editing of the original draft. All authors contributed to the article and approved the submitted version.

## REFERENCES


Ahmed, W., Tan, Q., Ghulam, M. S., Hamid, W., Nadeem, A. K., Sharafat, A., et al. (2020). Assessing and prioritizing the climate change policy objectives for sustainable development in Pakistan. *Symmetry* 12:1203. doi: 10.3390/sym12081203

Ali, S., Liu, Y., Ishaq, M., and Shah, T. (2017). Aasir Ilyas, and Izhar Ud din. "climate change and its impact on the yield of major food crops: evidence from Pakistan" *Foods* 6:39. doi: 10.3390/foods6060039

Babar, S., Gul, S., Amin, A., and Mohammad, I. (2015). Climate change: region and season specific agriculture impact assessment (thirty year analysis of Khyber Pakhtunkhwa ie 1980–2010). *FWU J. Soc. Sci.* 9:88.

Baessler, C., and Klotz, S. (2006). Effects of changes in agricultural land-use on landscape structure and arable weed vegetation over the last 50 years. *Agric. Ecosyst. Environ.* 115, 43–50. doi: 10.1016/j.agee.2005.12.007

Bloomfield, J. P., Williams, R. J., Gooddy, D. C., Cape, J. N., and Guha, P. M. (2006). Impacts of climate change on the fate and behaviour of pesticides in surface and groundwater—a UK perspective. *Sci. Total Environ.* 369, 163–177. doi: 10.1016/j.scitotenv.2006.05.019

Blunden, J., and Arndt, D. S. (2012). State of the climate in 2011. *Bull. Am. Meteorol. Soc.* 93, S1–S282. doi: 10.1175/2012BAMSStateoftheClimate.1

Clapp, J. (2017). Food self-sufficiency: making sense of it, and when it makes sense. *Food Policy* 66, 88–96. doi: 10.1016/j.foodpol.2016.12.001

Correspondent (2021). Poor Air Quality Index: LHC Hints at lockdown in Lahore. The News International. Available at: https://www.thenews.com.pk/print/913431-poor-air-quality-index-lhc-hints-at-lockdown-in-city (Accessed May 13, 2022).

Coumou, D., and Rahmstorf, S. (2012). A decade of weather extremes. *Nat. Clim. Chang.* 2, 491–496. doi: 10.1038/nclimate1452

Creswell, J. W., and Creswell, J. D. (2017). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. United States: Sage Publications.

Daccache, A. C., Keay, R. J., Weatherhead, E. K., Stalham, M. A., and Knox, J. W. (2012). Climate change and land suitability for potato production in England and Wales: impacts and adaptation. *J. Agri. Sci.* 150, 161–177. doi: 10.1017/S0021859611000839

Dessai, S., and Hulme, M. (2004). Does climate adaptation policy need probabilities? *Clim. Pol.* 4, 107–128. doi: 10.1080/14693062.2004.9685515

Dhimal, M., Bhandari, D., Mandira, L. D., Naviya, K., Prajwal, P., Narayan, M., et al. (2021). Impact of climate change on health and well-being of people in hindu-kush-himalayan (HKH) region-a review. *Front. Physiol.* 12:1139. doi: 10.3389/fphys.2021.651189

Eckstein, D., Künzel, V., Schäfer, L., and Winges, M. (2019). *Global Climate Risk Index 2020*. Bonn: Germanwatch.

Fahad, S., Inayat, T., Wang, J., Dong, L., Guangyin, H., Khan, S., et al. (2020). Farmers' awareness level and their perceptions of climate change: A case of Khyber Pakhtunkhwa province, Pakistan. *Land Use Policy* 96:104669. doi: 10.1016/j.landusepol.2020.104669

Feng, S., Hao, Z., Zhang, X., and Hao, F. (2021). Changes in climate-crop yield relationships affect risks of crop yield reduction. *Agric. For. Meteorol.* 304-305:108401. doi: 10.1016/j.agrformet.2021.108401

Fielding, K. S., and Hornsey, M. J. (2016). A social identity analysis of climate change and environmental attitudes and behaviors: insights and opportunities. *Front. Psychol.* 7:121. doi: 10.3389/fpsyg.2016.00121

Fleming, A., and Vanclay, F. (2010). Farmer responses to climate change and sustainable agriculture: a review. *Agron. Sustain. Dev.* 30, 11–19. doi: 10.1051/agro/2009028

García-Martínez, A., Rivas-Rangel, J., Rangel-Quintos, J., José, A. E., Cecilio, B., and Pablos-Heredero, C. (2016). A methodological approach to evaluate livestock innovations on small-scale farms in developing countries. *Future Internet* 8:25. doi: 10.3390/fi8020025

Gitay, H., Suárez, A., Watson, R. T., and Dokken, D. J. (2002). Climate Change and Biodiversity. Available at: https://www.tnrf.org/files/E-INFO_IPCC_2002_Climate_Change_and_Biodiversity_0.pdf (Accessed January 11, 2022).

Huang, J., Ji, M., Xie, Y., Wang, S., He, Y., and Ran, J. (2016). Global semi-arid climate change over last 60 years. *Clim. Dyn.* 46, 1131–1150. doi: 10.1007/s00382-015-2636-8

Iqbal, T., Muhammad, T. Y., Sabeen, A., Kinza, S., Muhammad, Q. S., and Usman, H. (2018). There's no such thing as free lunch but envy among young facebookers. *KSII Trans. Internet. Info. Sys.* 12, 4724–4737. doi: 10.3837/tiis.2018.10.006

Jentsch, A., Kreyling, J., Boettcher-Treschkow, J. E. G. O. R., and Beierkuhnlein, C. (2009). Beyond gradual warming: extreme weather events alter flower phenology of European grassland and heath species. *Global Change Biol.* 15, 837–849. doi: 10.1111/j.1365-2486.2008.01690.x

Kabeer, N., Mumtaz, K., and Sayeed, A. (2010). Beyond risk management: vulnerability, social protection and citizenship in Pakistan. *J. Int. Dev. Assoc.* 22, 1–19. doi: 10.1002/jid.1538

Kamal, A., Yingjie, M., and Ali, A. (2019). Significance of billion tree tsunami afforestation project and legal developments in forest sector of Pakistan. *Int. J. Law Soc* 1:157. doi: 10.11648/j.ijls.20180104.13

Kaukoranta, T., and Hakala, K. (2008). Impact of spring warming on sowing times of cereal, potato and sugar beet in Finland. *Agri. Food Sci.* 17:165. doi: 10.2137/145960608785328198

Komba, C., and Muchapondwa, E. (2012). Adaptation to climate change by smallholder farmers in Tanzania. *ERSA* 299, 67–91.

Kreft, S., Eckstein, D., and Melchior, I. (2013). Global Climate Risk Index 2014. Who Suffers Most From Extreme Weather Events. Available at: www.germanwatch.org/en/cri (Accessed February 22, 2022).

Lasco, R. D., Rafaela, J. P., Delfino, D. C., Catacutan, E. S., and Wilson, D. M. (2014). Climate risk adaptation by smallholder farmers: the roles of trees and agroforestry. *Curr. Opinion Environ. Sustainability* 6, 83–88. doi: 10.1016/j.cosust.2013.11.013

Lobell, D. B., and Burke, M. B. (2008). Why are agricultural impacts of climate change so uncertain? The importance of temperature relative to precipitation. *Environ. Res. Lett.* 3:034007. doi: 10.1088/1748-9326/3/3/034007

Lososová, Z., Chytrý, M., Kühn, I., Hájek, O., Horáková, V., Pyšek, P., et al. (2006). Patterns of plant traits in annual vegetation of man-made habitats in Central Europe. *Persp. Plant Ecol. Evol. Sys.* 8, 69–81. doi: 10.1016/j.ppees.2006.07.001

Mahmood, N., Arshad, M., Kaechele, H., Muhammad, F. S., Ayat, U., and Klaus, M. (2020). Fatalism, climate resiliency training and farmers' adaptation responses: implications for sustainable rainfed-wheat production in Pakistan. *Sustainability* 12:1650. doi: 10.3390/su12041650

Maponya, P., Mpandeli, S., and Oduniyi, S. (2013). Climate change awareness in Mpumalanga province, South Africa. *J. Agric. Sci.* 5:273. doi: 10.5539/jas.v5n10p273

Maryam, A., Khan, S., Khan, K., Khan, M. A., Rabbi, F., and Ali, S. (2014). The perception of local community about the effects of climate change in upper swat, Khyber Pakhtunkhwa, Pakistan. *J. Earth Sci. Clim. Change* 5:2. doi: 10.4172/2157-7617.1000183

Menon, S., Denman, K. L., Brasseur, G., Chidthaisong, A., Ciais, P., Cox, P. M., et al. (2007). *Couplings Between Changes in the Climate System and Biogeochemistry*. Berkeley, CA, United States: Lawrence Berkeley National Lab.

Moretti, C. L., Mattos, L. M., Calbo, A. G., and Sargent, S. A. (2010). Climate changes and potential impacts on postharvest quality of fruit and vegetable crops: A review. *Food Res. Int.* 43, 1824–1832. doi: 10.1016/j.foodres.2009.10.013

Morgan, K. (1970). *Sample Size Determination Using Krejcie and Morgan Table*. Kenya: Kenya Projects Organization (KENPRO).

Nakagawa, H., Horie, T., and Matsui, T. (2003). "Effects of climate change on rice production and adaptive technologies." in *Rice Science: Innovations and Impact for Livelihood. Proceedings of the International Rice Research Conference, Beijing, China*; September 16–19, 2002.

Ofoegbu, C., Chirwa, P., Francis, J., and Babalola, F. (2017). Assessing vulnerability of rural communities to climate change: A review of implications for forest-based livelihoods in South Africa. *Int. J. Climate Change Strategies Manage.* 9, 374–386. doi: 10.1108/IJCCSM-04-2016-0044

Parncutt, R. (2019). The human cost of anthropogenic global warming: semi-quantitative prediction and the 1,000-Tonne rule. *Front. Psychol.* 10:2323. doi: 10.3389/fpsyg.2019.02323

Rauf, A., Zhang, J., Li, J., and Amin, W. (2018). Structural changes, energy consumption and carbon emissions in China: empirical evidence from ARDL bound testing model. *Struct. Chang. Econ. Dyn.* 47, 194–206. doi: 10.1016/j.strueco.2018.08.010

Robinson, T. M. P., and Katherine, L. G. (2010). The impact of altered precipitation variability on annual weed species. *Am. J. Bot.* 97, 1625–1629. doi: 10.3732/ajb.1000125

Rosenzweig, C., Elliott, J., Deryng, D., Ruane, A. C., Müller, C., Arneth, A., et al. (2014). Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison. *Proce. Nat. Acad. Sci.* 111, 3268–3273. doi: 10.1073/pnas.1222463110

Rotz, C., Alan, R. H., Skinner, A. M. K., and Hayhoe, K. (2016). Evaluating greenhouse gas mitigation and climate change adaptation in dairy production using farm simulation. *Trans. ASABE* 59, 1771–1781. doi: 10.13031/trans.59.11594

Saqib, S. E., Kuwornu, J. K. M., Panezia, S., and Ubaid, A. (2018). Factors determining subsistence farmers' access to agricultural credit in flood-prone areas of Pakistan. *J. Soc. Sci.* 39, 262–268. doi: 10.1016/j.kjss.2017.06.001

Saunders, M. N. (2011). *Research Methods for Business Students. 5th Edn*. India: Pearson Education India.

Shabbir, M., Junaid, A., and Zahid, J. (2019). Smog: A Transboundary Issue and its Implications in India and Pakistan. Available at: http://hdl.handle.net/11540/9584 (Accessed February 22, 2022).

Shah, T., Hayat, U., Tariq, M., Khan, S. B., and Wang, L. (2021). An economic assessment of model FARM services CENTER in terms on FARMERS'PERFORMANCE. *JAPS* 31:269. doi: 10.36899/JAPS.2021.3.0269

Shah, F., Huang, J., Cui, K., Liming Nie, T., Shah, C. C., and Wang, K. (2011). Impact of high-temperature stress on rice plant and its traits related to tolerance. *J. Agri. Sci.* 149, 545–556. doi: 10.1017/S0021859611000360

Sörqvist, P. (2016). Grand challenges in environmental psychology. *Front. Psychol.* 7:583. doi: 10.3389/fpsyg.2016.00583

Sun, S., and Ertz, M. (2021). Theory-based roadmap for assessing sustainability in the collaborative economy. *Front. Psychol.* 12:4574. doi: 10.3389/fpsyg.2021.752867

Tokatlidis, I. S. (2013). Adapting maize crop to climate change. *Agron. Sustain. Dev.* 33, 63–79. doi: 10.1007/s13593-012-0108-7

Ullah, W., Nafees, M., Khurshid, M., and Nihei, T. (2019). Assessing farmers' perspectives on climate change for effective farm-level adaptation measures in Khyber Pakhtunkhwa, Pakistan. *Environ. Monitor. Assess.* 191, 547–518. doi: 10.1007/s10661-019-7651-5

Ullah, A., Zeb, A., Saqib, S. E., and Kächele, H. (2022). Landscape co-management and livelihood sustainability: lessons learned from the billion trees afforestation project in Pakistan. *Land Use Policy* 115:106034. doi: 10.1016/j.landusepol.2022.106034

Under Play (2019). Under the KP Prohibition of interest Act accessed from lead Pakistan. Available at: https://leadpakistan.com.pk/news/under-play-under-the-kp-prohibition-of-interestct/#:~:text=Under%20this%20exercise%20the%20lender(Bargain)%20to%20get%20cas (April 10, 2022).

Valdés, A., Hazell, P. B. R., and Pomareda, C. (1986). *Crop Insurance for Agricultural Development: Issues and Experience*. Costa Rica: IICA.

Weckroth, M., and Ala-Mantila, S. (2022). Socioeconomic geography of climate change views in Europe. *Glob. Environ. Chang.* 72:102453. doi: 10.1016/j.gloenvcha.2021.102453

White, B. (2012). Agriculture and the generation problem: rural youth, employment and the future of farming. *IDS Bull.* 43, 9–19. doi: 10.1111/j.1759-5436.2012.00375.x

Wisdom, J., and Creswell, J. W. (2013). *Mixed Methods: Integrating Quantitative and Qualitative Data Collection and Analysis while Studying Patient-Centered Medical Home Models*. Rockville: Agency for Healthcare Research and Quality.

Yousafzai, M. T., Nawaz, M., Xin, C., Tsai, S.-B., and Lee, C.-H. (2020). Sustainability of waste picker sustainopreneurs in Pakistan's informal solid waste management system for cleaner production. *J. Cleaner Prod.* 267:121913. doi: 10.1016/j.jclepro.2020.121913

Zhao, C., Liu, B., Piao, S., Wang, X., Lobell, D. B., and Huang, Y. et al. (Eds.) (2017). Temperature increase reduces global yields of major crops in four independent estimates. *Proc. Nat. Acad. Sci.* 114, 9326–9331. doi: 10.1073/pnas.1701762114

**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers | Frontiers in Psychology

BRIEF RESEARCH REPORT
published: 06 June 2022
doi: 10.3389/fpsyg.2022.913162

# Simulating Extreme Environmental Conditions *via* Mental Imagery: The Case of Microgravity and Weight Estimation

*Matteo Gatti, Rocco Palumbo, Alberto Di Domenico and Nicola Mammarella**

*Department of Psychological Sciences, Health and Territory, University of Chieti, Chieti, Italy*

Mental imagery can be used for recreating an extreme environment experience. Here we assessed whether microgravity effects over cognition, that typically occur during a space mission, may be reproduced *via* mental imagery. Participants were randomly assigned to one of two conditions in which they were guided to imagine to be (1) in outer space or (2) in a nature scenario and subsequently estimate the weight of common objects. We found that only for those who engaged in a space scenario imagery, there was a decrease in object weight estimation compared with a prior rating. This finding is the first to indicate that the effects of weightlessness on cognition can be simulated *via* an imagery-based technique and add to the ongoing debate about the importance of trying to disentangle the effect of microgravity alone on human performance. Moreover, our findings ultimately suggest that imagery can be used as a less expensive simulated scenario for studying the impact of extreme environmental conditions over astronauts' cognition and behavior.

**Keywords: mental imagery, microgravity, extreme environments, weight estimation, space environment adaptation**

OPEN ACCESS

***Edited by:***
*Massimiliano Palmiero, University of L'Aquila, Italy*

***Reviewed by:***
*Elena Cavallini, University of Pavia, Italy*
*Otmar Bock, German Sport University Cologne, Germany*

***Correspondence:**
*Nicola Mammarella*
*n.mammarella@unich.it*

***Specialty section:***
*This article was submitted to Environmental Psychology, a section of the journal Frontiers in Psychology*

***Received:*** *05 April 2022*
***Accepted:*** *17 May 2022*
***Published:*** *06 June 2022*

***Citation:***
*Gatti M, Palumbo R, Di Domenico A and Mammarella N (2022) Simulating Extreme Environmental Conditions via Mental Imagery: The Case of Microgravity and Weight Estimation. Front. Psychol. 13:913162. doi: 10.3389/fpsyg.2022.913162*

## INTRODUCTION

Space can be considered par excellence an extreme environment and microgravity is one of its most relevant physical stressors in space, along with cosmic radiation and altered light/dark cycles (see Kanas and Manzey (2008) for a review; Mammarella (2020a)). One of the main features of being in space is the experience of weightlessness due to the absence of gravity (although there is always some degree of gravity around us). Weightless conditions have been shown to affect human spatially oriented behaviors due the fact that gravity no longer acts as an essential vertical reference, creating a discrepancy between vestibular, visual, and sensorimotor signals (see Kanas and Manzey (2008)). Much of what we know about the impact of microgravity on astronauts' body and mind stems from research in real microgravity conditions such as the International Space Station (ISS) or parabolic flights. In addition, simulations such as short- and long-term head-down tilt bed rest helped to unravel microgravity effects better (Mammarella, 2020b).

Although some authors wrote about the benefits of mental and motor imagery in the context of spaceflights and space missions (Bock et al., 2015; Guillot and Debarnot, 2019; Gravano et al., 2021), few, if any, considered imagination for reproducing microgravity-like effects on Earth. However, the definition of mental imagery *per sé* indicates that this can be the case. Imagery, in fact, is the ability to generate quasi-perceptual experiences in the absence of perceptual input (Kosslyn et al., 2001); the experience of sensory information without a direct external stimulus

(Pearson et al., 2015). Imagery, then, allows the simulation or the re-creation of perceptual experiences across different sensory modalities (Fisher, 2006; Kosslyn et al., 2006; Pearson et al., 2008) or the ability to generate vivid images and maintaining them for goal-directed behaviors (Morris et al., 2005). As highlighted by Grabherr and Mast (2010), mental imagery is closely connected to perception and motor behavior. It aids important processes such as perceptual anticipation, problem solving and motor simulation, all of which are critical for space travel. In addition, a series of studies (e.g., Besnard et al., 2015; Bigelow and Agrawal, 2015) have also recently shown that vestibular information may play a crucial role in mental imagery, bodily self-consciousness and self-motion perception or, vice versa, that imagery can play a crucial role in vestibular cognition (e.g., Mast and Ellis, 2015). Altogether, these data support the assumption that mental imagery should be incorporated before (or during) space missions as a ground-based simulation method for studying microgravity-like effects on human performance. In fact, due to the inherent characteristics of weightlessness conditions and the intimacy between mental imagery and vestibular cognition, it can specifically simulate the activation of vestibular, visual, and sensorimotor information as in a real weightless condition. If so, the first step would be the development of a guided-imagery session of a space environment and subsequently testing whether it might affect 'vestibular cognition' in the "as if" manner. This may happen because when we engage in imagination, for instance, *via* guided imagery, subjective aspects (e.g., perceptual, motor, physiological and introspective) of an event and the knowledge about it, partially reactivate (Barsalou, 2008; Palmiero et al., 2019).

In order to investigate whether the perception of weightless or, to say it better, the typical effects of weightless, can be reproduced *via* mental imagery, a group of volunteers performed a weight estimation task before and after a guided-imagery session of a space scenario. If mental imagery is effective in reproducing weightlessness-like conditions, we should expect an impact on weight estimation (as one would typically expect in space, that is, objects should be perceived as less heavy) after the guided-imagery session of a space scenario. Moreover, we expected that participants of the space condition with a higher self-reported vividness (based on median values) would have provided significantly lower estimates than low-vividness subjects. The main experimental condition (space condition) was also compared with a control condition in which another group of volunteers (n = 32) performed the same task before and after a guided-imagery session of a nature scenario.

# METHOD

The present study was reviewed and approved by the Ethics Committee of the Department of Psychological Sciences, Health, and Territory at the University of Chieti.

## Participants and Procedure

The sample consisted of 64 participants (65.6% females; mean age 22,8 ± 3.86 SD) recruited voluntarily among undergraduates (age > 18 years) of the "D'Annunzio" University of Chieti-Pescara. Each person provided written informed consent before participating, as indicated by the ethical standards of the Declaration of Helsinki and by the IRB approval obtained from the Departmental Ethics Committee. Experimental methods were performed following approved guidelines. The experiment was administered remotely through the E-prime Go software (pstnet.com), due to the limitations imposed by the Italian government to contain the COVID-19 infection. Participants were required to sit in a quiet room, at a distance of 60cm from the PC screen. After entering their personal information, the experimental procedure began and participants were randomized equally ($n = 32$ in each condition) into one of the two conditions: space scenario or nature scenario. Students received extra credits for their participation.

A power analysis and sample size from power calculations using the program G*Power 3.1 with $\alpha = 0.05$, power = 95%, indicated that we require a total of $N = 6$ (large sized effect; $f = 0.4$), $N = 10$ (medium sized effect; $f = 0.25$), or $N = 50$ (small sized effect; $f = 0.1$), participants in total to achieve 95% power when employing the traditional 0.05 criterion of statistical significance.

## Stimulus Selection and Imagery Session

In line with the guidelines for developing an effective imagery session (e.g., Lang, 1979; Holmes and Mathews, 2010; Ji et al., 2016), our mental imagery phase included a video and a guided-imagery session. In particular, before presenting the auditory imaginative script, participants were shown a video. In fact, in line with the literature on sport performance and imagery (Smith and Holmes, 2004; Wright and Smith, 2009), combining video and imagery sessions improves performance to a greater extent than imagery alone. The rationale being that providing visual stimuli allows participants to focus more on kinesthetic aspects of movement (Holmes and Calmels, 2008).

Forty object pictures were retrieved from *The Bank of Standardized Stimuli* (BOSS, Brodeur et al., 2010); additional 10 pictures were selected *via* Google Images web search. Images were adapted for size (35 × 48) and brightness and presented in the center of the screen. A group of 147 participants previously rated them in terms of weight. From those fifty stimuli, only forty were chosen as targets for the experimental task and four items were used as filler stimuli at the start and end of the task in order to reduce primacy and recency effects. Six stimuli were excluded because of the extreme variability in the estimates provided. Two different video tracks were created by editing existing videos from the *YouTube* platform. Each one lasted 2 min and 30 s. In the space video, there was an astronaut floating in the outer space and during a parabolic flight. In the nature video, there was a man walking, jumping, and crossing a naturalistic landscape with a backpack on his shoulder. Videos had no sound. Participants were asked to silently watch the video trying to internally reproduce the physical sensations that people were experiencing.

A female researcher recorded two main tracks for the guided-imagery session (one for the space scenario and one for the nature scenario). We chose standard audio scripts to reduce

the effect of other auditory variables on speech recording (e.g., mood, emphasis, and prosody of the speaker, as well as quality and duration of the session, etc.). Each track lasted about 100 s. and was made of 14 sentences with an average of 83.5 words. Each sentence was followed by a pause of 5 s aimed at fostering imaginative listening. Moreover, the audio-track ended with encouraging participants to feel and enjoy their sensations (free imaginative phase). Background sounds were deleted and pauses were added *via* the free *Audacity* software. A final sentence signaled the end of the guided-imagery, prompting participants to open their eyes and continue with the experiment. An example of the guided-imagery track for the space scenario is given below:

> *"Now imagine you are in outer space. If you prefer, you can close your eyes. Look around. Feel the absence of weight. Look at floating objects. If there are other people, try navigating toward them. Imagine everything you see floating. Listen carefully to all sounds. Smell the odors. Look at the lights and appreciate the dark. Look at everything that comes your way. Feel the absence of weight. Feel how you move. Take some time to enjoy this feeling."*

The experiment was delivered *via E-prime go* software. After collecting demographic information, participants performed the weight estimation task (t1), which consisted of evaluating the weight of the selected everyday objects' on a 0 to 100 grams scale (VAS scale). A bar appeared on the screen underneath the object picture and volunteers had to move a red cursor with the mouse in order to respond. Subsequently, participants watched video followed by the audio instructions for the guided-imagery session. At the end, all participants performed the weight estimation task (t2) for the same objects' pictures seen before. In both tasks, of course, stimuli were randomized.

In order to be sure that participants were engaging in imagination, we also performed a manipulation check as we asked volunteers to rate the vividness and the involvement they were experiencing during the guided-imagery on a 9-point scale (from 1 = "not at all" to 9 = "extremely"). Vividness is typically used as a non-physiological measure of mental imagery (e.g., Holmes and Mathews, 2010; Iachini, 2011; Pearson et al., 2013).

## RESULTS

We conducted a 2 (type of imagery scenario: Nature vs. Space) x 2 (time of estimation: t1 vs. t2) repeated-measure ANOVA (using *Statistica version 12)* to compare the weight estimation at t1 and at t2 of participants in the space and nature scenario conditions. *Post hoc* TukeyHSD analyses were run. Results showed a main effect of time $F_{(1,62)} = 10.\ 876$, $p < 0.005$; $\eta p2 = 0.149$ and a significant interaction between type of imagery scenario and time of weight estimation $F_{(1,62)} = 6.703$, $p < 0.05$; $\eta p2 = 0.098$. Specifically, participants estimated the objects as heavier at t1 ($M = 33.152$; SE = 1.700) compared with t2 ($M = 30.266$; SE = 1.819) independently of scenario conditions. Regarding the interaction, we observed only a significant difference in weight estimation of the objects between t1 ($M = 34.735$; SE = 2.268) and t2 ($M = 29.584$; SE = 2.324; $p < 0.001$) (**Figure 1** and **Table 1**) in the space scenario group. Thus, only participants that were engaged in a space scenario's imagery session gave significantly lower weight estimations. No main effect of type of imagery scenario was found $F_{(1,62)} = 0.\ 070$, $p = 0.792$; $\eta p2 = 0.001$. Specifically, the overall weight estimation in the nature condition ($M = 31.259$; SE = 2.410) was not different from the one in the space condition ($M = 32.159$; SE = 2.41).

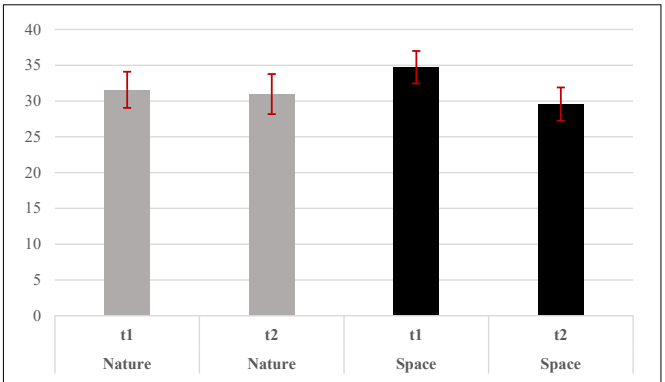



**FIGURE 1 |** Bar chart of means and standard errors of weight estimations given by subjects in the two conditions at t1 and t2.

**TABLE 1 |** Means and standard errors (in parenthesis) from the weight estimation task as a function of time (t1 vs. t2) and type of imagery scenario (space vs. nature).

| Imagery session | t1 | t2 |
|---|---|---|
| Space | 34.735 (2.268) | 29.584 (2.324) |
| Nature | 31.570 (2.530) | 30.948 (2.798) |

Furthermore, a Student's *t*-test revealed that there was no difference in vividness or involvement across the two groups and there were no significant differences in weight estimations between high and low-vividness participants (based on the median value per condition, in all cases $p > 0.5$).

## DISCUSSION

Mental imagery is a cognitive function strictly connected to perception, visual and motor processing. It has been defined as a "weak form of perception" (Pearson, 2019) able to generate a weak form of experience, with all the neural, physiological, and psychological correlates of real perception. The primary function of imagery is to simulate reality by analyzing actions and situations' consequences and it seems able to amplify conscious and unconscious human functions, sustain decision-making, problem-solving and even to exert control over emotions (Taylor et al., 1998; Moulton and Kosslyn, 2009; Mammarella, 2020c; Gatti et al., 2022). Due to its special features, mental imagery has been used across multiple disciplines, e.g., clinical psychology, sports and rehabilitation sciences, to cite only few. For example, in the clinical domain, Murphy et al. (2015) compared a computerized mental imagery-based training with a classical cognitive training procedure in order to modify

cognitive biases in aging. In particular, an imagery-based training (see also Lang et al. (2012), Blackwell et al. (2015)) typically consisted of 12 sessions (six auditory and six visual) across four weeks. Participants in the imagery condition were asked to create a mental image of the stimuli presented. In the six auditory sessions, participants listened to brief descriptions of everyday situations and were instructed to imagine themselves actively involved and seeing the scenario through their own eyes. Each scenario was initially ambiguous, but all descriptions eventually resolved positively. In the other six sessions, participants were shown ambiguous pictures of everyday scenes paired with a few words that resolved the scene positively. Controls, instead, were asked to concentrate on the words and meanings of the descriptions, to rate the difficulty of understanding the meaning of the descriptions on a 5-point Likert-type scale, to generate a sentence by combining the picture and words, and finally rate the difficulty of generating a sentence. While both conditions improved interpretive bias modification, imagery-based training improved positive affect and vividness of positive prospective imagery (as measured by the Prospective imagery test, PIT, based on Stöber (2000)) to a greater extent. In sport sciences, instead, motor imagery has been shown to be effective in enhancing strength performance (Lebon et al., 2010; Wakefield and Smith, 2011). In this regard, the use of the PETTLEP protocol (Holmes and Collins, 2001) is very common. Specifically, PETTLEP is the acronym for Physical, Environment, Task, Timing, Learning, Emotion, Perspective, that is, the functional equivalence that imagery needs to have with the real movements to be effective. Smith et al. (2019) made a single-case design study to investigate whether combining motor imagery and action observation improves biceps strength performance in four subjects with a mean age of 24 years (SD = 3.54). Participants were assessed at baseline with the Movement Imagery Questionnaire 3 (MIQ-3, Williams et al., 2012), in which they had to reproduce visual and kinesthetic imagery of four movements (knee lift, jump, arm movement, and toe touch) and then rate their own ability on a 7-point Likert-type scale. This was followed by a phase of PETTLEP-based imaginative practice of bicep curl machine, with and without action observation, in a counterbalanced way, for a total of 8 weeks of intervention (4 weeks per intervention, with trice a week imagery session). Participants, then, completed a weekly bicep curl one repetition maximum (1 R.M.) in order to measure their performance. Combining action observation with PETTLEP imagery protocol improved performance but not significantly more than the PETTLEP alone, supporting the robustness of this motor imagery protocol per sé. In this regard, also Bock et al. (2015) highlighted the role of mental practice of some basic movements in space (or weightlessness conditions) as a relevant countermeasure technique for reducing microgravity effects.

In line with the above-mentioned studies, our goal was to understand whether an imagery-based training could also be a viable road for the study of microgravity-like effects over cognition. Of course, we are in a preliminary phase of our research and this can be considered as an exploratory study. However, the present work is the first to simulate a space mission scenario *via* imagery and to obtain significant effects on cognitive processing. Indeed, imagery is a cost-effective and non-invasive method (Guillot and Debarnot, 2019): its intrinsic simulative feature would make it an interesting device for enhancing astronauts' performance and promoting their adaptation to extreme environmental conditions. Our hypothesis was that observing astronauts floating and inviting to imagine a weightlessness condition would lead to a reduction in weight estimation compared with imagining a nature scenario. Astronauts typically estimate the objects as less heavy in real microgravity conditions (e.g., parabolic flights, see Ross and Reschke (1982)). Here, we wanted to verify if the imagery session inducing feelings of lightness and weightlessness could affect the cognitive estimation of the weight of objects in the same manner. The rationale behind our research is rooted in the embodied cognition theories (Barsalou et al., 2003) and is oriented in investigating if a guided-imagery session of a space scenario reactivates sensorimotor aspects of weightlessness, so that participants should lower their weight estimation scores compared with controls. Our findings seem to point to this direction and suggest that imagery of a weightlessness-like condition can be effective in reactivating knowledge about space missions.

It is also important to address several shortcomings and prospects of the present study. Unfortunately, in the context of this study, it was not feasible to include real objects and compare the effectiveness of our procedure with them. Although we used a series of object pictures previously rated in terms of weight, the findings of the present research should be interpreted with caution. New research in our lab is trying to replicate findings of the current study with a design that includes real objects. Furthermore, the distinction between mass and weight of objects was not specified to participants. Weight is, in fact, the amount of gravity acting on an object mass; mass, instead, is the amount of matter that does not change with gravity. Ross and Reschke (1982), for instance, first studied mass estimation and discrimination in real microgravity conditions by asking participants to shake an object in order to generate a sensation of heaviness. An interesting avenue could be replicating these data with our guided-imagery condition. Thus, future studies should examine the effectiveness of our imaginary simulation with real objects to gain a better understanding of changes in behavioral performance. Virtual reality too may be used in this regard and provide an interesting possibility for implementing vestibular cognitive tasks. This method will additionally promote the study of integration between visual, auditory, and tactile input during simulation and increase research interest in this domain. Finally, even if the guided-imagery session seems to have an effect only in the space scenario and not in the nature scenario, our results should be interpreted with caution due to the trend of the means in the two conditions at t1. Although the weight estimation in the space scenario at t1 does not differ from the weight estimation in the nature scenario at t1, the trend of the means might suggest an apparent difference between the two tasks at baseline (before the imagery session). Therefore, further studies are needed to disentangle the effects of imagery session and potential differences due to the type of task that participants are

performing. To conclude, our data first show that microgravity-like effects, that stem from an extreme environment such as space, can be reproduced *via* mental imagery and affect cognitive estimations of weight of everyday objects. Other studies adopting this methodology can help deepening our knowledge about the impact of different variables on human performance during a spaceflight. This finding, finally, can be crucial for the future of space exploration, for example, in order to understand the extent to which microgravity alone influences vestibular cognition-based tasks and adds to the development of countermeasures for long-term duration explorations (e.g., Mammarella and Gatti, 2020). Given that the number of space travelers is going to raise in next few years, we ultimately hope that our date will stimulate new research in this direction.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Departmental Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

NM designed the work. MG contributed to the participants' selection and testing. NM and MG prepared the original draft of the manuscript. RP and AD revised it critically. All authors read and approved the final version of the manuscript.

## ACKNOWLEDGMENTS

We thank all volunteers who accepted to participate to this study.

## REFERENCES


Barsalou, L. W. (2008). Grounded cognition. *Ann. Rev. Psychol.* 59, 617–645.

Barsalou, L. W., Simmons, W. K., Barbey, A. K., and Wilson, C. D. (2003). Grounding conceptual knowledge in modality-specific systems. *Trends Cogn. Sci.* 7, 84–91. doi: 10.1016/s1364-6613(02)00029-3

Besnard, S., Lopez, C., Brandt, T., Denise, P., and Smith, P. F. (2015). Editorial: the vestibular system in cognitive and memory processes in mammalians affiliations expand. *Front. Integr. Neurosci.* 9:55. doi: 10.3389/fnint.2015.00055

Bigelow, R. T., and Agrawal, Y. (2015). Vestibular involvement in cognition: visuospatial ability, attention, executive function, and memory. *J. Vestib. Res.* 25, 73–89. doi: 10.3233/VES-150544

Blackwell, S. E., Browning, M., Mathews, A., Pictet, A., Welch, J., Davies, J., et al. (2015). Positive imagery-based cognitive bias modification as a web-based treatment tool for depressed adults. *Clin. Psychol. Sci.* 3, 91–111. doi: 10.1177/2167702614560746

Bock, O., Schott, N., and Papaxanthis, C. (2015). Motor imagery: lessons learned in movement science might be applicable for spaceflight. *Front. Syst. Neurosci.* 9:75. doi: 10.3389/fnsys.2015.00075

Brodeur, M. B., Dionne-Dostie, E., Montreuil, T., and Lepage, M. (2010). The bank of standardized stimuli (BOSS), a new set of 480 normative photos of objects to be used as visual stimuli in cognitive research. *PLoS One* 5:e10773. doi: 10.1371/journal.pone.0010773

Fisher, J. C. (2006). Does simulation theory really involve simulation? *Philos. Psychol.* 19, 417–432.

Gatti, M., Palumbo, R., Di Domenico, A., and Mammarella, N. (2022). Affective health and countermeasures in long-duration space exploration. *Helyion* 8:e09414. doi: 10.1016/j.heliyon.2022.e09414

Grabherr, L., and Mast, F. W. (2010). Effects of microgravity on cognition: the case of mental imagery. *J. Vestib. Res.* 20, 53–60. doi: 10.3233/VES-2010-0364

Gravano, S., Lacquaniti, F., and Zago, M. (2021). Mental imagery of object motion in weightlessness. *NPJ Microgravity* 7:50. doi: 10.1038/s41526-021-00179-z

Guillot, A., and Debarnot, U. (2019). Benefits of motor imagery for human space flight: a brief review of current knowledge and future applications. *Front. Physiol.* 10:396. doi: 10.3389/fphys.2019.00396

Holmes, E. A., and Mathews, A. (2010). Mental imagery in emotion and emotional disorders. *Clin. Psychol. Rev.* 30, 349–362. doi: 10.1016/j.cpr.2010.01.001

Holmes, P. S., and Calmels, C. (2008). A neuroscientific review of imagery and observation use in sport. *J. Motor Behav.* 40, 433–445. doi: 10.3200/JMBR.40.5.433-445

Holmes, P. S., and Collins, D. J. (2001). The PETTLEP approach to motor imagery: a functional equivalence model for sport psychologists. *J. Appl. Sport Psychol.* 13, 60–83.

Iachini, T. (2011). Mental imagery and embodied cognition: a multimodal approach. *J. Ment. Imag.* 35, 1–66.

Ji, J., Heyes, S., MacLeod, C., and Holmes, E. (2016). Emotional mental imagery as simulation of reality: fear and beyond. A tribute to Peter Lang. *Behav. Ther.* 47, 702–719. doi: 10.1016/j.beth.2015.11.004

Kanas, N. A., and Manzey, D. (2008). *Space Psychology and Psychiatry*, 2nd Edn. Dordrecht, NE: Space Technology Library, Springer.

Kosslyn, S. M., Ganis, G., and Thompson, W. L. (2001). Neural foundations of imagery. *Nat. Rev. Neurosci.* 2, 635–642. doi: 10.1038/35090055

Kosslyn, S. M., Thompson, W. L., and Ganis, G. (2006). *The Case for Mental Imagery*. New York, NY: Oxford University Press, Inc.

Lang, P. J. (1979). A bio-informational theory of emotional imagery. *Psychophysiology* 16, 495–512. doi: 10.1111/j.1469-8986.1979.tb01511.x

Lang, T. J., Blackwell, S. E., Harmer, C. J., Davison, P., and Holmes, E. A. (2012). Cognitive bias modification using mental imagery for depression: developing a novel computerized intervention to change negative thinking styles. *Eur. J. Pers.* 26, 145–157. doi: 10.1002/per.855

Lebon, F., Collet, C., and Guillot, A. (2010). Benefits of motor imagery training on muscle strength. *J. Strength Condit. Res.* 24, 1680–1687. doi: 10.1519/JSC.0b013e3181d8e936

Mammarella, N. (2020a). *Nella Mente dell'Astronauta. Psicologia delle Missioni Spaziali*. Roma, IT: Carocci Editore.

Mammarella, N. (2020b). The effect of microgravity-like conditions on high-level cognition: a review. *Front. Astron Space Sci.* 7:6. doi: 10.3389/fspas.2020.00006

Mammarella, N. (2020c). Towards the affective cognition approach to human performance in space. *Aerospace Med. Hum. Perform.* 91, 1–3. doi: 10.3357/AMHP.5568.2020

Mammarella, N., and Gatti, M. (2020). Cognitive training as a countermeasure for cognitive changes during a space mission. *J. Space Explor.* 9:161.

Mast, F. W., and Ellis, A. W. (2015). Internal models, vestibular cognition, and mental imagery: conceptual considerations. *Multisens. Res.* 28, 443–460. doi: 10.1163/22134808-00002503

Morris, T., Spittle, M., and Watt, A. P. (2005). *Imagery in Sport*. Champaign, IL: Human Kinetics Books.

Moulton, S., and Kosslyn, S. (2009). Imagining predictions: mental imagery as mental emulation. *Philos. Trans. R. Soc. Lond. Series B Biol. Sci.* 364, 1273–1280. doi: 10.1098/rstb.2008.0314

Murphy, S. E., Clare, O., Donoghue, M., Drazich, E. H. S., Blackwell, S. E., Christina Nobre, A., et al. (2015). Imagining a brighter future: the effect of positive imagery training on mood, prospective mental imagery and emotional bias in older adults. *Psychiatry Res.* 230, 36–43. doi: 10.1016/j.psychres.2015.07.059

Palmiero, M., Piccardi, L., Giancola, M., Nori, R., D'Amico, S., and Olivetti Belardinelli, M. (2019). The format of mental imagery: from a critical review

to an integrated embodied representation approach. *Cogn. Process.* 3, 277–289. doi: 10.1007/s10339-019-00908-z

Pearson, J. (2019). The human imagination: the cognitive neuroscience of visual mental imagery. *Nat. Rev. Neurosci.* 20, 624–634. doi: 10.1038/s41583-019-0202-9

Pearson, D. G., Deeprose, C., Wallace-Hadrill, S. M., Burnett Heyes, S., and Holmes, E. A. (2013). Assessing mental imagery in clinical psychology: a review of imagery measures and a guiding framework. *Clin. Psychol. Rev.* 33, 1–23. doi: 10.1016/j.cpr.2012.09.001

Pearson, J., Clifford, C., and Tong, F. (2008). The functional impact of mental imagery on conscious perception. *Curr. Biol.* 18, 982–986. doi: 10.1016/j.cub.2008.05.048

Pearson, J., Naselaris, T., Holmes, E. A., and Kosslyn, S. M. (2015). Mental imagery: functional mechanisms and clinical applications. *Trends Cogn. Sci.* 19, 590–602. doi: 10.1016/j.tics.2015.08.003

Ross, H. E., and Reschke, M. F. (1982). Mass estimation and discrimination during brief periods of zero gravity. *Percept. Psychophys.* 31, 429–436. doi: 10.3758/bf03204852

Smith, D., and Holmes, P. (2004). The effect of imagery modality on golf putting performance. *J. Sport Exerc. Psychol.* 26, 385–395.

Smith, D., Romano-Smith, S., Wright, D. J., Deller-Rust, B., and Wakefield, C. J. (2019). The effects of combining PETTLEP imagery and action observation on bicep strength: a single-case design. *J. Appl. Sport Psychol.* 32, 377–391.

Stöber, J. (2000). Prospective cognitions in anxiety and depression: replication and methodological extension. *Cogn. Emot.* 14, 725–729.

Taylor, S. E., Pham, L. B., Rivkin, I. D., and Armor, D. A. (1998). Harnessing the imagination. Mental simulation, self-regulation, and coping. *Am. Psychol.* 53, 429–439. doi: 10.1037//0003-066x.53.4.429

Wakefield, C., and Smith, D. (2011). From strength to strength: a single-case design study of PETTLEP imagery frequency. *Sport Psychol.* 25, 305–320.

Williams, S. E., Cumming, J., Ntoumanis, N., Nordin-Bates, S. M., Ramsey, R., and Hall, C. (2012). Further validation and development of the movement imagery questionnaire. *J. Sport Exerc. Psychol.* 34, 621–646. doi: 10.1123/jsep.34.5.621

Wright, C. J., and Smith, D. (2009). The effect of PETTLEP imagery on strength performance. *Int. J. Sport Exerc. Psychol.* 7, 18–31. doi: 10.1186/1741-7015-9-75

**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Publisher's Note:** All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

frontiers | Frontiers in Psychology

ORIGINAL RESEARCH
published: 07 June 2022
doi: 10.3389/fpsyg.2022.871143

# Watching Nature Videos Promotes Physiological Restoration: Evidence From the Modulation of Alpha Waves in Electroencephalography

*Simone Grassini[1,2]*, Giulia Virginia Segurini[3] and Mika Koivisto[3]*

[1] Department of Social Studies, University of Stavanger, Stavanger, Norway, [2] Department of Psychology, Norwegian University of Science and Technology, Trondheim, Norway, [3] Department of Psychology, University of Turku, Turku, Finland

Various lines of evidence have shown that nature exposure is beneficial for humans. Despite several empirical findings pointing out to cognitive and emotional positive effects, most of the evidence of these effects are correlational, and it has been challenging to identify a cause-effect relationship between nature exposure and cognitive and emotional benefits. Only few of the published studies use psychophysiological methods to assess the biological correlates of these positive effects. Establishing a connection between human physiology and contact with natural settings is important for identifying cause-effect relationships between exposure to natural environments and the positive effects commonly reported in connection to nature exposure. In the present study, we recorded physiological indexes of brain activity (electroencephalography) and sympathetic nervous system (electrodermal activity), while the participants were presented with a series of videos displaying natural, urban, or neutral (non-environmental, computerized) scenes. Participants rated the scenes for their perceived relaxing value, and after each experimental condition, they performed a cognitive task (digit span backward). Participants rated natural videos as the most relaxing. Spectral analyses of EEG showed that natural scenes promoted alpha waves, especially over the central brain. The results suggest that experiencing natural environments virtually produces measurable and reliable brain activity markers which are known to be related to restorative processes.

**Keywords: EEG, EDA, nature, restoration, cognition**

OPEN ACCESS

***Edited by:***
*Sabrina Fagioli,*
*Roma Tre University, Italy*

***Reviewed by:***
*Chris Neale,*
*University of Huddersfield, United Kingdom*
*David Strayer,*
*The University of Utah, United States*

****Correspondence:***
*Simone Grassini*
*simone.grassini@ntnu.no*

***Specialty section:***
*This article was submitted to Environmental Psychology, a section of the journal Frontiers in Psychology*

***Received:*** *07 February 2022*
***Accepted:*** *06 May 2022*
***Published:*** *07 June 2022*

***Citation:***
*Grassini S, Segurini GV and Koivisto M (2022) Watching Nature Videos Promotes Physiological Restoration: Evidence From the Modulation of Alpha Waves in Electroencephalography. Front. Psychol. 13:871143. doi: 10.3389/fpsyg.2022.871143*

## BACKGROUND

The literature on environmental psychology has defined a restorative environment as one that can help to restore drained emotional and/or cognitive resources. Outdoor environments that feature natural elements have been shown to effectively promote restorative effects (Hettinger, 2012). Human exposure to natural settings has been shown to be associated to psychological and psychophysiological positive effects, such as stress reduction, improvement of moods and mental health (as, e.g., reducing symptoms of anxiety and depression – see Grassini, 2022 for a review), and cognitive recovery from task overload (Ulrich, 1979; Kaplan and Kaplan, 1989; Berman et al., 2008; Hartig et al., 2014).

A long line of empirical evidence has shown that natural settings can promote stress reduction and ease physiological arousal (Laumann et al., 2003; Stigsdotter and Grahn, 2004; Tyrväinen et al., 2014). Placing natural elements in urban areas has been shown to improve mental health (Tzoulas et al., 2007), and natural elements indoor has been shown to promote psychological well-being (Raanaas et al., 2016). In addition, viewing nature from a window helps faster recovery from physical exercise (Engell et al., 2020). The positive effects of nature have been extensively studied in the context of work well-being, and it has been shown that interactions with natural settings may be beneficial to reduce work-related stress (Korpela and Kinnunen, 2010; Korpela et al., 2015).

Current scientific literature has extensively investigated the ability of natural settings to restore attentional and cognitive abilities. Current theories of the cognitive effects of exposure to natural stimuli (see Kaplan and Kaplan, 1989; Kaplan, 1995) propose that cognitive abilities are restored by natural settings, and therefore predict that after the exposure to a natural environment (compared, e.g., to an urban one), people would perform better in cognitive and memory tasks. Several lines of evidence have indicated that natural settings have the capacity to restore human attentional and cognitive abilities (for reviews, Ohly et al., 2016; Stevenson et al., 2018). Among cognitive skills, being exposed to natural elements has been shown to increase performance in working memory tasks (Bratman et al., 2015), improve performance in sustained attention exercises (Berto, 2005), increase cognitive control, and concentration (Hartig et al., 2003; Berman et al., 2008, 2012).

The mechanisms underpinning the restorative effect of nature for humans have been extensively studied (Berto, 2005; Haga et al., 2016; Joye et al., 2016). A widely reported theoretical point of view is that humans have an innate tendency to experience positively the contact with natural environments. In this context, the Biophilia hypothesis is often cited (Wilson, 1984). According to this hypothesis, humans are biologically prepared to positively respond to the environments with positive attributes for biological survival (see also Joye and Van den Berg, 2011). Some studies have found that some specific features of natural stimuli are related to restorative effect. Images of nature were shown to be rated as more restorative than images of other types of environments (Berto, 2005). Factors other than physical stimulus features have been also studied regarding their restorative effects (Haga et al., 2016; Egner et al., 2020). A number of different types of auditory and visual stimuli have been found to be perceived as restorative. Natural sounds have been shown to help restore mental fatigue (Ratcliffe et al., 2013; Benfield et al., 2014; Emfield and Neider, 2014; Jahncke et al., 2015).

The empirical findings of the benefits associated to the exposure to natural environments are often theoretically explained with two prominent theories (Hartig et al., 1996). The first theory, the Stress Reduction Theory (SRT; Ulrich, 1983; Ulrich et al., 1991) put emphasis on psycho-physiological stress, while the other one, the Attention Restoration Theory (ART; Kaplan and Kaplan, 1989; Kaplan, 1995), focuses on the cognitive recovery from directed attention fatigue. The SRT (Ulrich, 1983; Ulrich et al., 1991) underlines the physiological effect of the exposure to natural settings. The theory suggests that qualitative features commonly found in natural settings may directly support psychophysiological stress recovery, and this may occur because nature elicits positive effects. The SRT finds its background on the theories of human evolution: humans may be biologically prepared to optimally respond to environmental features that imply possibilities for biological survival, and therefore there may be an evolutionary basis for aesthetic and restorative responses to some types of natural scenes. Such theoretical approach is connected to the Biophilia hypothesis (Wilson, 1984). The ART (Kaplan and Kaplan, 1989; Kaplan, 1995) put its emphasis on the ability of natural environments to promote cognitive restoration and on the positive effect of natural settings on human attentional fatigue. Researchers have proposed that these two theories may not be mutually exclusive and that they complement each other (Hartig et al., 2003), as several studies have found attentional fatigue and stress to be linked (Cohen and Spacapan, 1978; Ulrich et al., 1991; Kaplan, 1995; Lepore and Evans, 1996). However, it has also been argued (see, e.g., Egner et al., 2020) that the attention restoration produced by nature may be a secondary effect, primarily dependent on the relaxation.

A considerable number of studies have examined human health and cognitive functions associated with viewing images, videos, and other simulations of nature (Ohly et al., 2016; Stevenson et al., 2018), including in recent years, highly immersive virtual reality (Browning et al., 2020; Yeo et al., 2020). However, only a handful of studies have attempted to understand the brain dynamics in response to natural or non-natural settings. Kim et al. (2010) employed functional magnetic resonance imaging (fMRI) to examine the brain areas activated in response to natural or urban images. Their results revealed that perception of urban images was associated with an enhanced activity in the amygdala, an area known to be associated with impulsivity (Gopal et al., 2013; Kerr et al., 2015), anxiety (Hahn et al., 2011; Kim et al., 2011), and stress (Veer et al., 2011; Sripada et al., 2012). The perception of natural scenes was found to be associated with an increased activity in the anterior cingulate and insula areas (Kim et al., 2010). These brain areas were found by previous studies to be related to positive social behavior (e.g., empathy and altruism, see Fan et al., 2011; Lamm et al., 2011). Neurophysiological experiments have shown that exposure to natural environments stimulate brain activity related to tranquility (Hunter et al., 2010).

Several studies have used electroencephalography (EEG) to examine brain functional dynamics related to the experience of natural settings in different frequency bands. The frequency bands are delta (0.5–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), beta (13–30 Hz), and gamma (>30 Hz) bands. The alpha activity has received most attention because it is related to relaxed state of mind. The alpha waves are understood to be produced from postsynaptic potentials in a neural network involving the dorsal anterior cingulate cortex, the anterior insula, the anterior prefrontal cortex, and the thalamus that is associated with alertness and attention (Sadaghiani et al., 2010). It has been suggested that such brain network is responsible for internalized alertness (Coste and Kleinschmidt, 2016) and is associated with variations in involuntary attention (Dosenbach et al., 2008). It

has been proposed that alpha waves recorded using EEG may be indexes an inhibitory mechanism generated by a thalamic-cortical loop (Foxe and Snyder, 2011). Several previous studies have found alpha waves to be modulated while experiencing natural environments. An increase in alpha power in the EEG (8–13 Hz) has been found to be a marker of the experience of natural vs. urban photographs (Ulrich, 1981; Chang et al., 2008; Grassini et al., 2019). It has also been suggested that the experience of natural environments is able to modulate brain activity associated with cognitive-inhibitory mechanisms, and that this effect is reflected by an increase of alpha brain activity markedly over the brain's central areas (Ulrich, 1981; Grassini et al., 2019). A recent review (Norwood et al., 2019) reported several studies that connected higher alpha over frontal lobes to the experience of natural environments or other environmental settings perceived as positive (Chang and Chen, 2005; Choi et al., 2015; Chiang et al., 2017; Bailey et al., 2018).

The physiological basis of the beta rhythms has been long being disputed. It has been proposed that beta waves are generated in basal ganglia and thalamic structures (Bevan et al., 2002; Leventhal et al., 2012). Later studies have shown that beta waves may emerge within internal dynamics of the neocortex that are dependent on extrinsic synaptic drive originating in other structures as basal ganglia and thalamus (Sherman et al., 2016). Beta oscillations have been shown to be associated to the activity of the motor cortex, to sensory perception, and to selective and spatial attention (Neuper and Pfurtscheller, 2001; Siegel et al., 2008; Jones et al., 2010; Miller et al., 2012). Grassini et al. (2019) found that while viewing nature images increased alpha activity, the beta activity was at the same time decreased, suggesting that less attentional resources were used during viewing nature images, compared to urban ones.

Whereas delta and gamma bands have not received practically any attention in studies on the psychological effects of nature, there is some evidence that theta band activity may be modulated during viewing natural stimuli. Theta activity has been associated with cognitive control and error processing, and an origin of increase theta power has been found in the anterior cingulate cortex (Cavanagh et al., 2010, 2012; Cavanagh and Shackman, 2015). Sahni and Kumar (2020) reported that viewing nature videos increased both theta and alpha power, suggesting that natural stimuli provoke a relaxed but alert state of mind.

Other studies have employed EEG as method to estimate the positive emotions related to the experience of natural settings (Roe et al., 2013; Aspinall et al., 2015), and their findings confirmed that natural environments promote more positive emotions and higher level of relaxation. However, these latter studies did not directly analyze the EEG data but relied on the proprietary algorithms of the EEG manufacturer for data analysis, and therefore is not possible to understand whether alpha waves were modulated by their experimental conditions.

Non-brain physiological indexes such as heart rate (HR; see Annerstedt et al., 2013; Yu et al., 2018), heart-rate variability (HRV; see Park et al., 2007, 2010; Gladwell et al., 2016), and electrodermal activity (EDA, sometimes referred in the literature as skin conductance or galvanic skin responses, Alvarsson et al., 2010; Hedblom et al., 2019; Browning et al., 2020) have been also used to understand the human physiological response to the exposure to natural settings.

Heart rate variability (HRV) is defined as the variation in the intervals between heartbeats. Such physiological index is often used as an indicator of the activity of the autonomic nervous system (ANS). Higher HRV has been linked with an increased adaptability of the ANS and has been proposed to be associated with positive health factors (Brown et al., 2013). Several studies have showed that HRV is related to stress and that different components of HRV can be linked to stressors (for a review see Kim et al., 2018). Previous studies have shown that exposure to natural environments increases HRV (Park et al., 2007, 2010; Gladwell et al., 2016), suggesting that nature exposure is accompanied with reduced stress and enhanced relaxation.

Electrodermal activity is controlled by the sympathetic nervous system, and it is modulated by the activity of the skin sweat glands. EDA is often used to measure psychological or physiological arousal (Critchley, 2002). Previous studies have found that EDA is reduced when people are exposed to natural settings (Alvarsson et al., 2010; Hedblom et al., 2019; Elsadek et al., 2020). However, the inverse effect has been also found (Browning et al., 2020), suggesting that other variables or experimental factors may be contribute to the modulation of EDA in relation to the exposure to natural settings.

A small number of studies have considered the use of more than one physiological measure to cross-validate their results across different methods. The recently published study of Elsadek et al. (2020) analyzed physiological activity using EDA and EEG on people looking outside a window facing urban or green spaces. It found a higher level of alpha waves over the frontal and occipital brain areas, and a decrease in skin conductance level. However, this study only offered a limited spatial resolution on the brain data, due to the low-density EEG equipment using only four electrodes (two frontal and two occipital). This choice is probably attributable to the electrode positions provided by the Emotiv EPOC equipment that was used in the study, but it comes at odd with the reported localization of alpha increase during nature exposure, which was revealed to be prevalently over the central brain areas in the studies of Ulrich (1981) and Grassini et al. (2019).

One limitation that is shared by many of these studies is the lack of a control or neutral condition when comparing the influence of natural and urban environments. The studies that focus on comparing urban and natural environment (see, e.g., Ulrich, 1981; Aspinall et al., 2015; Grassini et al., 2019; Elsadek et al., 2020) generally fail to answer the question whether the natural or the urban stimuli are responsible for the reduction/or increase of physiological arousal (e.g., indexed with EDA) and modulation of cognitive mechanisms (e.g., indexed using EEG).

The present study aimed to use both brain (EEG) and non-brain (EDA) indexes (together with subjective evaluations) to understand physiological dynamics of the interaction with natural settings. This was done in a laboratory setting, where videos of nature (without audio) were showed to the participants while biological signals were recorded. Furthermore, we attempted to understand whether urban environments or natural environments were responsible for an eventual

modulation of physiological brain and non-brain activity by adding control condition to the experiment. Our hypotheses were that the vision of nature video would modulate brain early alpha waves recorded over the central brain areas as shown in previous lab-controlled studies employing static images (Ulrich, 1981; Grassini et al., 2019). We did not have a hypothesis about whether nature or urban environment would be responsible of such effect when compared to a neutral stimulation. We expected EDA to be reduced when watching nature videos, but we had no preliminary hypothesis about whether the effect would be more pronounced versus neutral or urban videos.

# MATERIALS AND METHODS

## Participants

Twenty-four neurologically healthy students with normal or corrected-to-normal vision participated in the study (mean age = 24.8, SD = 5.1, range = 19–36 years, ten men). They were selected from the pool of participants from the introductory psychology courses in University of Turku. The students received course credits as reward for their participation. The experiment was conducted in accordance with the Declaration of Helsinki and with the understanding and written consent of each participant and was approved by the Ethics Committee for Human Sciences at the University of Turku. Before the experimental session, the participants were asked to read an information sheet on the experiment, to read and sign the informed consent, and to self-assess their handedness. Only students reporting to be right-handed were tested. The sample size was determined based on the observed effect and n from previously published EEG studies on brain activity in response to environmental exposure (Grassini et al., 2019). The number of participants recruited for our study is also in line with recent investigations on the relationship between participants number and EEG data reliability for relatively long tasks during EEG recording (Vozzi et al., 2021). Data from two participants were excluded from the analysis of cognitive task (digit-span backward scores), and two were excluded from the analysis of the EDA data due to technical issues in data collection.

## Stimuli and Procedure

The stimuli consisted of videos depicting natural, urban, or neutral settings (referred hereinafter as the three experimental conditions). A total of nine videos per condition were selected by the study authors. Every participant was exposed to four consecutive videos of the same environment type (natural, urban, or neutral) before passing to four consecutive videos of another environment, and four consecutive videos of the last environment. The four videos for each environment type were selected randomly among the nine available videos. The order of the experimental conditions (i.e., environment type) was randomized across participants. Every video lasted for 3 min, for a total of 12 min of exposure per each experimental condition. Natural settings videos depicted a variety of natural environments, among those, mountain lakes, beaches, forest, and fields. Urban environment videos showed city-like landscapes, and depicted for example traffic, buildings, and other types of common environments displaying urban or industrial buildings. Urban videos contained eventually some natural elements (e.g., threes on the edges of a street, or a city seaside view). Natural videos were selected appositely to avoid any type of non-natural element. The videos were selected from material retrieved from the internet. The authors SG and GS selected independently a list of suitable videos, and together reviewed and chose those that were judged as the most appropriate for the present study. Criteria that were used to selecting the videos were: high enough quality of details, absence of numbers/words in the environment, absence of close-ups of people/faces. Furthermore, markedly unpleasant urban environments were avoided, trying not to suggest a strong judgment bias to the participants. For the neutral setting condition, lines depicting slowly changing colorful shapes or patch of colors were selected, alike those often used in computer screensavers. All videos were displayed with a resolution of 1920 × 1080 pixels, and a frame rate of 24 frames/second, and were viewed at around 2 m of distance on a 17-inch LCD screen. After each video, the word "relaxing" was presented on screen and the participants rated how relaxing (from 1 to 9; 1 = not at all, 9 = very much) they found the video. The "relax" score for each condition was then averaged across videos of the same type for each participant. The experiment was run using E-prime 2. **Figure 1** shows an exemplification of the stimuli used in the experiment and the experimental procedure.

After each condition (i.e., block of four-videos), the participants were asked to perform a digitalized visual version of the Digit Span Backward Task (DSB). After the participants had been instructed to the task, they were asked to perform the DSB before the beginning of the experiment. This was done to allow the participants to familiarize with the task. In the DSB, a series of digits were displayed on the screen, following one another. The digit displayed were randomly chosen from 1 to 9. Participants were instructed to recall the digits backward (e.g., if "3, 4, 5" were presented, the subject had to press the keys "5, 4, 3" using the keyboard). In the case the task was successful for two times in a row, participants were then asked to perform the task again with a longer list of digits. The task started with only 2 digits, and the participants could go to indefinitely long list of digits according with their performance. The digit list was made longer until the point when participant failed to inversely recall the list for two succeeding trials. The score for each participant was calculated on the length of the longest list the participant successfully performed. The DSB task aimed to detect cognitive restorative effect from the exposure to the videos (working memory). Several studies have implemented this type of cognitive task to assess the restorative effect arising from the exposure to natural settings (Ohly et al., 2016 for a review). The subjects were presented with a computerized, visual version of the DSB [similarly to the one used in Grassini et al. (2019)], and participants were instructed to perform the task using a keyboard. However, it is worth nothing that the commonly used DSB task generally uses vocal stimuli and verbal response recall. Previous studies have also used a computerized

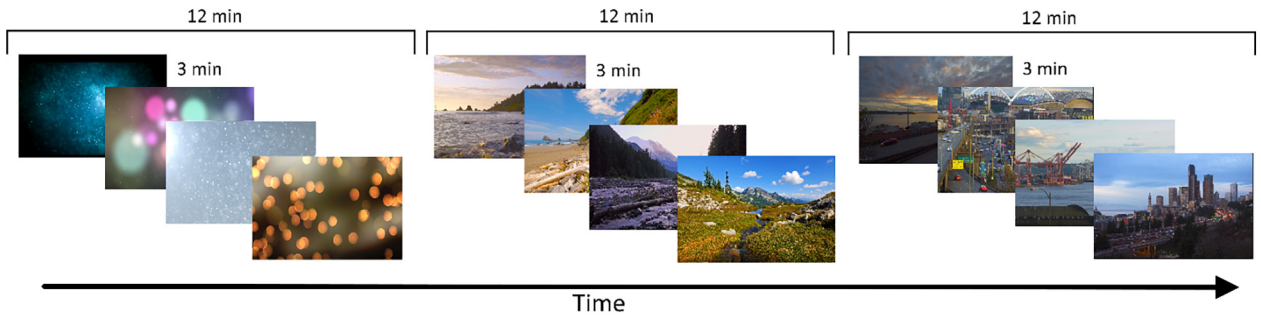



**FIGURE 1 |** Example of the experimental procedure. In this example, four videos of the neutral condition are followed by four videos of the nature conditions, and four videos of the urban condition concluded the experimental session. Each condition was composed of four 3-min videos.

version of the DSB to successfully assess working memory (AuBuchon et al., 2015).

## Electroencephalography

Electroencephalographic brain activity was assessed at 64 sensors placed according to the international 10–10 electrode system. The electrodes were placed on the head using a sintered Ag/AgCl cap featuring active electrodes (Easycap GmbH, Herrsching, Germany). NeurOne 1.3.1.26 software and Tesla #MRI 2013011 and #MRI 2013012 amplifiers (Bittium Corporation, Oulu, Finland) were used for data collection. Signal was referenced online to Cz, and the ground electrode was placed on position AFz. The recording sampling rate was set to 500 Hz.

Electroencephalography data was processed offline using MATLAB (v. R2019a; The MathWorks, Inc., Natick, MA, United States) and with the EEGLAB toolbox version v2021.0 (Delorme and Makeig, 2004). Intervals between the videos (where the participants were asked to answer a question on their subjective evaluation of the latest video) were removed from the recorded signal. Data was high-pass filtered at 1 Hz with a Hamming windowed-sinc FIR filter ("pop_eegfiltnew"). Line noise was removed using the cleanLineNoise function included in the PREP pipeline toolbox v. 0.55.4 (Bigdely-Shamlo et al., 2015). Artifactual data in the continuous EEG recording and bad electrodes were then automatically attenuated or removed using the Artifact Subspace Reconstruction method implemented in the Clean Rawdata plug-in ("clean_rawdata," Kothe, 2013; Piazza et al., 2016). Removed electrodes were interpolated using spherical interpolation, and data was then re-referenced to average. EEG data was submitted to extended Infomax independent component analysis (ICA, "pop_runica.m") to detect and afterward remove non-neural activity (eye and muscle movements). An automatic component classifier method (Multiple Artifact Rejection Algorithm: MARA; Winkler et al., 2014) was used to automatically identify and eliminate artifactual independent components.

The EEG data pre-processing pipeline was created adapting the suggestions reported in Miyakoshi (2021). Power Spectra Density (PSD) was computed using the EEGLAB spectopo function (pwelch, see Welch, 1967), and the data was analyzed over segments of 2 s, with a 50% overlap between segments (hamming window, zero-padding to 1024 data-point epochs length). Average values of PSDs for each of the experimental conditions, for all the EEG electrodes, and for all the frequencies from 2 to 30 Hz were obtained, to be able to have an overview of the activity for delta, theta, alpha, and beta waves.

## Electrodermal Activity

Electrodermal activity was measured using an electrode couples connected (long finger and index finger on the palmar side) to a wireless handcuff placed on the left, non-dominant hand. The recording baseline was individually adjusted using the Biopac default function for each participant prior to the experiment. The equipment used was the Biopac MP150 recording system (Biopac Systems, Inc., Goleta, CA, United States) and the amplifier BN-PPGED-R with 16-bit resolution and a sampling rate of 2 kHz. Participants were asked to avoid movements and to keep the left hand as still and relaxed as possible. The EDA data was operationalized computing two different variables exploring different aspects of the activity of sympathetic nervous system, the skin conductance level (SCL), and the number of skin conductance responses (SCRs). The SCL shows tonic and long-lasting activity of the sympathetic nervous system, while SCRs indicate phasic activity reflecting the number of stimulated nerve impulses regulating the secretion of sweat (Benedek and Kaernbach, 2010). SCRs were analyzed using the MATLAB Ledalab toolbox (Ledalab 3.4.9; Benedek and Kaernbach, 2010). Signal was first down-sampled (factor mean function) to 10 Hz, and then analyzed using continuous decomposition analyses (extraction of continuous phasic/tonic activity). The number of SCRs (during each of the videos) were then computed (amplitude threshold for inclusion of phasic responses = 0.01 μS), and absolute values were then exported for each participant. Average tonic SCL amplitude for each of the experimental conditions was also exported (μS). Results for videos of the same category (natural, urban, neutral/control), where averaged together, to obtain a unique index per each condition and for each participant.

## Statistical Analyses

Electroencephalography results were analyzed using the data analysis package integrated in the EEGLAB study function.

The difference between the three experimental conditions were first analyzed for the early alpha waves (8–11 Hz), as brain waves at these frequencies were found to be the most affected by the presentation of natural vs. non-natural sceneries in static photos (Grassini et al., 2019). The differences in the low alpha waves (PSD) were analyzed for all the electrodes. In computing statistic for the scalp topography, the presented exact *p*-values were obtained with parametric ANOVAs, while multiple comparisons were corrected with spatial clustering, using the traditional threshold of significance level of $p < 0.05$ (method: triangulation, cluster statistic: maxsum) as provided in the Matlab toolbox Fieldtrip (Fieldtrip Lite v20210330). Repeated-measures ANOVA was computed using experimental conditions (3) as factor, and *post hoc t*-tests were computed to study differences of activity in low alpha between the experimental conditions.

To control for the specificity of the effect for early-alpha waves (as reported in previous studies, see, e.g., Grassini et al., 2019), a further analysis in the wave-spectral domain was performed for two cluster of electrodes (central and occipital) that were reported to show prominent effects in processing. Therefore, PSD values for the electrodes placed over the center-frontal (electrodes FCz, FC1, and FC2 – central cluster) and center-occipital (electrodes Oz, O1, and O2 – occipital cluster) were averaged for each participant separately for the three experimental conditions, and the values compared over the spectral domain using an ANOVA and *post hoc t*-tests.

IBM SPSS v. 26 was used for the rest of the statistical analyses. Data from the subjective evaluations of the videos were analyzed using a repeated-measures ANOVA comparing the mean relaxation ratings between the three different experimental conditions, the statistically significant effects followed by pair-wise comparisons with two-tailed *t*-tests. Analyses of EDA and DSB were computed in the same way. For these analyses, when the data sphericity assumption was violated, Greenhouse–Geisser corrected *p*-values were reported.

# RESULTS

## Subjective Ratings

The relaxation ratings given after each of the four videos/condition were averaged to obtain a single score for each of the three experimental conditions. The scores ranged from a minimum of 1 to a maximum of 9. **Figure 2** shows the descriptive results for behavioral data. The one-way ANOVA showed that the perception of relaxation differed between the conditions, $F(2,46) = 43.05$, $p < 0.001$, e2 $= 0.652$. *Post hoc t*-tests revealed that natural environment videos were rated as the most relaxing and differed statistically both from the neutral ($p < 0.001$) and urban ($p < 0.001$) ones. Ratings did not differ between neutral and urban environments ($p = 0.184$).

## Digit Span Backward Task

ANOVA analysis showed that there were not statistically significant differences between the DSB task scores between the experimental conditions ($p = 0.189$). Descriptive data are reported in **Figure 3**.

## Electroencephalography

Oscillatory activity during the display of the videos (3) were compared for every recorded electrode (64), and for the early-alpha frequency band (from 8 to 11 Hz). **Figure 4**

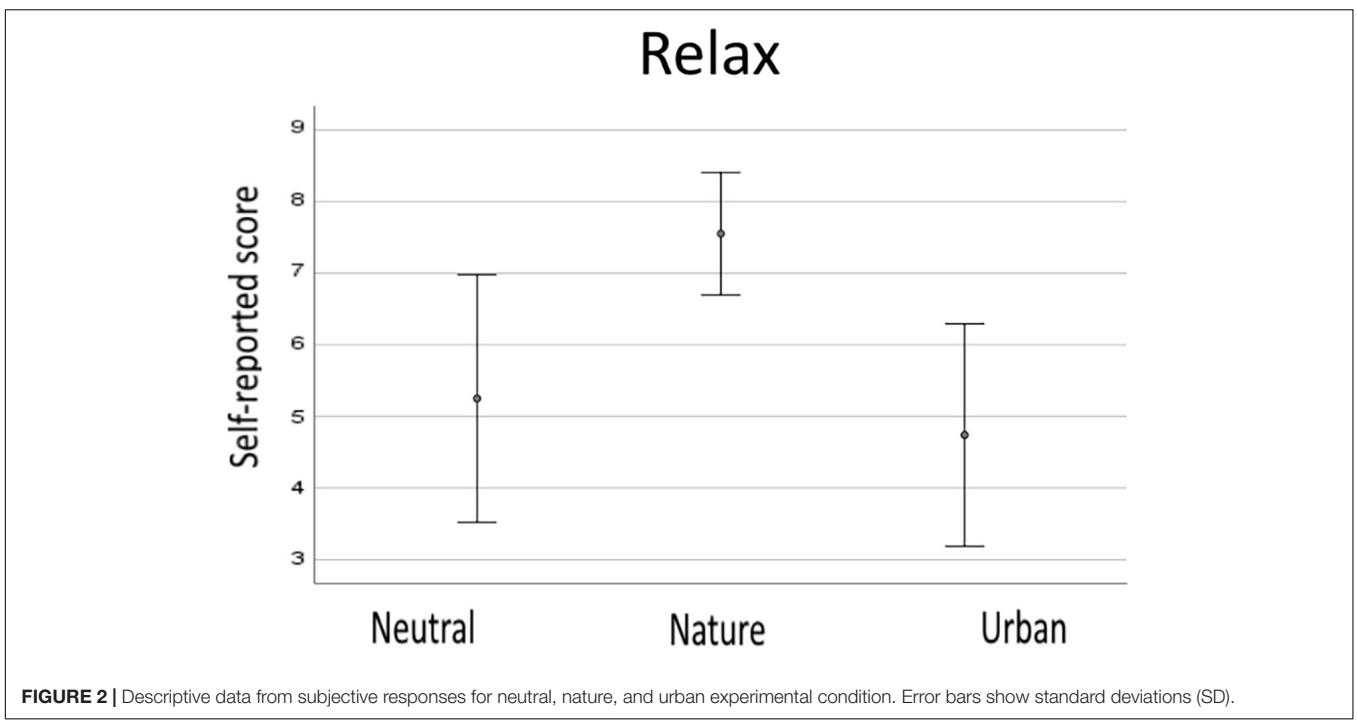



**FIGURE 2 |** Descriptive data from subjective responses for neutral, nature, and urban experimental condition. Error bars show standard deviations (SD).

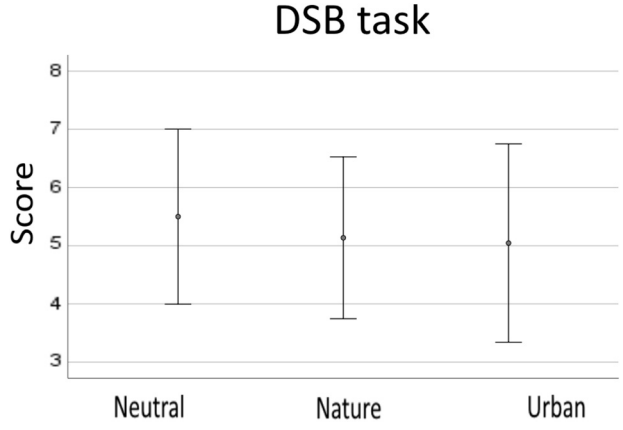



**FIGURE 3 |** Descriptive data from the DSB task for neutral, nature, and urban experimental condition. Error bars show standard deviations (SD).

(top panel) shows raw values and the results from the one-way ANOVA comparing the three experimental conditions. Visual inspection of the raw scores revealed that in low alpha waves frequencies, brain activity was generally higher across all the scalp during the videos displaying natural environments, compared with other conditions, while the neutral environment videos promoted the lowest level of early-alpha across all the scalp areas. Statistical analyses showed that the three experimental conditions differed, in the low alpha spectrum, over occipital-temporal and central sensors. *Post hoc* *t*-tests (**Figure 4** bottom panel) showed that videos of natural environments enhanced the production of early-alpha waves vs. neutral videos (over occipital-temporal areas), and vs. urban videos (over central-frontal areas). No statistically significant differences were revealed for any electrodes between neutral and urban conditions.

Based on the differences revealed by the ANOVA in the previous analyses, two electrode cluster were individuated (central and occipital) and the signal was analyzed in the spectral domain from 2 to 30 Hz. This analysis aimed to study whether the effects of viewing nature videos on spectral power was restricted specifically to the lower alpha band or whether they could be observed also in other frequencies. For the central cluster (**Figure 5**), the ANOVA showed that the three experimental conditions differed in early alpha (8–9 Hz) as well as in late theta (7–8 Hz) activity. Nature videos increased waves both in the early alpha and late theta, as compared with neutral and urban videos. Urban and neutral conditions differed only in slow theta frequencies between 5 and 6 Hz. Average values and distribution are shown in **Figure 6**.

For the occipital cluster (**Figure 7**), ANOVA showed that the three experimental conditions differed in early alpha (from 8 up to 11 Hz) as well as in early delta (2–4 Hz), and late alpha (11–13 Hz) up to early beta waves (13–15 Hz). Nature videos promoted higher alpha and early theta waves vs. the neutral videos in early delta (2–4 Hz), late theta (7–8), early and late alpha (8–13 Hz), as well as in early beta (13–15 Hz). No differences were found between nature and urban conditions. Urban videos showed to promote early-delta (2–4 Hz), late-alpha (11–13 Hz), and early-beta waves (13–15 Hz) compared to neutral ones. Average values and distribution are shown in **Figure 8**.

## Electrodermal Activity

The number of SCRs recorded for each of the experimental conditions were averaged and a singular numerical score was obtained for each condition. EDA – SCR scores were of 198.33 (SD = 32.57) for nature videos, 200.65 (SD = 33.53) nSCR for neutral videos, and 201.61 (SD = 33.86) for urban videos. One-way ANOVA showed that phasic activity SCRs did not differ between the three types of videos, $p = 0.068$ (**Figure 6**, left chart). Data for the tonic EDA (SCL) was averaged and analyzed in the same way as that for SCRs. EDA – SCL scores were of 1.43 (SD = 0.48) μS for nature videos, 1.49 (SD = 0.49) μS for neutral videos, and 1.39 (SD = −51) for urban videos. One-way ANOVA detected a statistically significant difference between the experimental conditions, $F(2,42) = 3.45$, $p = 0.041$. *Post hoc* *t*-tests, revealed that the lowest tonic activity was recorded in response to urban videos, and it statistically differed from the tonic activity recorded during the vision of the neutral videos ($p = 0.025$) but not from tonic activity related to the vision of nature videos ($p = 0.256$). Nature videos produced the second lowest level of EDA-SCL, but it did not differ from the one associated with neutral videos ($p = 0.146$). Data averages and distribution is shown in **Figure 9**.

# DISCUSSION

Even though it is widely acknowledged in the scientific literature that natural environments provide restoration and promote positive feelings (Kaplan and Kaplan, 1989; Hartig et al., 2014), it is still unknown how this exactly happens, or which biological processes are mediating the restorative effects.

The recently published studies of Grassini et al. (2019) and Elsadek et al. (2020) showed that exposure to natural settings, either real or in digitalized form, modulates brain activity and non-brain physiological responses, in line with results from older studies (Ulrich, 1981). Importantly, the reported EEG data pointed out that exposure to natural setting may be associated to an increase in brain alpha waves (especially early-alphas), that was hypothetically attributed to a down-modulation of attentional and cognitive processes (Grassini et al., 2019). Other studies have found that alpha-waves are associated to the experience of environments with positive values (Chang and Chen, 2005; Choi et al., 2015; Chiang et al., 2017; Bailey et al., 2018).

The present study aimed to confirm previous findings using more immersive scenes compared to some of the previous studies (Ulrich, 1981; Chang et al., 2008; Grassini et al., 2019). Furthermore, the present study aimed to compare EEG and EDA activity in response to nature environment not only to urban environments (as commonly done in this field of research), but also to a control condition. In this way we attempted to understand if the effect of modulation of physiological

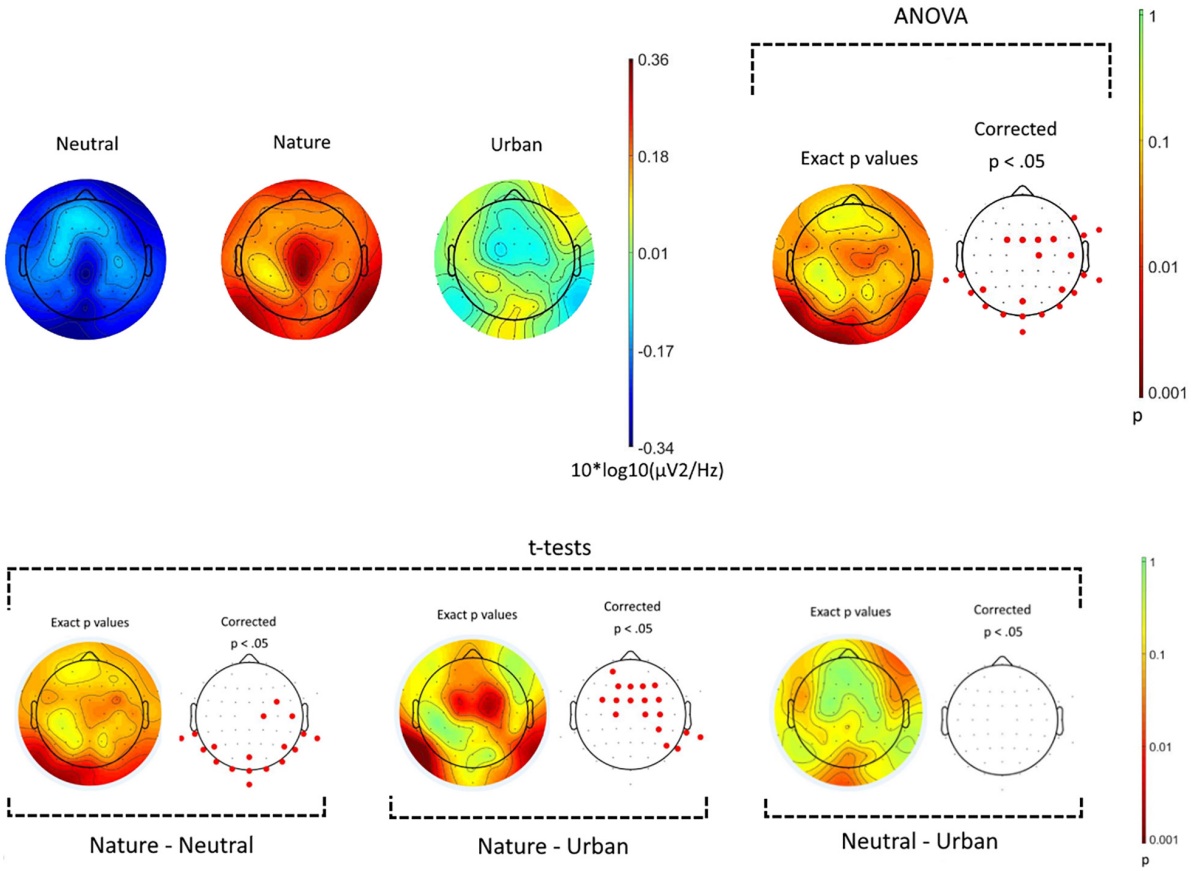



**FIGURE 4 |** Spatial distribution of power spectral density for early-alpha frequency band (8–11 Hz). The top panel shows the power spectral density for the three experimental conditions (neutral, nature, and urban videos). On the top-right side, the results from the ANOVA showing in red the electrodes where *ps* < 0.05. The bottom panel show the results of the *post hoc t*-tests.

arousal (measured using EDA) and EEG early alpha waves were modulated for the natural or for the urban environment compared to the control condition.

In the present experiment we recorded EEG and electrodermal activity while the participants viewed passively a series of scenes from natural, urban, or "control" environments. The control environment was obtained using computerized non-realistic scenes. After viewing each video, the participants were asked to self-report how relaxing they found the video. In line with several previous findings, participants rated as more relaxing the presentation of natural environments compared to those of urban environments. Ratings of perceived relaxation did not differ between neutral and urban environments video.

Our results are in line with our prediction concerning the modulation of early-alpha waves during the experience of videos of natural environments. The distribution of the early-alpha waves modulation showed to be mainly over central brain areas, in line with the findings of Ulrich (1981) and Grassini et al. (2019). The analyzed central early-alpha activity in response to the control condition videos did not differ from the one in urban videos, arguing for the early-alpha wave effect to be driven by the nature condition and not by the urban one. This finding may have important theoretical and practical implication: the scientific literature – especially the one on psychopathology (Van Os, 2004; McKenzie et al., 2013) – has often been focused on the detrimental role of urban settings on human health, instead of speculating for an "opposite" effect of the benefits driven instead from the exposure to natural environments.

Visual examination of spectral power density patterns in the scalp topographic activity map showed that the difference in early-alphas was not limited to the central brain areas but extended also for the activity recorded over the occipital-central brain area. We performed exploratory analysis for this brain area, and we found similar patterns than those for the centralized alpha activity. However, in this case the difference between the conditions extended more toward the beta powers, and brain activity in response to nature and urban videos were very similar over all the frequency spectra, while different from the activity recorded for the control condition. A speculative explanation may be related to the very different visual content (fast lines and colors) of the neutral condition, which may be able to modulate in a very different manner the visual cortex compared to the other two more slowly changing and realistic experimental conditions.

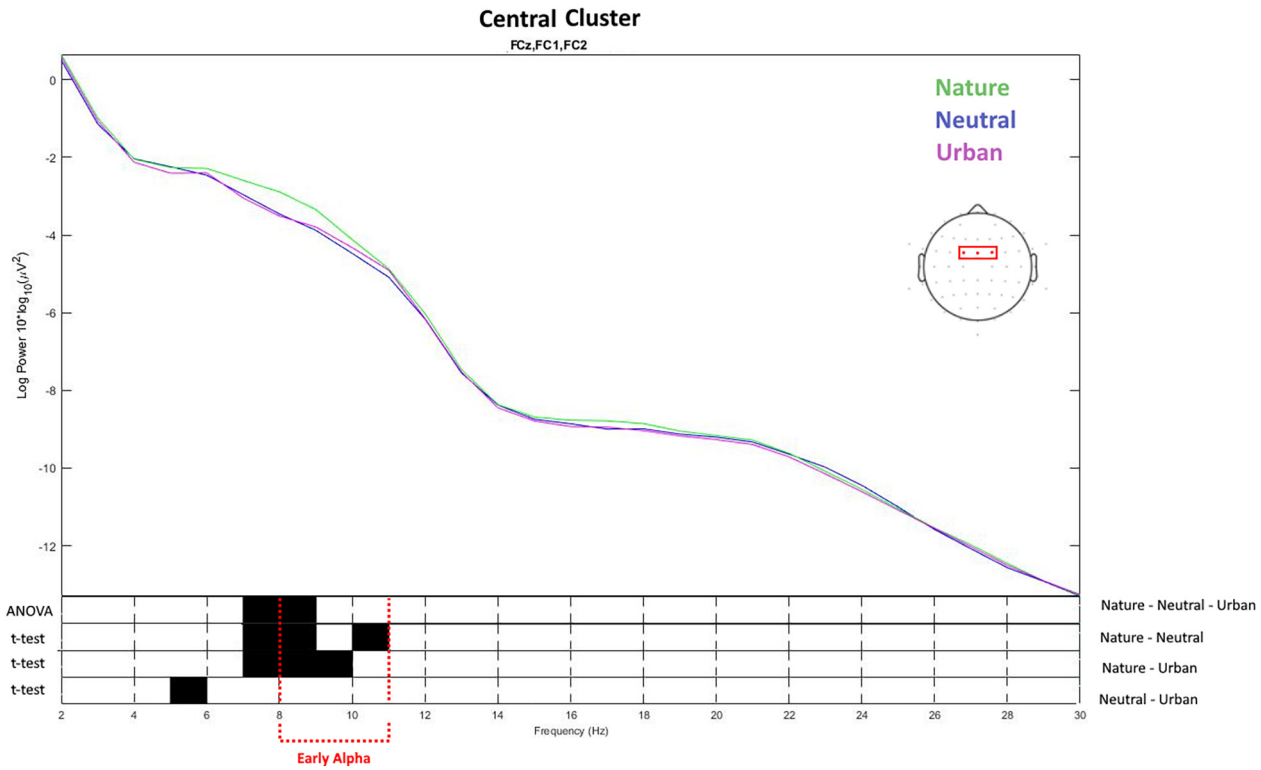



**FIGURE 5 |** The top of the figure presents the values of spectral power obtained averaging the values for the electrodes placed over the central brain area. The frequency (*X*-axis) and spectral power (*Y*-axis) for the three experimental conditions (neutral, nature, and urban videos). The bottom of the figure shows the results of ANOVA and *t*-tests on the differences between the conditions on the spectral power for each frequency from 2 to 30 Hz. The black color shows the frequency values in which the spectral power values were statistically different between the conditions.

Further visual inspection of the brainwaves pattern in graphical presentation of the power density × frequency analyses for the central cluster revealed that, alike early-alpha, a difference between the condition was also shown in late-theta spectral power density. This difference may be because of the higher perceived relaxation in response to the nature video condition. Several investigations have found that both alpha and theta power are associated to the activities of mindfulness and meditation (Aftanas and Golocheikine, 2001; Lagopoulos et al., 2009; Lomas et al., 2015), and therefore these brain waves may be both modulated in the same way during nature experiences in response to a relaxation and positive emotions. This effect seems to be in line with two recent studies [the lab-study of Sahni and Kumar (2020), and the real-life static exposure study of Chen et al. (2020)] showing that nature videos may modulate both alpha and theta power.

A recent study (Hopman et al., 2020) recorded resting state EEG brain activity before, during, and after a long, multi-day trip as exposure to natural environment. The researchers reported that posterior alpha power was significantly lower during the nature exposure when compared to measures taken before and after the visit to the natural environment. The authors did not analyze alpha waves over the central brain as such brain area was outside their a-priori brain region of interest, and therefore it is not possible from their data to understand the alpha modulation over the central brain. However, their midfrontal electrodes showed the same pattern reported from the posterior alpha power. These results show an opposite pattern compared to ours where instead exposure to natural settings increased alpha

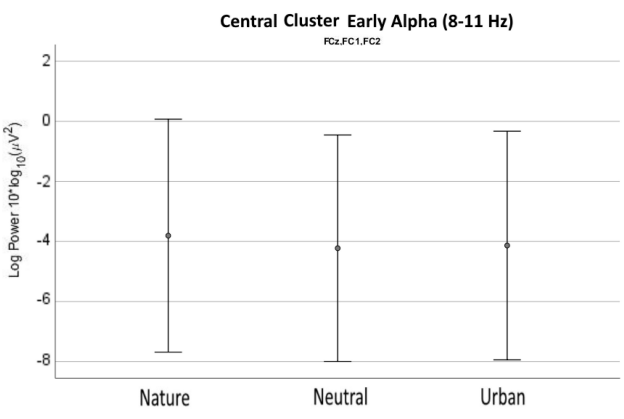



**FIGURE 6 |** Early alpha waves power density values as recorded (averaged) over the central cluster for neutral, nature, and urban experimental conditions. Error bars show standard deviations (SD).

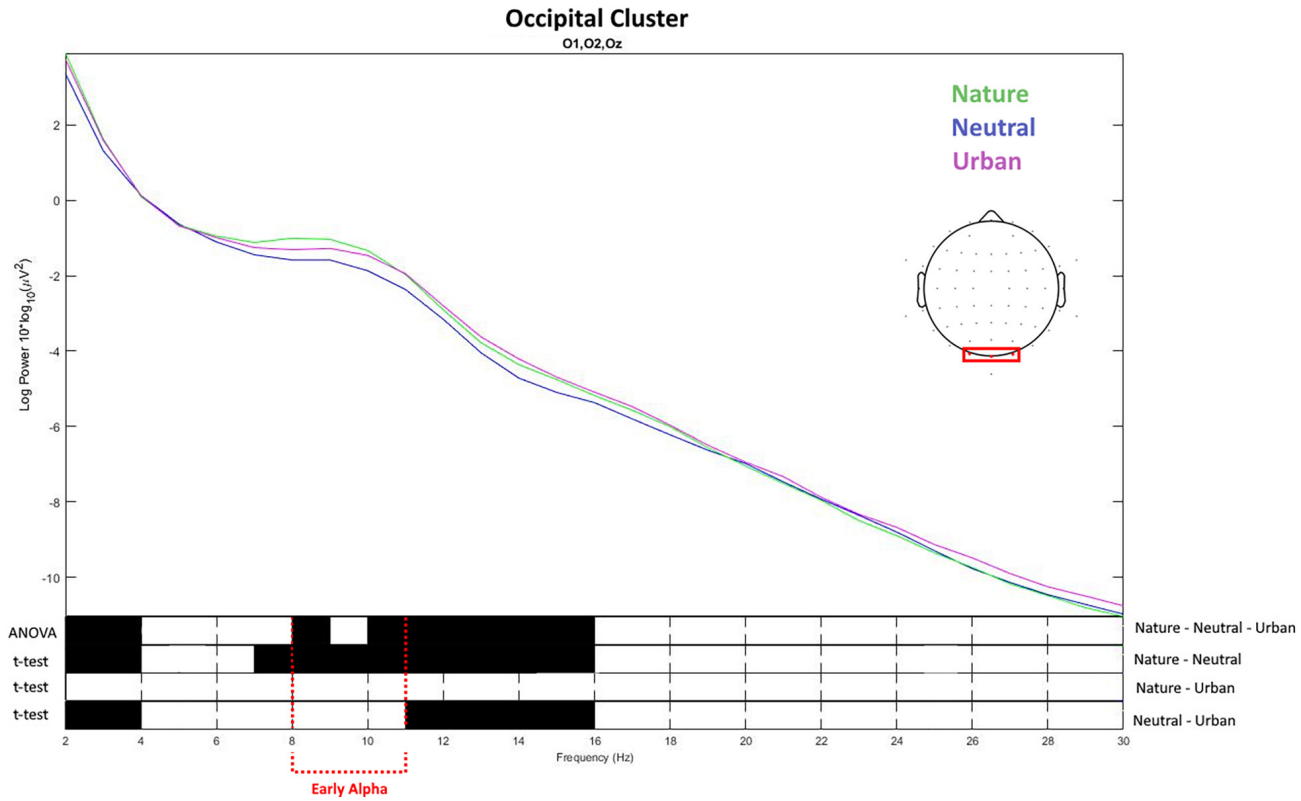



**FIGURE 7 |** The top of the figure presents the values of spectral power obtained averaging the values for the electrodes placed over the occipital brain area. The frequency (*X*-axis) and spectral power (*Y*-axis) for the three experimental conditions (neutral, nature, and urban videos). The bottom of the figure shows the results of ANOVA and *t*-tests for the difference between the conditions on the spectral power for each frequency from 2 to 30 Hz. Black color shows the frequency values in which the spectral power values were statistically different between the conditions.

power over most of the brain, and especially as recorded over central and occipital brain areas. Such difference in results may be due to the different types of exposure to natural environments and different level of multi-sensory perception and integration. One should note that Hopman et al. (2020) did not include a similar multi-day trip to urban or other non-natural environment as a control condition. However, our lab experiment was more controlled than the experiment of Hopman et al. (2020), and the trip in natural settings intervention that they provided in their experiment may have brought with it several uncontrolled factors that may have affected physiological responses (e.g., familiarity with the visited environment, activities specific to the trip, moods/affections/stressors modulated by the trip, etc.). Therefore, it is not clear what explains the differences between our results [and similar results reported by earliest studies of Ulrich (1981) and Grassini et al. (2019)] and the results reported in Hopman et al. (2020).

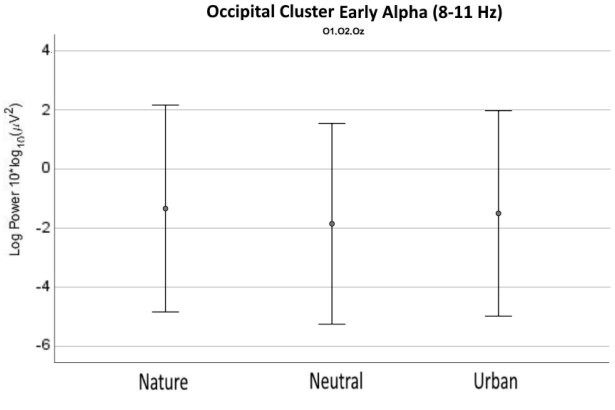



**FIGURE 8 |** Early alpha waves power density values as recorded (averaged) over the occipital cluster for neutral, nature, and urban experimental conditions. Error bars show standard deviations (SD).

The increase in alpha waves observed in our experiment suggests that the experience of nature video may be related to an increase activity of the inhibitory mechanism related to the activity of the thalamic-cortical circuit (Foxe and Snyder, 2011). In inhibiting attentional mechanisms, natural environments could be mediating stress reduction. The increase of theta activity over the mid-frontal brain areas during the vision of videos containing natural scenery may be related to increased cognitive control (Cooper et al., 2015). Cognitive control has been as well may have been related to stress (De Lissnyder et al., 2012). Both alpha and theta waves have been shown to be related to psychological states promoting relaxation as in the case

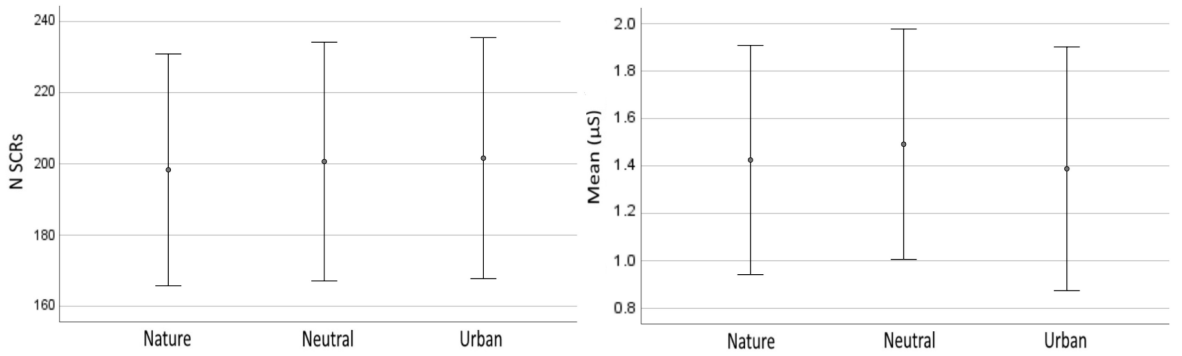



**FIGURE 9 |** Electrodermal activity in neutral, nature, and urban experimental conditions. Error bars show standard deviations (SD).

of different types of meditation and mindfulness practices (Aftanas and Golocheikine, 2001; Lagopoulos et al., 2009; Lomas et al., 2015).

Statistical analyses for SCRs did not show any statistically significant differences between the studied conditions. Analyses for SCL showed that the lowest level of tonic activity was recorded during the urban videos, but the follow-up *t*-tests showed that the difference was statistically significant only in the comparison against the neutral condition. These findings are difficult to explain and are against the expected results (Alvarsson et al., 2010; Hedblom et al., 2019). However, recent studies have also reported heterogeneous findings regarding the modulation of EDA in response to natural environments (Browning et al., 2020). Some experimental characteristics (e.g., participants engagement, salience of the stimuli, etc.) may be modulating EDA in ways that were not experimentally controlled. Furthermore, it is possible that a more immersive stimulation (e.g., experiencing multi-sensory natural stimuli) may be more effective in modulating EDA, as compared with the videos in experimentally controlled settings.

Contrarily with some previous investigations [as reported in the review of Ohly et al. (2016)], the DSB task did not show an increase in performance after exposure to nature (but see Grassini et al., 2019). Nevertheless, in many of the previous studies revealing this effect the participants were exposed to a real and multi-sensorial experience of nature (e.g., exposure to real natural settings) of a long duration and generally connected with a physical activity in nature (e.g., walking, see Berman et al., 2008; Berman et al., 2012). The short duration of our exposure to natural stimuli, or the lack of a task involving physical activity during the exposure, may have affected the measurable effect of restoration in the DSB task. In our study, the relatively low level of immersion provided by digitalized videos, the short exposure to natural settings provided by the experimental setting, and the possible nuisance of wearing the EEG cap and EDA sensors, may have compromised the possibility of natural scenes to provide attention restoration. Furthermore, many of the previous studies showing attention restoration after nature exposure had given cognitive stressors to their participants prior to the experimental session, to give the possibility for cognitive restoration to baseline to happen. As no stressor was given to our participants, their baseline level of cognitive load may have been low enough and not allowing to detect eventual cognitive restorative effects of the exposure to nature videos. Also, the effect sizes reported in studies reporting DSB changes in response to environmental exposure are generally small, and therefore the present study was probably underpowered to detect these cognitive effects.

Additionally, the DSB used in our experiment was digitalized and visual, while the most used type of DSB in the literature has been auditory and with verbal responses (see, e.g., Berman et al., 2008, 2012). However, please note that previous studies have also used the type of DSB employed in the present investigation (see AuBuchon et al., 2015; Grassini et al., 2019). We cannot exclude that a different type of sensory stimulation or the different modality of administration of the test may influence the ability of the test to detect cognitive restoration.

The main limitation of the present study was that brain activity may be modulated by uncontrolled factors (e.g., colors, shapes, presence of moving items, etc.) systematically affecting one of the other experimental conditions. Furthermore, the "neutral" condition may arguably not be neutral but depicting man-made computerized objects which are processed similarly to urban ones (e.g., for some uncontrolled low-level visual similarities, such as sharp shapes).

## CONCLUSION

The results presented in our study, together with the ones presented in previous investigations (Ulrich, 1981; Grassini et al., 2019; Sahni and Kumar, 2020), showed that experiencing natural environments in various real or computerize forms produces measurable and reliable brain activity markers which are known to be related to cognitive and emotional restorative processes (Aftanas and Golocheikine, 2001; Lagopoulos et al., 2009; Baijal and Srinivasan, 2010). Therefore, they can be argued to promote restorative processes. The present study shows that even a type of nature visualization providing a relatively low-level of immersion – as videos – may be enough to promote some level of restoration. The presented results showed that brain activity – especially early-alpha waves recorded over the central brain – may represent a reliable index for nature-induced restoration,

strengthening previous findings. On the other hand, contrarily to our expectations but in line with some recent literature, EDA-related indexes were not able to detect nature-induced restoration in our experimental setting. Differently to most previous studies on the topic, our investigation has the advantage of employing simultaneously both physiological and psychological methods to understand restorative processes during a lab-controlled exposure to videos, featuring both brain (EEG) and non-brain (EDA) physiological measures, and both self-assessment (relax rating of the videos), and behavioral test (DSB scores). In our knowledge, our study is one of the first ones attempting to understand if the positive effects reported in connection with natural experience may be driven by detrimental effect of urban settings or by proprieties of natural settings, our results supporting the latter alternative.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee for Human Sciences at the University of Turku. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

SG developed the study idea, conceptualized the study design, responsible for the choice of the study methodology, developed the experimental paradigm, trained and supervised the laboratory assistants, responsible for the data analysis, data pre-processing scripts, and data curation, and had the main role in writing the manuscript draft. GS assisted the study planning and selection of experimental stimuli and responsible for the laboratory tests. MK assisted the development of the study, supervised the research project, and assisted the writing of the final version of the manuscript and the revisions of it. All authors contributed to the article and approved the submitted version.

## REFERENCES


Aftanas, L. I., and Golocheikine, S. A. (2001). Human anterior and frontal midline theta and lower alpha reflect emotionally positive state and internalized attention: high-resolution EEG investigation of meditation. *Neurosci. Lett.* 310, 57–60. doi: 10.1016/s0304-3940(01)02094-8

Alvarsson, J. J., Wiens, S., and Nilsson, M. E. (2010). Stress recovery during exposure to nature sound and environmental noise. *Int. J. Environ. Res. Public Health* 7, 1036–1046. doi: 10.3390/ijerph7031036

Annerstedt, M., Jönsson, P., Wallergård, M., Johansson, G., Karlson, B., Grahn, P., et al. (2013). Inducing physiological stress recovery with sounds of nature in a virtual reality forest—results from a pilot study. *Physiol. Behav.* 118, 240–250. doi: 10.1016/j.physbeh.2013.05.023

Aspinall, P., Mavros, P., Coyne, R., and Roe, J. (2015). The urban brain: analysing outdoor physical activity with mobile EEG. *Br. J. Sports Med.* 49, 272–276. doi: 10.1136/bjsports-2012-091877

AuBuchon, A. M., Pisoni, D. B., and Kronenberger, W. G. (2015). Short-term and working memory impairments in early-implanted, long-term cochlear implant users are independent of audibility and speech production. *Ear Hear.* 36:733. doi: 10.1097/AUD.0000000000000189

Baijal, S., and Srinivasan, N. (2010). Theta activity and meditative states: spectral changes during concentrative meditation. *Cogn. Proc.* 11, 31–38. doi: 10.1007/s10339-009-0272-0

Bailey, A. W., Allen, G., Herndon, J., and Demastus, C. (2018). Cognitive benefits of walking in natural versus built environments. *World Leisure J.* 60, 293–305. doi: 0.1080/16078055.2018.1445025

Benedek, M., and Kaernbach, C. (2010). A continuous measure of phasic electrodermal activity. *J. Neurosci. Methods* 190, 80–91. doi: 10.1016/j.jneumeth.2010.04.028

Benfield, J. A., Taff, B. D., Newman, P., and Smyth, J. (2014). Natural sound facilitates mood recovery. *Ecopsychology* 6, 183–188.

Berman, M. G., Jonides, J., and Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychol. Sci.* 19, 1207–1212. doi: 10.1111/j.1467-9280.2008.02225.x

Berman, M. G., Kross, E., Krpan, K. M., Askren, M. K., Burson, A., Deldin, P. J., et al. (2012). Interacting with nature improves cognition and affect for individuals with depression. *J. Affect. Disord.* 140, 300–305. doi: 10.1016/j.jad.2012.03.012

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *J. Environ. Psychol.* 25, 249–259. doi: 10.1016/j.jenvp.2005.07.001

Bevan, M. D., Magill, P. J., Terman, D., Bolam, J. P., and Wilson, C. J. (2002). Move to the rhythm: oscillations in the subthalamic nucleus–external globus pallidus network. *Trends Neurosci.* 25, 525–531. doi: 10.1016/s0166-2236(02)02235-x

Bigdely-Shamlo, N., Mullen, T., Kothe, C., Su, K. M., and Robbins, K. A. (2015). The PREP pipeline: standardized preprocessing for large-scale EEG analysis. *Front. Neuroinform.* 9:16. doi: 10.3389/fninf.2015.00016

Bratman, G. N., Daily, G. C., Levy, B. J., and Gross, J. J. (2015). The benefits of nature experience: improved affect and cognition. *Landscape Urban Plann.* 138, 41–50. doi: 10.1016/j.landurbplan.2015.02.005

Brown, D. K., Barton, J. L., and Gladwell, V. F. (2013). Viewing nature scenes positively affects recovery of autonomic function following acute-mental stress. *Environ. Sci. Technol.* 47, 5562–5569. doi: 10.1021/es305019p

Browning, M. H., Mimnaugh, K. J., van Riper, C. J., Laurent, H. K., and LaValle, S. M. (2020). Can simulated nature support mental health? comparing short, single-doses of 360-degree nature videos in virtual reality with the outdoors. *Front. Psychol.* 10:2667. doi: 10.3389/fpsyg.2019.02667

Cavanagh, J. F., and Shackman, A. J. (2015). Frontal midline theta reflects anxiety and cognitive control: meta-analytic evidence. *J. Physiology-Paris* 109, 3–15. doi: 10.1016/j.jphysparis.2014.04.003

Cavanagh, J. F., Figueroa, C. M., Cohen, M. X., and Frank, M. J. (2012). Frontal theta reflects uncertainty and unexpectedness during exploration and exploitation. *Cereb. Cortex* 22, 2575–2586. doi: 10.1093/cercor/bhr332

Cavanagh, J. F., Frank, M. J., Klein, T. J., and Allen, J. J. (2010). Frontal theta links prediction errors to behavioral adaptation in reinforcement learning. *Neuroimage* 49, 3198–3209. doi: 10.1016/j.neuroimage.2009.11.080

Chang, C. Y., and Chen, P. K. (2005). Human response to window views and indoor plants in the workplace. *HortScience* 40, 1354–1359. doi: 10.21273/HORTSCI.40.5.1354

Chang, C. Y., Hammitt, W. E., Chen, P. K., Machnik, L., and Su, W. C. (2008). Psychophysiological responses and restorative values of natural environments in Taiwan. *Landscape Urban Plann.* 85, 79–84. doi: 10.1016/j.landurbplan.2007.09.010

Chen, Z., He, Y., and Yu, Y. (2020). Attention restoration during environmental exposure *via* alpha-theta oscillations and synchronization. *J. Environ. Psychol.* 68:101406. doi: 10.1016/j.jenvp.2020.101406

Chiang, Y. C., Li, D., and Jane, H. A. (2017). Wild or tended nature? the effects of landscape location and vegetation density on physiological and psychological responses. *Landscape Urban Plann.* 167, 72–83. doi: 10.1016/j.landurbplan.2017.06.001

Choi, Y., Kim, M., and Chun, C. (2015). Measurement of occupants' stress based on electroencephalograms (EEG) in twelve combined environments. *Building Environ.* 88, 65–72. doi: 10.1016/j.buildenv.2014.10.003

Cohen, S., and Spacapan, S. (1978). The aftereffects of stress: an attentional interpretation. *Environ. Psychol. Nonverbal Behav.* 3, 43–57. doi: 10.1016/j.actpsy.2009.06.008

Cooper, P. S., Wong, A. S., Fulham, W. R., Thienel, R., Mansfield, E., Michie, P. T., et al. (2015). Theta frontoparietal connectivity associated with proactive and reactive cognitive control processes. *Neuroimage* 108, 354–363. doi: 10.1016/j.neuroimage.2014.12.028

Coste, C. P., and Kleinschmidt, A. (2016). Cingulo-opercular network activity maintains alertness. *Neuroimage* 128, 264–272. doi: 10.1016/j.neuroimage.2016.01.026

Critchley, H. D. (2002). Electrodermal responses: what happens in the brain. *Neuroscientist* 8, 132–142. doi: 10.1177/107385840200800209

De Lissnyder, E., Koster, E. H., Goubert, L., Onraedt, T., Vanderhasselt, M. A., and De Raedt, R. (2012). Cognitive control moderates the association between stress and rumination. *J. Behav. Ther. Exp. Psychiatry* 43, 519–525. doi: 10.1016/j.jbtep.2011.07.004

Delorme, A., and Makeig, S. (2004). EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *J. Neurosci. Methods* 134, 9–21.

Dosenbach, N. U., Fair, D. A., Cohen, A. L., Schlaggar, B. L., and Petersen, S. E. (2008). A dual-networks architecture of top-down control. *Trends Cogn. Sci.* 12, 99–105. doi: 10.1016/j.tics.2008.01.001

Egner, L. E., Sütterlin, S., and Calogiuri, G. (2020). Proposing a framework for the restorative effects of nature through conditioning: conditioned restoration theory. *Int. J. Environ. Res. Public Health* 17:6792. doi: 10.3390/ijerph17186792

Elsadek, M., Liu, B., and Xie, J. (2020). Window view and relaxation: viewing green space from a high-rise estate improves urban dwellers' wellbeing. *Urban Forestry Urban Green.* 55:126846.

Emfield, A. G., and Neider, M. B. (2014). Evaluating visual and auditory contributions to the cognitive restoration effect. *Front. Psychol.* 5:548. doi: 10.3389/fpsyg.2014.00548

Engell, T., Lorås, H. W., and Sigmundsson, H. (2020). Window view of nature after brief exercise improves choice reaction time and heart rate restoration. *New Ideas Psychol.* 58:100781.

Fan, Y., Duncan, N. W., de Greck, M., and Northoff, G. (2011). Is there a core neural network in empathy? an fMRI based quantitative meta-analysis. *Neurosci. Biobehav. Rev.* 35, 903–911. doi: 10.1016/j.neubiorev.2010.10.009

Foxe, J. J., and Snyder, A. C. (2011). The role of alpha-band brain oscillations as a sensory suppression mechanism during selective attention. *Front. Psychol.* 2:154. doi: 10.3389/fpsyg.2011.00154

Gladwell, V. F., Kuoppa, P., Tarvainen, M. P., and Rogerson, M. (2016). A lunchtime walk in nature enhances restoration of autonomic control during night-time sleep: results from a preliminary study. *Int. J. Environ. Res. Public Health* 13:280. doi: 10.3390/ijerph13030280

Gopal, A., Clark, E., Allgair, A., D'Amato, C., Furman, M., Gansler, D. A., et al. (2013). Dorsal/ventral parcellation of the amygdala: relevance to impulsivity and aggression. *Psychiatry Res.: Neuroimaging* 211, 24–30. doi: 10.1016/j.pscychresns.2012.10.010

Grassini, S. (2022). A systematic review and meta-analysis of nature walk as an intervention for anxiety and depression. *J. Clin. Med.* 11:1731. doi: 10.3390/jcm11061731

Grassini, S., Revonsuo, A., Castellotti, S., Petrizzo, I., Benedetti, V., and Koivisto, M. (2019). Processing of natural scenery is associated with lower attentional and cognitive load compared with urban ones. *J. Environ. Psychol.* 62, 1–11.

Haga, A., Halin, N., Holmgren, M., and Sörqvist, P. (2016). Psychological restoration can depend on stimulus-source attribution: a challenge for the evolutionary account? *Front. Psychol.* 7:1831. doi: 10.3389/fpsyg.2016.01831

Hahn, A., Stein, P., Windischberger, C., Weissenbacher, A., Spindelegger, C., Moser, E., et al. (2011). Reduced resting-state functional connectivity between amygdala and orbitofrontal cortex in social anxiety disorder. *Neuroimage* 56, 881–889. doi: 10.1016/j.neuroimage.2011.02.064

Hartig, T., Böök, A., Garvill, J., Olsson, T., and Gärling, T. (1996). Environmental influences on psychological restoration. *Scand. J. Psychol.* 37, 378–393. doi: 10.1111/j.1467-9450.1996.tb00670.x

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., and Gärling, T. (2003). Tracking restoration in natural and urban field settings. *J. Environ. Psychol.* 23, 109–123.

Hartig, T., Mitchell, R., De Vries, S., and Frumkin, H. (2014). Nature and health. *Annu. Rev. Public Health* 35, 207–228.

Hedblom, M., Gunnarsson, B., Iravani, B., Knez, I., Schaefer, M., Thorsson, P., et al. (2019). Reduction of physiological stress by urban green space in a multisensory virtual experiment. *Sci. Rep.* 9:10113. doi: 10.1038/s41598-019-46099-7

Hettinger, N. (2012). "Nature restoration as a paradigm for the human relationship with nature," in *Ethical Adaptation to Climate Change: Human Virtues of the Future,* eds A. Thompson and J. Bendik-Keymer (Cambridge, MA: MIT Press), 27–46.

Hopman, R. J., LoTemplio, S. B., Scott, E. E., McKinney, T. L., and Strayer, D. L. (2020). Resting-state posterior alpha power changes with prolonged exposure in a natural environment. *Cogn. Res. Principles Implicat.* 5:51. doi: 10.1186/s41235-020-00247-0

Hunter, M. D., Eickhoff, S. B., Pheasant, R. J., Douglas, M. J., Watts, G. R., Farrow, T. F., et al. (2010). The state of tranquility: subjective perception is shaped by contextual modulation of auditory connectivity. *Neuroimage* 53, 611–618. doi: 10.1016/j.neuroimage.2010.06.053

Jahncke, H., Eriksson, K., and Naula, S. (2015). The effects of auditive and visual settings on perceived restoration likelihood. *Noise Health* 17:1. doi: 10.4103/1463-1741.149559

Jones, S. R., Kerr, C. E., Wan, Q., Pritchett, D. L., Hämäläinen, M., and Moore, C. I. (2010). Cued spatial attention drives functionally relevant modulation of the mu rhythm in primary somatosensory cortex. *J. Neurosci.* 30, 13760–13765. doi: 10.1523/JNEUROSCI.2969-10.2010

Joye, Y., and Van den Berg, A. (2011). Is love for green in our genes? a critical analysis of evolutionary assumptions in restorative environments research. *Urban Forestry Urban Green.* 10, 261–268.

Joye, Y., Steg, L., Ünal, A. B., and Pals, R. (2016). When complex is easy on the mind: internal repetition of visual information in complex objects is a source of perceptual fluency. *J. Exp. Psychol. Hum. Percept. Perform.* 42:103. doi: 10.1037/xhp0000105

Kaplan, R., and Kaplan, S. (1989). *The Experience of Nature: A Psychological Perspective*. Cambridge: Cambridge university press.

Kaplan, S. (1995). The restorative benefits of nature: toward an integrative framework. *J. Environ. Psychol.* 15, 169–182.

Kerr, K. L., Avery, J. A., Barcalow, J. C., Moseman, S. E., Bodurka, J., Bellgowan, P. S., et al. (2015). Trait impulsivity is related to ventral ACC and amygdala activity during primary reward anticipation. *Soc. Cogn. Affect. Neurosci.* 10, 36–42. doi: 10.1093/scan/nsu023

Kim, G. W., Jeong, G. W., Kim, T. H., Baek, H. S., Oh, S. K., Kang, H. K., et al. (2010). Functional neuroanatomy associated with natural and urban scenic views in the human brain: 3.0 T functional MR imaging. *Korean J. Radiol.* 11, 507–513. doi: 10.3348/kjr.2010.11.5.507

Kim, H. G., Cheon, E. J., Bai, D. S., Lee, Y. H., and Koo, B. H. (2018). Stress and heart rate variability: a meta-analysis and review of the literature. *Psychiatry Invest.* 15:235. doi: 10.30773/pi.2017.08.17

Kim, M. J., Gee, D. G., Loucks, R. A., Davis, F. C., and Whalen, P. J. (2011). Anxiety dissociates dorsal and ventral medial prefrontal cortex functional connectivity with the amygdala at rest. *Cereb. Cortex* 21, 1667–1673. doi: 10.1093/cercor/bhq237

Korpela, K., and Kinnunen, U. (2010). How is leisure time interacting with nature related to the need for recovery from work demands? testing multiple mediators. *Leisure Sci.* 33, 1–14.

Korpela, K., De Bloom, J., and Kinnunen, U. (2015). From restorative environments to restoration in work. *Intell. Build. Int.* 7, 215–223.

Kothe, C. (2013). *The Artifact Subspace Reconstruction Method.* Available online at: https://sccn.ucsd.edu/githubwiki/files/asr-final-export.pdf (accessed January 25, 2022).

Lagopoulos, J., Xu, J., Rasmussen, I., Vik, A., Malhi, G. S., Eliassen, C. F., et al. (2009). Increased theta and alpha EEG activity during nondirective meditation. *J. Alternative Complementary Med.* 15, 1187–1192. doi: 10.1089/acm.2009.0113

Lamm, C., Decety, J., and Singer, T. (2011). Meta-analytic evidence for common and distinct neural networks associated with directly experienced pain and empathy for pain. *Neuroimage* 54, 2492–2502. doi: 10.1016/j.neuroimage.2010.10.014

Laumann, K., Gärling, T., and Stormark, K. M. (2003). Selective attention and heart rate responses to natural and urban environments. *J. Environ. Psychol.* 23, 125–134.

Lepore, S. J., and Evans, G. W. (1996). "Coping with multiple stressors in the environment," in *Handbook of Coping: Theory, Research, Applications*, eds M. Zeidner and N. S. Endler (Hoboken, NJ: John Wiley & Sons), 350–377.

Leventhal, D. K., Gage, G. J., Schmidt, R., Pettibone, J. R., Case, A. C., and Berke, J. D. (2012). Basal ganglia beta oscillations accompany cue utilization. *Neuron* 73, 523–536. doi: 10.1016/j.neuron.2011.11.032

Lomas, T., Ivtzan, I., and Fu, C. H. (2015). A systematic review of the neurophysiology of mindfulness on EEG oscillations. *Neurosci. Biobehav. Rev.* 57, 401–410. doi: 10.1016/j.neubiorev.2015.09.018

McKenzie, K., Murray, A., and Booth, T. (2013). Do urban environments increase the risk of anxiety, depression and psychosis? an epidemiological study. *J. Affect. Disord.* 150, 1019–1024. doi: 10.1016/j.jad.2013.05.032

Miller, K. J., Hermes, D., Honey, C. J., Hebb, A. O., Ramsey, N. F., Knight, R. T., et al. (2012). Human motor cortical activity is selectively phase-entrained on underlying rhythms. *PLoS One* 8:e1002655. doi: 10.1371/journal.pcbi.1002655

Miyakoshi, M. (2021). *'s Preprocessing Pipeline*. Available online at: https://sccn.ucsd.edu/wiki/'s_preprocessing_pipeline (accessed September, 13, 2021).

Neuper, C., and Pfurtscheller, G. (2001). Event-related dynamics of cortical rhythms: frequency-specific features and functional correlates. *Int. J. Psychophysiol.* 43, 41–58. doi: 10.1016/s0167-8760(01)00178-7

Norwood, M. F., Lakhani, A., Maujean, A., Zeeman, H., Creux, O., and Kendall, E. (2019). Brain activity, underlying mood and the environment: a systematic review. *J. Environ. Psychol.* 65:101321.

Ohly, H., White, M. P., Wheeler, B. W., Bethel, A., Ukoumunne, O. C., Nikolaou, V., et al. (2016). Attention restoration theory: a systematic review of the attention restoration potential of exposure to natural environments. *J. Toxicol. Environ. Health Part B* 19, 305–343. doi: 10.1080/10937404.2016.1196155

Park, B. J., Tsunetsugu, Y., Kasetani, T., Hirano, H., Kagawa, T., Sato, M., et al. (2007). Physiological effects of shinrin-yoku (taking in the atmosphere of the forest)—using salivary cortisol and cerebral activity as indicators—. *J. Physiol. Anthropol.* 26, 123–128. doi: 10.2114/jpa2.26.123

Park, B. J., Tsunetsugu, Y., Kasetani, T., Kagawa, T., and Miyazaki, Y. (2010). The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan. *Environ. Health Prevent. Med.* 15, 18–26. doi: 10.1007/s12199-009-0086-9

Piazza, C., Miyakoshi, M., Akalin-Acar, Z., Cantiani, C., Reni, G., Bianchi, A. M., et al. (2016). "An automated function for identifying eeg independent components representing bilateral source activity," in *Proceedings of the XIV Mediterranean Conference on Medical and Biological Engineering and Computing 2016*, (Cham: Springer). doi: 10.1007/978-3-319-32703-7_22

Raanaas, R. K., Patil, G., and Alve, G. (2016). Patients' recovery experiences of indoor plants and viewsof nature in a rehabilitation center. *Work* 53, 45–55. doi: 10.3233/WOR-152214

Ratcliffe, E., Gatersleben, B., and Sowden, P. T. (2013). Bird sounds and their contributions to perceived attention restoration and stress recovery. *J. Environ. Psychol.* 36, 221–228. doi: 10.1016/j.ctcp.2017.08.004

Roe, J. J., Aspinall, P. A., Mavros, P., and Coyne, R. (2013). Engaging the brain: the impact of natural versus urban scenes using novel EEG methods in an experimental setting. *Environ. Sci.* 1, 93–104.

Sadaghiani, S., Scheeringa, R., Lehongre, K., Morillon, B., Giraud, A. L., and Kleinschmidt, A. (2010). Intrinsic connectivity networks, alpha oscillations, and tonic alertness: a simultaneous electroencephalography/functional magnetic resonance imaging study. *J. Neurosci.* 30, 10243–10250. doi: 10.1523/JNEUROSCI.1004-10.2010

Sahni, P., and Kumar, J. (2020). Effect of nature experience on fronto-parietal correlates of neurocognitive processes involved in directed attention: an ERP study. *Ann. Neurosci.* 27, 136–147. doi: 10.1177/0972753121990143

Sherman, M. A., Lee, S., Law, R., Haegens, S., Thorn, C. A., Hämäläinen, M. S., et al. (2016). Neural mechanisms of transient neocortical beta rhythms: converging evidence from humans, computational modeling, monkeys, and mice. *Proc. Natl. Acad. Sci. U S A.* 113, E4885–E4894. doi: 10.1073/pnas.1604135113

Siegel, M., Donner, T. H., Oostenveld, R., Fries, P., and Engel, A. K. (2008). Neuronal synchronization along the dorsal visual pathway reflects the focus of spatial attention. *Neuron* 60, 709–719. doi: 10.1016/j.neuron.2008.09.010

Sripada, R. K., King, A. P., Garfinkel, S. N., Wang, X., Sripada, C. S., Welsh, R. C., et al. (2012). Altered resting-state amygdala functional connectivity in men with posttraumatic stress disorder. *J. Psychiatry Neurosci. JPN* 37:241. doi: 10.1503/jpn.110069

Stevenson, M. P., Schilhab, T., and Bentsen, P. (2018). Attention Restoration Theory II: a systematic review to clarify attention processes affected by exposure to natural environments. *J. Toxicol. Environ. Health Part B* 21, 227–268. doi: 10.1080/10937404.2018.1505571

Stigsdotter, U. A., and Grahn, P. (2004). "A garden at your workplace may reduce stress," in *Design & Health*, ed. A. Dilani (Stockholm: Research center for Design and Health).

Tyrväinen, L., Ojala, A., Korpela, K., Lanki, T., Tsunetsugu, Y., and Kagawa, T. (2014). The influence of urban green environments on stress relief measures: a field experiment. *J. Environ. Psychol.* 38, 1–9.

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kaźmierczak, A., Niemela, J., et al. (2007). Promoting ecosystem and human health in urban areas using green infrastructure: a literature review. *Landscape Urban Plann.* 81, 167–178. doi: 10.1016/j.scitotenv.2018.09.030

Ulrich, R. S. (1979). Visual landscapes and psychological well-being. *Landscape Res.* 4, 17–23. doi: 10.1080/01426397908705892

Ulrich, R. S. (1981). Natural versus urban scenes: some psychophysiological effects. *Environ. Behav.* 13, 523–556. doi: 10.1177/0013916581135001

Ulrich, R. S. (1983). "Aesthetic and affective response to natural environment," in *Behavior and the Natural Environment*, eds I. Altman and J. F. Wohlwill (Boston, MA: Springer). doi: 10.3389/fnhum.2021.676032

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., and Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *J. Environ. Psychol.* 11, 201–230. doi: 10.1016/S0272-4944(05)80184-7

Van Os, J. I. M. (2004). Does the urban environment cause psychosis? *Br. J. Psychiatry* 184, 287–288. doi: 10.1192/bjp.184.4.287

Veer, I. M., Oei, N. Y., Spinhoven, P., van Buchem, M. A., Elzinga, B. M., and Rombouts, S. A. (2011). Beyond acute social stress: increased functional connectivity between amygdala and cortical midline structures. *NeuroImage* 57, 1534–1541. doi: 10.1016/j.neuroimage.2011.05.074

Vozzi, A., Ronca, V., Aricò, P., Borghini, G., Sciaraffa, N., Cherubino, P., et al. (2021). The sample size matters: to what extent the participant reduction affects the outcomes of a neuroscientific research. a case-study in neuromarketing field. *Sensors* 21:6088. doi: 10.3390/s21186088

Welch, P. (1967). The use of fast Fourier transform for the estimation of power spectra: a method based on time averaging over short, modified periodograms. *IEEE Trans. Audio Electroacoust.* 15, 70–73. doi: 10.1109/TAU.1967.1161901

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

Winkler, I., Brandl, S., Horn, F., Waldburger, E., Allefeld, C., and Tangermann, M. (2014). Robust artifactual independent component classification for BCI practitioners. *J. Neural Eng.* 11:035013. doi: 10.1088/1741-2560/11/3/035013

Yeo, N. L., White, M. P., Alcock, I., Garside, R., Dean, S. G., Smalley, A. J., et al. (2020). What is the best way of delivering virtual nature for improving mood? an experimental comparison of high definition TV, 360 video, and computer generated virtual reality. *J. Environ. Psychol.* 72:101500. doi: 10.1016/j.jenvp.2020.101500

Yu, C. P., Lee, H. Y., and Luo, X. Y. (2018). The effect of virtual reality forest and urban environments on physiological and psychological responses. *Urban Forestry Urban Green.* 35, 106–114.

**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Publisher's Note:** All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

frontiers | Frontiers in Psychology

TYPE Perspective
PUBLISHED 25 August 2022
DOI 10.3389/fpsyg.2022.977703



OPEN ACCESS

EDITED BY
Matt W. Hayward,
University of Newcastle, Australia

REVIEWED BY
Meera Anna Oommen,
Dakshin Foundation, India
Rosie Cooney,
Australian National University, Australia

*CORRESPONDENCE
Simon Pooley
s.pooley@bbk.ac.uk

SPECIALTY SECTION
This article was submitted to Environmental Psychology, a section of the journal Frontiers in Psychology

RECEIVED 24 June 2022
ACCEPTED 25 July 2022
PUBLISHED 25 August 2022

CITATION
Pooley S (2022) The challenge of compassion in predator conservation. *Front. Psychol.* 13:977703. doi: 10.3389/fpsyg.2022.977703



# The challenge of compassion in predator conservation

Simon Pooley[1,2]*

[1]Department of Geography, Birkbeck, University of London, London, United Kingdom, [2]School of Life Sciences, University of KwaZulu-Natal, Scottsville, South Africa

This paper argues that compassion for wild animals and the humans living alongside them should be integral to wildlife conservation. Nowhere is this more apparent than in predator conservation, and case studies are used to explore the consequences of wild animal attacks for human victims. Some arguments for extending compassionate consideration to animals seen as individuals are considered, along with the challenges these pose for predator conservation. A way forward from this apparent impasse is suggested, drawing on the capacity approach to embrace human with animal actors. The paper concludes with implications for predator conservation and recommendations, including incident responses sensitive to the traumatic impacts of attacks, and more collaborative approaches to handling human-wildlife interactions taking account of the capacities of local humans and wildlife.

KEYWORDS

**human-wildlife conflict, coexistence, predators, crocodiles, compassion, ethics**

## Introduction

Consideration of the impacts of conserving wildlife on locals has emerged into the mainstream in conservation since the 1990s in the case of (in particular) indigenous peoples (Posey, 1999), and others sharing landscapes with wildlife. In the case of individual wild animals, this emerges into conservation specifically in the 2010s (e.g., Paquet and Darimont, 2010; Wallach et al., 2018), with deeper roots in animal rights thinking (Singer 1975) and what are loosely termed "animal studies" and "human-animal studies" (Echeverri et al., 2018). In this paper, I will address the need for compassion in conservation science through the lens of human-wildlife conflicts and coexistence, specifically. I will first draw on case studies from my research on human-crocodilian interactions to demonstrate the challenges of conserving dangerous animals, in particular for those who must share landscapes with them, and reflect on the role of the conservationist and the need for compassion for victims of wildlife attacks. I will then consider the awkward question of whether animals or humans should be prioritized for compassion in conservation. And if animals should be accorded respect and ethical consideration, how can this be done without paralyzing conservation action? I will conclude with the recommendation that ethical conservation research, policy and practice requires thinking of human-animal communities in interaction: compassion for animals with humans, not animals or humans.

## Background

Working to conserve large predators like the Nile crocodile (*Crocodylus niloticus*) and the mugger crocodile (*C. palustris*) brings responsibilities. Successful conservation of these species, which are seldom confined to protected areas, brings consequences for

those sharing landscapes with them, and for both of these species across their extensive ranges, far more habitat lies outside of protected areas than within (Choudhury and de Silva, 2013; Isberg et al., 2019). To date conservationists have responded to this kind of challenge through a focus on managing negative interactions, and providing incentives to tolerate them–in the case of crocodilians, though providing economic benefits through commercial farming and ranching, and ecotourism, and through education about the ecological importance of crocodilians. A toolkit of strategies for mitigating crocodile attacks on humans and livestock has been developed (CSG, 2022a,b).

The human dimensions of conflicts involving wildlife have emerged as a major conservation concern since the 2010s. This includes explicitly addressing the indirect impacts (e.g., fear, opportunity costs) of living with wildlife for locals (Barua et al., 2013). The IUCN initiated a Task Force on Human-Wildlife Conflict in 2016, which evolved into a permanent Specialist Group on Human-Wildlife Conflict and Coexistence in 2022. Research on coexistence focuses on the experiences and perspectives of those sharing landscapes with wildlife outside of protected areas (Pooley et al., 2022).

There has been some work on the social and cultural dimensions of human-crocodilian relations (e.g., Pooley, 2016; Brackhane et al., 2019). However, as is the case for many large predators, there has been little attention focused on the personal and social impacts of traumatic encounters with crocodilians. One exception is Chowdhury et al. (2013) study of what they call Post Traumatic Eco-Stress Disorder in India's Sundarban Delta, including attacks by tigers, sharks and crocodiles.

While I don't wish to develop a conceptual framework for thinking through compassion in conservation in this short piece, I feel that, particularly for consideration of specific challenges around the treatment of animals, Amartya Sen's capabilities approach as developed by Martha Nussbaum provides a useful framework. When considering humans impacted upon by wildlife, this provides the possibility of avoiding cultural relativism on the one hand, and a dictatorial approach insisting on universal rights and values on the other (as IPBES have found, the latter is both unethical and impractical; IPBES, 2019).

Nussbaum's approach is predicated on the idea that all humans should have the freedom to achieve wellbeing. There are ten capabilities (possibilities of functioning people have a realistic possibility of achieving) which all humans should have the right to fulfill, should they choose to. These include life, bodily health and integrity, the ability to sense, imagine and think, feel a range of emotions including love, grief and anger, apply practical reason and reflect on life, affiliate with whom one chooses, have concern for nature and other species, play, and have control over one's environment (Robyns and Byskov, 2020). An ethical approach to conservation, in this view, requires consideration of whether policies and interventions will enable or impinge on these capabilities.

## Shifting from studying victims as data, to engaging with victims' experiences

My research trajectory began with building a long-term database of crocodile attacks in South Africa and eSwatini, to look for patterns and causal links emerging from the aggregated data (Pooley et al., 2019). While doing so I read media stories written at the time of the attacks, and became very aware of the traumatic nature of such attacks. This led me to wonder what the longer term consequences were. The only obvious way to investigate this was to travel to meet victims or their families and friends, which I began to do in the early 2010s.

It was obvious that such encounters must be very sensitively approached and conducted. I was aware that for many attack survivors, or the relatives of those who were killed, the story–as presented in the media, and "resolved" by conservationists through dealing with the problem crocodile or where available providing compensation–was not over. Many had either lost someone close to them, of great importance in their personal lives, with emotional and social and often economic consequences, or suffered life-changing injuries.

If I was advocating the survival of crocodilians in the habitats which they shared (and increasingly share, as climate change, demographic change and land conversion for agriculture and other uses pushes people into formerly uninhabited wetlands) with humans and their livestock, then I needed to understand the consequences for those on the "sharp end" of crocodilian conservation. I began by researching media reports and literature in attacks in more detail, but then by tracking down and interviewing victims in South Africa and eSwatini.

Then, in 2019, I was hosted by Anirudhkumar Vasava and Dhaval Patel of the Vidyanagar Nature Conservancy (VNC) in Gujarat India, to explore human-mugger conflict and coexistence (see Vasava et al., 2015). We traveled around the Charotar region (in Anand and Kheda districts) with Vishal Mistry, Niyati Patel and VNC colleagues, and then in Vadodara District with mugger expert Dr Raju Vyas. In this exploratory visit, we traveled to 19 villages and numerous wetlands to speak with victims of mugger attacks (Pooley et al., 2020).

In this paper I will choose just seven case studies (see Supplementary material for a table of interviews) from these travels and interviews, to illustrate the range of consequences traumatic encounters with predators can have, and highlight the need for compassion in conservation. These are the stories of poor rural people after the sensational event of their being attacked, and the consequences for their lives after the media and the authorities have lost interest in them. My purposes in talking to them were fully explained, and informed consent obtained. All of those discussed here wanted their stories told, and did not want anonymity. My argument is that conservationists must never lose interest in them. Further, I would urge psychologists and others to focus far more interest on studying trauma including PTSD in the victims of attacks by wild animals.

## Case studies

### Sihle Sibonelo Hlatjwako

On 28 March, 2018, I interviewed Sihle Sibonelo Hlatjwako at her homestead near the Mbuluzi River, north of Simunye in northeastern eSwatini (formerly Swaziland). Sihle was then an 18-year-old schoolgirl, in her penultimate year of school. In January 2018, Sihle had been washing clothes in the river below the homestead, when a crocodile seized by her by the wrist and pulled her into the river. She struggled, being submerged and re-surfacing five times, before managing to grab onto some reeds and scream for help. She was rescued by two brave teenage boys. Although game reserve staff were quickly on hand, the family waited for the police to fetch Sihle and take her to hospital. It was explained that those who can't afford to pay only get free treatment if the police bring you to hospital.

Sihle was in some sense lucky to escape with her life, and only damage to her wrist. However, months after the attack, the skin graft was very visible, and she had not recovered full use of her left hand. The Nkomo family, with whom she lives, are very poor and couldn't afford to both pay school fees and physio treatment to help her regain use of her hand. They therefore decided to pay for her treatment, and took her out of school. Sihle is a bright girl, and once her shyness had worn off, we spoke in English. Remarkably, she bore the crocodile no ill will, and regarded the attack as an unfortunate accident. She was very interested in learning about crocodiles, and I gave her a booklet and poster I have developed.

The point of this case study is, primarily, that this brave girl will almost certainly never complete school. Of passing interest to the press, the attack was regarded as "minor" and there is no compensation paid for such attacks. For a poor girl from a rural background, this event has seriously limited her future life possibilities, and leaves her with a partial disability. It is unsurprising that locals resent the presence of crocodiles which are protected animals, dislike the lack of control over their environment in not being able to deal with crocodiles, and hold conservationists responsible for preventing attacks.

### Vikram Gohil

On 27 September 2019, I interviewed a young man named Vikram Gohil on the edge of the wetland of Deva village, Anand District, Gujarat State in India. Almost exactly a year previously, he had swum out into the pond to help one of his water buffalo which had become entangled in water hyacinth. He was neck-deep when a mugger seized him by the shoulder. He struggled, but it wouldn't let go, and another two small mugger also approached, though did no damage beyond scratches. He managed to struggle to shore, where the mugger left him.

Vikram belongs to the Waghri community, and though he received treatment at the government hospitals in Deva and Vasol, he claims that it was traditional medicine (monitor lizard fat) that healed him. While physically, the only traces of Vikram's encounter are scars, he is clearly still psychologically troubled by the attack. He is now afraid of the water, and believes that the mugger, having tasted his blood, will attack him if he enters the pond. At the same time, he doesn't believe harm should come to the mugger, and suggests it may have been a mother defending young.

In discussing the incident, he kept repeating how frightened he had been, and eventually admitted that while he has no bad dreams, he still experiences "moments of fear."

### Ratilal Vasava

Another victim of a mugger attack, Ratilal Vasava from Pingal Wada Village in Vadodara District, Gujarat, was pulled into the Dhadhar River by a mugger while tending his cattle. He managed to fight free, without serious injury. However, when we visited he was taking antibiotics to cope with the serious infections that often result from crocodile bites, and he is now fearful of the river he has lived next to all his life. Like Vikram, Ratilal now also experiences "moments of fear," which he described with the Gujarati term "*bhankara*" meaning something like an illusion that spontaneously comes to you.

### Vinu Vasava

We interviewed Vinu Vasava in Pingal Wada village. Her husband Radha was killed by a mugger, and she said she was in shock for 3 months afterwards. She is a mother of five daughters, and having lost her husband, who was the breadwinner, had to become an agricultural laborer. She hadn't heard about compensation, and didn't receive any. Her life has changed fundamentally, as she must work to support her family and pay for the marriages of her four unmarried daughters. As a devotee of the Hindu goddess Khodiyar, always shown astride a mugger crocodile, she bears no ill will to mugger crocodiles.

### Madhuben Naran Vasava

In Mahadev village, Vadodara District, we interviewed Madhuben Naran Vasava. This petite, elderly widow had been bitten on the left arm by a mugger while washing clothes 5 years previously. Three months of treatments and a skin graft left her with an emaciated, scarred arm which doesn't fully function. Her compensation covered a fifth of the cost of her treatment, forcing her to mortgage her agricultural land, and she is still paying it off. When asked how she felt about the mugger, she replied that

she knew she couldn't express her feelings, because that would be illegal. She thought the Forest Department should trap and remove the mugger from the river.

## Kalapn Rana

We interviewed Kalapn Rana at her home near Goraj, in eastern Vadodara District. Several years previously, the family had enjoyed a picnic on the banks of the Dhadhar River. It was very hot, and after the others left, Kalapn and her mother-in-law Manhar took a quick swim. Afterwards Kalapn was wringing out her petticoat when a mugger seized her by the left hand and pulled her into the water. Manhar jumped into the river and a tug of war ensued, the mugger dragging both across to the opposite bank. Amazingly, Manhar managed to drag Kalapn back across the river. Two men then came to the rescue, forcing the mugger to release Kalapn and retreat into the river.

Kalapn by this time had been bitten several times on the left forearm, shredding muscles and splintering bones. Fortunately, the family are reasonably well off, as she had to then endure 9 operations to repair her arm (see Figure 1). As she was 2 months pregnant, and required anesthesia and radiation, they had to abort the fetus.

For 3 months, Kalapn dreamed of being taken by the mugger [(Chowdhury et al., 2013) note one case of bad dreams following a crocodile attack], and it took 2.5 years to recover from her injuries. However, she still has fixed flexion disability, and this young mother (she has a baby now) can't comb her own hair. At the time of the attack, she had recently graduated and had intended to continue her academic studies (which clearly was the expectation of her mother-in-law), but she had to give this up. Kalapn now avoids the river completely, and can't swim in a pool without checking for mugger first. The Forest Department paid compensation (a tenth of the cost of her treatment), and tried but failed to catch the mugger, which is still living locally.

FIGURE 1
Kalapn Rana during her treatment following a crocodile attack.

### Compassion for victims

There is something important to be said about fatalities in animal attacks. This is the outrageous assertion that rural folks in remote communities somehow value life more "cheaply" and are in some way "philosophical" about losing husbands, wives, children, friends. This perception was voiced in a comment on a story on crocodile attacks I published in *The Conversation* (Pooley and Marchini, 2020). I can assure anyone who might share this view that (for example) the parents I interviewed, some several years after an attack, were still devastated by the loss of their child.

Finally, it should be noted that asking people to share their experiences is asking a lot. It requires respectful and sympathetic attention, and great care and tact in questioning (Pooley et al., 2020). Many relatives of victims show me photographs of their loved ones after attacks. It seems impossibly grim that they cling to this evidence of their final memories of their loved ones. For the conservationist, absorbing relatives' grief, and witnessing the often horrific images of damaged corpses, also takes a toll. I feel it is a necessary one, particularly where conservationists and supporters of conservation live far removed from the consequences of their successful efforts to conserve dangerous wildlife.

## What should be the focus of compassion in conservation, animals or people?

When it comes to compassion in conservation, there is an awkward fracture between human-focused and animal-focused rights orientations. In an epoch of crashing biodiversity, almost entirely due to anthropogenic impacts, this is not an easy dichotomy to address (e.g., Pooley and Redpath, 2018; Vucetich et al., 2018). Supporters of Compassionate Conservation (Wallach et al., 2020) criticize conservation for justifying harm to sentient animals through instrumentalism (the animal as means to an end), holism or collectivism (species are more important than individuals) and nativism (human-assisted species are unnatural). They argue that in fact all sentient beings are persons, as recognized in some non-Western traditions, and thus worthy of respect and compassion. It is not sufficient for them that "ethical concern for individual animals [forms] an important element in conservation best practices" (as argued by Hayward et al., 2019), if that is subordinated to landscape-level biodiversity protection concerns. They argue that conservation's prioritization of "native" and "wild" animals is misplaced and shouldn't justify violence to either wild or feral or domesticated non-human animals. Compassion, in this view,

links us ethically to *all* non-human "persons" equally (Wallach et al., 2020).

Just as animal rights pressure on conservationists has improved the care of captive wild animals, for example, so compassionate conservation's focus on the fates of individual animals can be a corrective to indifference to them where that exists. Further, widening consideration of what is valuable beyond ideas about "pristine" or "wild" landscapes, and only native wild animals, is valuable on our fast-changing, human-dominated planet. However, there remain key challenges to how compassionate conservation works out on the ground, particularly pertinent for those managing potentially dangerous animals like crocodiles. For example, what of the rights of local people living with dangerous wildlife not to like or want that wildlife around, and their right to be angry about depredations on their communities and to dislike individual animals for their actions (Smith, 2020). How do we work in landscapes where some locals revere and respect particular species of wildlife, while others see them as a dangerous threat, or where locals identify particular problematic individuals as were-animals, different to "normal" animals (Pooley, 2016)?

If compassion requires consideration of all the actors involved in human-wildlife interactions, and humane actions including (if, as a last resort, required) lethal control (humanely performed), then that seems implementable. If it means that every individual has an inviolable right to life, including for example an introduced predator threatening the existence of a native species, or a crocodile threatening the lives of local farmers, then that does not. While trapping and removal of a problem animal may be preferable, it isn't always possible, or not in time to prevent disaster. Finally, if we follow rights approaches to logical conclusions, there are awkward questions around the assumed rights of prey not to be predated upon (Keulartz, 2016).

## The capability approach for non-human animals

How else, then, might compassion for non-human animals be integrated into conservation? How can we include animals in an ethical conservation without being limited to observing the inviolable rights of each individual animal? How might we be empowered to act compassionately and proactively, rather than get stuck on what we cannot do? How can the need of certain animals to attack and eat others be acknowledged in framework that grants them all ethical consideration?

I find Nussbaum (2006; as discussed in Bendik-Keymer, 2014) capabilities approach to a more-than-human ethics interesting here, as a basis for ethical consideration of non-human animals not confined to proscriptions on the treatment of individual animals. Nussbaum suggests that if humans can feel wonder looking at nature or a complex organism, then that suggests it is good and right for it to flourish and persist as the kind of thing it is. It is, then, a being worthy of respect, and so is its striving to persist and flourish. So much for extending the circle of ethical consideration beyond humans. When it comes to what should guide ethical action, it is *empathy* which guides us to which beings worthy of wonder deserve justice (not all do, in this interpretation). If we can imagine other beings as having a stake in their own existence, and hence a capacity to be wronged (thwarted), then those beings have a claim to justice.

The capacity of charismatic mammals like elephants to experience social and individual trauma and PTSD-like symptoms has been recognized (Bradshaw et al., 2005; Münster, 2016), and is an interesting area of research, albeit proscribed by human sympathies in terms of species (though see Zanette and Clinch, 2020), as is the capacity of wild animals for compassion. Apparent tolerance of "habituated" animals for humans, in situations where they must share landscapes, may mask heightened stress levels with adverse effects on individuals and populations (Whittaker and Knight, 1998; Bejder et al., 2009). Of course, the same goes for humans living alongside dangerous wildlife.

Nussbaum's approach attaches moral significance to species, and not solely to individuals (Keulartz, 2016). In an age of what some call ecocide (e.g., Posey, 1999), this extends moral consideration beyond the individual to the species, and by extension (in terms of their needs) to habitat.

If we look beyond solely what *shouldn't* be done to individual animals, which is the focus of much animal rights work, we then can also consider what a species-specific norm of flourishing might look like. That is, what is the appropriate benchmark for judging if a member of a species has the necessary opportunities to flourish (fulfill its capabilities). Humans have a proactive positive role to play here, a duty to support the capabilities of other beings (how widely that circle is drawn is another matter), up to a minimum threshold level calibrated for their species. Flourishing is, after all, about more than just the absence of pain or discomfort. This approach to ethics also allows for a coherent approach to interventions where it is not possible, due to external circumstances like habitat destruction, to allow wild animals to continue with their lives free of human influence (Keulartz, 2016). It need not be limited by notions of wildness or pristineness, either.

## Beyond compassion for humans, or compassion for animals

Humans and wildlife have shared landscapes for millennia, and even in the partitioned lands of North America and Western Europe, factors like urbanization, land abandonment and climate change are increasingly forcing them to cohabit rural and even urban landscapes (König et al., 2020). There are a

diversity of ways of understanding and dealing with the resulting situations, shaped by particular cultures, knowledge systems, traditions of using and interacting with the land, histories of interaction, and the particular ecological contexts and fauna (species, individuals, communities). Different sets of humans and animals (individuals, species, perhaps cultures) have learned to interact in particular, mutually influenced ways. The point is, it is nonsensical to consider compassion in conservation without thinking in terms of the communities of humans and non-humans where interactions and their consequences unfold.

So, if a capabilities approach were to be developed, there is collaborative context-specific work to be done in deciding on which capabilities particular species or other groupings of animals typically have, as a non-anthropocentric yardstick for determining how to ethically interact with them (Keulartz, 2016). Doing so requires acknowledging that species concepts, and taxonomies of species (including cultural ones), vary. Then there is consideration of communities of humans and species of wildlife in interaction in particular contexts, sharing spaces and resources. There will be important cultural dimensions to how we understand all this, and we have much to learn from indigenous peoples and locals who coexist with wildlife.

The context-specificity of human-wildlife conflict and coexistence means that there is unlikely to be a moral standard with 10 inalienable rights commandments applicable everywhere for all peoples and species. This doesn't mean it isn't possible to formulate principles relating to what should be considered when attempting to show compassion in conservation, or to understand coexistence where it occurs (and not mess it up with tone-deaf interventions), and to foster compassion and coexistence where they don't exist. It remains to be seen whether sets of capabilities could be formulated for agreed groupings of non-human beings. It is an intriguing possibility that, working with locals, it may be possible to formulate more precise versions for particular landscapes. These would need to be informed by both ecological and cultural understanding of individuals and types of particular non-human beings, and communities of interaction.

## Conclusion

I want to preface my conclusions with my final case study, the story of the Ode family. I spoke with Hemant Ode, a lean 42-year-old farmer and laborer, sitting on a wooden frame bed under a lean-to outside his home near the edge of Traj Village pond, in Kheda District, Gujarat. Those present included his wife Naniben, and Anirudhkumar Vasava (translating). Hemant told us how his only daughter, Hetal, had been seized and drowned by a mugger in the pond nearby while washing a big steel pot. She was only 9 years old. Both parents were clearly still devastated, and a framed portrait with the girl's necklace looped around it hangs on the front of their home. My own daughter was nine at the time of our interview, and afterwards I reflected on the despair and rage I would have felt, should this tragedy have befallen me and my family. Would I have continued to tolerate crocodiles living in the pond that we had to use daily for water?

Hemant Ode is now a "mugger mitra" (crocodile friend), who dedicates time to educating others on how to live more safely alongside crocodiles. In addition, he participates in rescues, that is, safe capture and removal of mugger found in areas where harm may ensue for people, or crocodiles. Remarkably, during my visit to Gujarat, he was involved in the safe capture and removal of a crocodile that was very possibly the one which had killed his daughter, and later an elderly man, in Traj Village pond. It had been removed to a nearby wetland, Pariyej, and was trying to return home to Traj pond (pers. comm. Vishal Mistry).

There is much to be learned about the motivations of someone like Hemant. For instance, in what ways is his compassionate response to a tragic event influenced by his cultural context, his personal beliefs, and his individual life history and experiences at the pond? Is his response a culturally mediated or perhaps more universal psychological coping mechanism for reframing a tragic event? There is much to learn about different cultures' mechanisms for coping with trauma, and specifically how particular cultures' explanations of the causality of animal attacks may provide adaptive ways of coping with this trauma, and enable coexistence with dangerous animals (Wilson, 2007; Pooley et al., 2020).

There is also much to be learned from the behavior of the mugger that share ponds, mostly peaceably, with humans in the wetlands of Gujarat, and perhaps from comparative study of where relations are hostile, in the same region. That is, rather than continue to consider humans and wild animals separately in ethical terms, and to study their behavior separately, we need to study human-wildlife communities and their interactions in more holistic and interdisciplinary ways.

For the conservationist, there are many levels at which compassionate consideration is required here: for the parents of a girl killed by a mugger; for locals living alongside mugger, with varying exposure to, and beliefs about mugger; for individual mugger crocodiles sharing habitat with humans and livestock; and for the challenges mugger crocodiles face in the agricultural landscapes of central Gujarat.

## Some implications

Conservationists involved in conserving dangerous wildlife have an ethical duty to engage with the consequences for local people living with these animals. Compassion for the victims of encounters is vital, not just for the plight of wildlife in

shared landscapes with humans, though this matters too. This requires personal engagement with individuals, not statistical analyses and solely instrumental or economic responses. There is much to learn about long-term consequences of life-changing encounters with dangerous wild animals, and what assistance can then be offered. There is also much to be learned from those who, like Hemant Ode, have found ways to surmount personal tragedies and work to facilitate coexistence with dangerous wild animals.

Some of the lessons may be cultural, emerging from societies with long experience of coexisting with dangerous wildlife; some may emerge from psychological study of how people cope with traumatic encounters; others from the study of animals' traumatic experiences and interactions with humans. Some will be very context-specific, while some may be portable and provide means of fostering coexistence elsewhere. Conservation researchers would benefit from working with psychologists and anthropologists when attempting such studies.

On a practical level, it seems advisable that conservation authorities shouldn't respond to traumatic incidents by sending in individuals untrained in the sensitivities of interacting with traumatized victims and their families, tasked only with performing essentially a law-enforcement function. Adjudicating on whether material compensation is warranted is not, in the first instance, the appropriate response. Training for first responders, and the involvement of professionals with context-specific knowledge and skills in handling traumatic situations and interacting with victims, would improve victims' experiences and relations between communities and organisations responsible for wildlife.

Responses to traumatic encounters with wildlife should also go beyond incident-response, to consider the longer-term consequences for individual humans, and wild animals, and their communities. The consequences for all actors, human and non-human, in terms of their capacity to flourish should be considered when deciding on interventions. The capability to live a full life should be considered, for all actors, but on occasion managers will have to weigh the threats to life posed by dangerous animals against their right to persist. They need to consider the consequences of sparing the life of a dangerous individual, in light of how it may impact on locals, and how it may influence local societies' tolerance for the species. If it cannot be safely and timeously removed to a secure place, that individual animal may have to be humanely killed. Let us also reserve some compassion for those who must take and enact such difficult decisions.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the author, without undue reservation.

## Ethics statement

The studies involving human participants were reviewed and approved by the School of Social Sciences History and Philosophy Ethics Committee, Birkbeck University of London. The participants provided their written or verbal informed consent to participate in this study. Informed consent was obtained from the individual for the publication of any identifiable images or data included in this article.

## Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

## Funding

This research was funded by a Birkbeck/Wellcome Trust Institutional Strategic Support Fund Grant.

## Acknowledgments

The author acknowledges the hospitality, guidance, translations, and insights of Anirudhkumar Vasava, Dr. Raju Vyas, Dhavel Patel, Niyati Patel, Vishal Mistry, and Mehul Patel and also the courage and generosity of those interviewed. Thanks also for the insightful comments of the two reviewers.

## Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.977703/full#supplementary-material

# References


Barua, M., Bhagwat, S., and Jadhav, S. (2013). The hidden dimensions of human–wildlife conflict: health impacts, opportunity and transaction costs. *Biol. Conserv.* 157, 309–316. doi: 10.1016/j.biocon.2012.07.014

Bejder, L., Samuels, L., Whitehead, A., Finn, H., and Allen, S. (2009). Impact assessment 142 research: use and misuse of habituation, sensitisation and tolerance in describing wildlife responses to anthropogenic stimuli. *Mar. Ecol. Prog. Ser.* 395, 177–185. doi: 10.3354/meps07979

Bendik-Keymer, J. (2014). "From humans to all of life: Nussbaum's transformation of dignity," in *Capabilities, Gender, Equality: Towards fundamental entitlements, eds* F. Comim, and M. C. Nussbaum (Cambridge: Cambridge University Press), 175–191.

Brackhane, S., Webb, G., Xavier, F. M. E., Trindade, J., Gusmao, M., and Pechacek, P. (2019). Crocodile management in Timor-Leste: drawing upon traditional ecological knowledge and cultural beliefs. *Hum. Dimens. Wildl.* 24, 314–331. doi: 10.1080/10871209.2019.1614240

Bradshaw, G. A., Schore, A. N., Brown, J. L., Poole, J. H., and Moss, C. J. (2005). Elephant breakdown. *Nature* 433, 807. doi: 10.1038/433807a

Choudhury, B. C., and de Silva, A. (2013). *Crocodylus palustris. The IUCN Red List of Threatened Species* 2013:eT5667A3046723.

Chowdhury, A. N., Mondal, R., Biswas, M. K., and Brahma, A. (2013). "Post Traumatic Eco-Stress Disorder (PTESD): A qualitative study from the Sundarban Delta, India," in *Mental Disorders: Theoretical and Empirical Perspectives,* eds R. Woolfolk, and L. Allen (London: IntechOpen), 309–347.

CSG (2022a). *Crocodilian Capacity Building Manual. IUCN SSC Crocodile Specialist Group*. Available online at: http://www.iucncsg.org/

CSG (2022b). *Human-Crocodile Conflict. IUCN SSC Crocodile Specialist Group*. Available online at: http://iucncsg.org/pages/Human%252dCrocodile-Conflict.html

Echeverri, A., Karp, D. S., Naidoo, R., Zhao, J., and Chan, K. M. A. (2018). Approaching human-animal relationships from multiple angles: a synthetic perspective. *Biol. Conserv.* 224, 50–62. doi: 10.1016/j.biocon.2018.05.015

Hayward, M. W., Callen, A., Allen, B. L., Ballard, G., Broekhuis, F., Bugir, C., et al. (2019). Deconstructing compassionate conservation. *Conserv. Biol.* 33:760–8. doi: 10.1111/cobi.13366

IPBES (2019). "Summary for policymakers of the global assessment report on biodiversity and ecosystem services," in *Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*, eds S. Díaz, J. Settele, E. S. Brondízio, H. T. Ngo, M. Guèze, J. Agard, et al. (Bonn: IPBES Secretariat), 56.

Isberg, S., Combrink, X., Lippai, C., and Balaguera-Reina, S. A. (2019). *Crocodylus niloticus. The IUCN Red List of Threatened Species* 2019:eT45433088A3010181.

Keulartz, J. (2016). "Towards an Animal Ethics for the Anthropocene," in *Animal ethics in the Age of Humans: Blurring boundaries in human-animal relationships*, eds B. Bovenkerk, and J. Keulartz (Berlin: Springer), 243–264.

König, H. J., Kiffner, C., Kramer-Schadt, S., Fürst, C., Keuling, O., and Ford, A. T. (2020). Human-wildlife coexistence in a changing world. *Conserv. Biol.* 34, 786–794.

Münster, U. (2016). "Challenges of coexistence: human-elephant conflicts in Wayanad, Kerala, South India," in *Conflict, Negotiation, and Coexistence*, eds P. Locke, and J. Buckingham (New Delhi: Oxford University Press), 321–352.

Nussbaum, M. C. (2006). *Frontiers of Justice. Disability, Nationality, Species Membership*. Cambridge, MA: Havard University Press.

Paquet, P. C., and Darimont, C. T. (2010). Wildlife conservation and animal welfare: two sides of the same coin. *Animal Welfare,* 19, 177–190.

Pooley, S. (2016). A cultural herpetology of Nile crocodiles in Africa. *Conserv. Soc.* 14, 391–405. doi: 10.4103/0972-4923.197609

Pooley, S., Bhatia, S., and Vasava, A. (2020). Rethinking the study of human-wildlife coexistence. *Conserv. Biol.* 35, 784–793. doi: 10.1111/cobi.13653

Pooley, S., Botha, H., Combrink, X., and Powell, G. (2019). Synthesizing Nile crocodile Crocodylus niloticus attack data and historical context to inform mitigation efforts in South Africa and eSwatini (Swaziland). *Oryx.* 54, 629–638. doi: 10.1017/S0030605318001102

Pooley, S., Linnell, J. D. C., Münster, U., van Dooren, T., and Zimmermann, A. (2022). *Understanding Coexistence with Wildlife*. Lausanne: Frontiers Media SA.

Pooley, S., and Marchini, S. (2020). *What Living Alongside Crocodiles Can Teach Us About Coexisting With Wildlife. The Conversation*, May 26. Available online at: https://theconversation.com/what-living-alongside-crocodiles-can-teach-us-about-coexisting-with-wildlife-139144

Pooley, S., and Redpath, S. (2018). A response to Vucetich et al., 2018 just conservation: what is it and should we pursue it? *Biol. Conserv.* 223, 186–187. doi: 10.1016/j.biocon.2018.04.020

Posey, D. A. (1999). *Cultural and Spiritual Values of Biodiversity*. Nairobi: UNEP.

Robyns, I., and Byskov, M. F. (2020). *The Capability Approach. Stanford Encyclopedia of Philosophy*. Available online at: https://plato.stanford.edu/entries/capability-approach/ (accessed July 22, 2022).

Smith, W. (2020). Beyond loving nature: affective conservation and human-pig violence in the Philippines. *Ethnos.* 1–19, 28970. doi: 10.1080/00141844.2020.1828970

Vasava, A., Patel, D., Vyas, R., Mistry, V., and Patel, M. (2015). *Crocs of Charotar. Status, Distribution and Conservation of Mugger Crocodiles in Charotar, Gujarat, India*. Voluntary Nature Conservancy: Vallabh Vidyanagar.

Vucetich, J. A., Burnham, D., Macdonald, E. A., Bruskotter, J. T., Marchini, S., Zimmermann, A., et al. (2018). Just conservation: what is it and should we pursue it? *Biol. Conserv*. 221, 23–33.

Wallach, A. D., Batavia, C., Bekoff, M., Alexander, S. M., Baker, L., Ben-Ami, D., et al. (2020). Recognizing animal personhood in compassionate conservation. *Conserv. Biol.* 34, 1097–1106. doi: 10.1111/cobi.13494

Wallach, A. D., Bekoff, M., Batavia, C., Nelson, M. P., and Ramp, D. (2018). Summoning compassion to address the challenges of conservation. *Conserv. Biol.* 32:1255–1265. doi: 10.1111/cobi.13126

Whittaker, D., and Knight, R. L. (1998). Understanding wildlife responses to humans. *Wildl. Soc. Bull.* 26:312–317.

Wilson, J. P. (2007). "The lens of culture: theoretical and conceptual perspectives in the assessment of psychological trauma and PTSD," in J. P. Wilson, C. S. Tang, eds. *Cross-Cultural Assessment of Psychological Trauma and PTSD*. (New York: Springer), 3–30.

Zanette, L. Y., and Clinch, M. (2020). Ecology and neurobiology of fear in free-living wildlife. *Annu. Rev. Ecol. Evol. Syst.* 51, 297–318.

frontiers | Frontiers in Psychology

TYPE Brief Research Report
PUBLISHED 03 October 2022
DOI 10.3389/fpsyg.2022.990056



OPEN ACCESS

EDITED BY
Fernando Blanco,
University of Granada,
Spain

REVIEWED BY
María Cristina Vanegas-Rico,
National Autonomous University of Mexico,
Mexico
Florian Fiebelkorn,
Osnabrück University,
Germany

*CORRESPONDENCE
Patrik Sörqvist
patrik.sorqvist@hig.se

SPECIALTY SECTION
This article was submitted to Environmental Psychology, a section of the journal Frontiers in Psychology

RECEIVED 09 July 2022
ACCEPTED 13 September 2022
PUBLISHED 03 October 2022

CITATION
Sörqvist P and Holmgren M (2022) The negative footprint illusion in environmental impact estimates: Methodological considerations.
*Front. Psychol.* 13:990056.
doi: 10.3389/fpsyg.2022.990056



# The negative footprint illusion in environmental impact estimates: Methodological considerations

Patrik Sörqvist* and Mattias Holmgren

Department of Building Engineering, Energy Systems and Sustainability Science, University of Gävle, Gävle, Sweden

Past research has consistently shown that carbon footprint estimates of a set of conventional and more environmentally friendly items in combination tend to be lower than estimates of the conventional items alone. This 'negative footprint illusion' is a benchmark for the study of how cognitive heuristics and biases underpin environmentally significant behavior. However, for this to be a useful paradigm, the findings must also be reliable and valid, and an understanding of how methodological details such as response time pressure influence the illusion is necessary. Past research has cast some doubt as to whether the illusion is obtained when responses are made on a ratio/quantitative scale and when a within-participants design is used. Moreover, in past research on the negative footprint illusion, participants have had essentially as much time as they liked to make the estimates. It is yet unknown how time pressure influences the effect. This paper reports an experiment that found the effect when participants were asked to estimate the items' emissions in kilograms $CO_2$ (a ratio scale) under high and under low time pressure, using a within-participants design. Thus, the negative footprint illusion seems to be a reliable and valid phenomenon that generalizes across methodological considerations and is not an artifact of specific details in the experimental setup.

KEYWORDS

**negative footprint illusion, methodology, response format, scale, cognitive bias**

## Introduction

Past research has consistently shown that carbon footprint estimates of a set of conventional and more environmentally friendly items in combination tend to be lower than estimates of the conventional items alone. This phenomenon has been coined the 'negative footprint illusion' (see Sörqvist et al., 2020, for a review). An averaging bias appears to be responsible for the illusion, whereby people average vices (e.g., conventional buildings) and virtues (e.g., "green" buildings) when they make estimates of the items in combination, rather than making a summative estimation (Holmgren et al., 2018a). This explanation is reinforced by the fact that the negative footprint illusion disappears when participants are primed to think in a summative manner (Holmgren et al., 2021). The negative footprint illusion is a benchmark for the study of how cognitive heuristics and

biases underpin environmentally significant behavior. However, for this to be a useful paradigm, the findings must also be reliable and valid, and an understanding of how methodological details influence the illusion is necessary.

The negative footprint illusion appears to be quite robust to many methodological considerations. For example, it does not seem to matter much whether the estimates concern food (Gorissen and Weijters, 2016; Kusch and Fiebelkorn, 2019; but see Threadgold et al., 2022), vehicles (Kim and Schuldt, 2018), or buildings (Holmgren et al., 2018a). It has also been shown in both within-participant designs (Holmgren et al., 2018b; but see Gorissen and Weijters, 2016) and between-participant designs (Holmgren et al., 2018a). The illusion seems therefore to be robust to some variations in the experimental setup. In turn, the illusion varies in size depending on the spatial distribution of the conventional and environmentally friendly items (Sörqvist et al., 2022) and it seems to vary in size with dispositional factors (MacCutcheon et al., 2020; Threadgold et al., 2022).

The response scale is one methodological consideration that is of particular interest to the current study. Asking participants to make the responses on a 9-point scale with endpoints labeled (very low impact vs. very high impact), or on a 9-point scale in which each point is labeled with a $CO_2$ value, seems to matter little (Gorissen and Weijters, 2016; see also Holmgren et al., 2018a). Requesting the participants to make "indirect" estimates of the carbon footprint, by asking them to estimate the number of trees (which binds carbon) needed to compensate for the emissions from the items results in just the same. There is a tendency to assign a smaller number of trees to a combination of environmentally certified and conventional buildings in comparison with the conventional buildings alone (Holmgren et al., 2018b). However, there is still reason to believe that the response format may influence the respondents' behavior (Weijters et al., 2010), in particular, if the response format is ambiguous to the participant.

With one exception (Holmgren et al., 2018b), all previous studies on the negative footprint illusion (Gorissen and Weijters, 2016; Holmgren et al., 2018a, 2021; Kim and Schuldt, 2018; Kusch and Fiebelkorn, 2019; MacCutcheon et al., 2020; Threadgold et al., 2022) have asked participants to make their estimates of environmental impact or carbon footprint on an ordinal, limited response scale. That is, on a scale ranging from, for example, 1–9 in which the possible responses are quite limited, the lowest value does not represent "0 carbon footprint/emissions/kg $CO_2$" and the size of the differences between the steps on the scale are ordinal rather than identical. This circumstance cast doubt as to whether the negative footprint illusion is truly a manifestation of cognitive biases or actually just a consequence of ambiguous task instructions and scales. For example, participants might activate a qualitative mindset when making responses on an ordinal/qualitative scale (*cf.* Gorissen and Weijters, 2016). When in this mindset, participants might interpret the task as if they should estimate how "good" or "bad" the item set is for the environment, rather than estimating the quantitative amount of carbon emissions. It could be argued that conventional items in combination with "green" items are indeed better for the environment than the conventional items alone, depending on perspective, and consequently, participants would be accurate in their qualitative evaluation of the items. Because of this, it is both methodologically and theoretically important to test whether the negative footprint illusion emerges when estimates are made on a quantitative/ratio scale. The current study aimed to test whether the negative footprint illusion is obtained when participants are asked to make their estimates on a ratio scale, in which "0" represents complete absence of emissions/kg $CO_2$, the size of the difference between scale steps is identical, and there is essentially no reason to believe that participants have misinterpreted the response scale.

A second methodological consideration of interest to the current study is response time pressure. Cognitive biases often become stronger when decisions and judgments must be made quickly and under time pressure (Roberts and Newton, 2001; Evans St. and Curtis-Holmes, 2005; Hilbig et al., 2012; Dekel and Sagi, 2020). In previous studies on the negative footprint illusion (e.g., Gorissen and Weijters, 2016; Holmgren et al., 2018a,b), the participants have had essentially as much time as they liked at their disposal to make the estimates. It is therefore yet unknown whether the negative footprint illusion becomes larger under time pressure, although it would be useful from both a theoretical and methodological viewpoint to know whether the effect behaves as expected from past research on the effects of time pressure on cognitive biases or if it behaves differently. The current study tested the effect of time pressure on the negative footprint illusion by comparing rapid responses with slow responses because it would reveal important information about the basic mechanisms behind the effect.

Finally, a third methodological consideration of interest here was the choice of experimental design. Previous research (Gorissen and Weijters, 2016) has been somewhat doubtful as to whether the negative footprint illusion can really be found in a within-participants design, presumably because within-participants designs allow participants to remember and compare their own estimates between conditions. The current study used a within-participants design to build further evidence on this issue.

In sum, the experiment aimed to test whether the negative footprint illusion can be detected when responses are made on a ratio scale, which has never been shown before. The time that was available for the participants to make their responses was manipulated to test whether time pressure influences the magnitude of the effect. And a within-participants design was selected to test whether the negative footprint illusion—typically studied in between-participant designs—generalizes to this design choice.

# Materials and methods

## Participants

A total of 120 participants were recruited to take part in the experiment. Eighteen of them were removed prior to the analysis

for reasons detailed below, resulting in a final sample of 102 participants (70% women, mean age = 34.25 years, SD = 10.94 years). The experiment was distributed by the crowd-sourcing platform Prolific academic. The inclusion criteria were to be between 18 and 65 years of age and living in the United Kingdom. All participants received a payment rate of around £8 per hour for their participation (note that participation only took a few minutes) and participated under informed consent.

## Materials

Data were collected by an online questionnaire created by the web-based survey instrument Qualtrics. After reading an information sheet (informing the participants that participation is voluntary and that they can withdraw from the study at any time) and responding to the consent form, the participants received information stating: *"In this survey you will be asked to make different kinds of estimates under a short time frame of 5 s. In the first block, you will be asked to make estimates related to colour-discrimination and in the second block you will be asked to make estimates related to $CO_2$-emissions. Before each block starts you will receive more information pertaining to that block. Please take your time and read the instructions carefully before proceeding."* Note that in the short response time window condition, the participants were told they had 5 s to respond as described above. In the long response time window condition, the participants were instead told they had 50 s to respond, all else being equal. The 5 s limit was selected because a pilot study with a handful of participants suggested that 5 s (but not less) was needed for participants to have enough time to be able to make the estimates.

### The training block

On the next page of the questionnaire, participants were introduced to a training block, which was constructed to make the participants familiar with the response format. In the training block, the participants were presented with images with various shades of gray, white, and black. These stimuli were chosen because they were clearly different from the stimuli used in the main task (see below) to avoid potential interference between the training block and the main block, while still allowing the participants to become acquainted with the response format. The information presented to the participants read: *"On the next slides you will see images. Your task is to estimate whether the image is dominantly black or white. You will be making each estimates by first clicking on the text box, then typing in a number from 0 to 99 by using the keyboard on your device. The lower estimates indicate "dominantly white" and the higher estimates indicate "dominantly black." For example a score of 0 would be a completely white picture whereas a score of 99 would be a completely black picture. You will have five seconds to respond to the question. Have your fingers ready to type in your response before continuing to your first estimate."* In the long response time window condition, the participants were instead told they had 50 s to respond, all else being equal. After reading the information, the participants proceeded through 10 trials where they were asked to estimate whether a picture was dominantly white or black. Between each trial, they received a text stating: *"When you are ready to make the next estimate, click on the arrow below."*

### The main task

When they had completed the training block, the participants were introduced to the critical judgment task. Before starting, they received information stating: *"On the next slides you will see several houses together. You will see two types of houses: conventional (having a yellow colour) and environmentally certified (having a green colour) houses. Note that environmentally certified houses produce less $CO_2$ emissions compared to conventional houses. Your task is to estimate what the environmental impact is, measured in kilograms of carbon dioxide (kg $CO_2$) emissions for all the houses in the image together. Your estimate should indicate the number of kilograms of $CO_2$ that the houses produce together due to, for example, ventilation, heating and energy-use. Click on the arrow below to get information on how you will make your estimate!"* To increase the possibility of avoiding non-responses, they were given a detailed instruction on how they were supposed to approach the task. This instruction read: *"You will be making each estimate by first clicking on the text box, then typing in a number from 0 to 99 by using the keyboard on your device. Remember, the number you type in in the text box should indicate the number of kilograms of $CO_2$ emissions the houses produce. A higher number is worse for the environment compared to a low number. You will have five seconds to respond to each question. Before moving on, have your fingers ready to type in your response before continuing to your first estimate!."* After reading this, they were introduced to seven trials consisting of pictures depicting either only conventional buildings or conventional buildings together with "green" buildings. They made their estimates by typing in the estimates, ranging from 0 (kilograms of carbon dioxide emissions) to 99 (kilograms of carbon dioxide emissions), in a text box. A digital clock counting down from 5 s (or 50 s, depending on condition) was shown during each trail. If the time expired before the participants were able to make an estimate, the computer continued automatically to the next trial. The first trial was not included in the analysis as it was used to make the participants used to the, slightly different, response format and stimuli. Between each trial, they received a text stating: *"When you are ready to make the next estimate, click on the arrow below."*

## Design and procedure

A mixed within-between participants design was used with two independent variables: display of buildings with two levels (only conventional buildings [conventional only condition] vs. conventional + "green" buildings ["green" addition condition]) and response time window with two levels (5 s vs. 50 s). The order between the two display conditions was counterbalanced between

participants. More specifically, the participants were randomly assigned to either starting with a trial consisting of only conventional buildings or a trial consisting of conventional + "green" buildings.

Moreover, three trials consisted of conventional buildings together with "green" buildings (75 conventional buildings + 25 green buildings; 20 conventional buildings + 20 "green" buildings; 15 conventional buildings + 5 "green" buildings) and three trials consisted of only conventional buildings (75 conventional buildings; 20 conventional buildings; 15 conventional buildings). In the analyses, an average for each participant was calculated for the responses in the display condition with items of both types, to obtain a single measure of kg $CO_2$ estimates in that condition for each participant, respectively. A similar calculation was made for the response in the display condition with only conventional items. Seventeen of the participants in the "5 s response time window" condition failed to make all six responses and they were therefore removed prior to the analysis, resulting in a final sample in that condition of 43 participants. One of the participants in the "50 s response time window" condition failed to make all six responses and was therefore also removed prior to the analysis, resulting in a final sample in that condition of 59 participants.

## Results

As shown in Figure 1, the typical negative footprint illusion was found in both response time conditions. Moreover, the effect was slightly larger in the short (5 s) response time window condition in comparison with the long (50 s) condition. The participants in the "5 s response time window" condition assigned more $CO_2$ to the conventional only items ($M = 65.78$ kg $CO_2$, SD = 26.72) in comparison with how much they assigned to the conventional items in combination with "green" items ($M = 48.66$ kg $CO_2$, SD = 15.41). This difference between conditions was statistically significant, $t$ (42) = 4.63, $p < 0.001$. Similarly, the participants in the "50 s response time window" condition assigned more $CO_2$ to the conventional only items ($M = 60.59$ kg $CO_2$, SD = 22.29) in comparison with how much they assigned to the conventional items in combination with "green" items ($M = 52.41$ kg $CO_2$, SD = 12.29). This difference between conditions was also statistically significant, $t$ (58) = 4.06, $p < 0.001$. A 2(display of buildings) × 2(response time window) analysis of variance with $CO_2$ estimates as dependent variable indicated that the difference between the two display conditions was larger in the "5 s response time window" condition, in comparison with the size of the difference in the "50 s response time window" condition as the interaction between the two factors was significant, $F$ (1, 100) = 5.15, $p = 0.025$. However, this interaction has to be treated with caution. Ten participants in the "5 s response time window" condition and seven participants in the "50 s response time window" condition made estimates of 99 kg $CO_2$ (the maximum estimate) in the conventional only display condition, suggesting that the interaction could potentially reflect a ceiling effect. When these participants were removed, the participants in the "5 s response time window" condition still assigned more $CO_2$ to the conventional only items ($M = 55.72$ kg $CO_2$, SD = 22.09) in comparison with how much they assigned to the conventional items in combination with "green" items ($M = 46.72$ kg $CO_2$, SD = 14.99); a difference that was still statistically significant, $t$ (32) = 2.56, $p = 0.016$. Similarly, the participants in the "50 s response time window" condition assigned more $CO_2$ to the conventional only items ($M = 55.43$ kg $CO_2$, SD = 18.31) in comparison with how much they assigned to the conventional items in combination with "green" items ($M = 50.38$ kg $CO_2$, SD = 11.64), $t$ (51) = 2.66, $p = 0.010$. However, an analysis of variance indicated that the interaction between the factors was not still significant, $F$ (1, 83) = 1.15, $p = 0.286$.

## Discussion

The first conclusion that can be made from the experiment reported here is that the negative footprint illusion can be detected when participants make their estimates on a ratio scale. While response format choices of past studies on the negative footprint illusion may cast some doubt on how the participants interpreted the task (*cf.* Gorissen and Weijters, 2016), the results reported here, together with the plethora of studies on this illusion published until now (Sörqvist et al., 2020), suggest that the illusion is quite robust to such details. If the negative footprint illusion had not been found with the response format used in the current study, it had been possible to argue that the effect found with ordinal response scales (e.g., Gorissen and Weijters, 2016; Holmgren et al., 2018a) is an artifact of the response scale—perhaps an ordinal response scale promotes a qualitative mindset while a ratio response scale promotes a quantitative mindset, or perhaps the participants do not fully understand the task. Finding the negative footprint illusion with a ratio response scale as in the current experiment suggests that the effect is rather a consequence of a cognitive bias (presumably an averaging bias) in environmental impact estimates, not an artifact of methodological peculiarities.

The experiment reported here also shows that the illusion is robust to a number of other methodological considerations. The illusion has mostly been studied in the context of between-participants designs with a few exceptions (Holmgren et al., 2018b; Threadgold et al., 2022) and one study in the past (Gorissen and Weijters, 2016) failed to find the effect in a within-participants design, while it was obtained in a between-participants design. The results reported here suggest that the illusion is robust also to this methodological choice. We can only speculate on the reason why the effect was found in the experiment reported here and not in the experiment by Gorissen and Weijters (2016). One possibility is that the fractional factorial design used by Gorissen and Weijters (2016), wherein each participant estimated a subset of a total of 24 stimulus sets, introduced too much error variance. In the current study, all participants made estimates of the same 6 stimulus sets, perhaps introducing less error variance.

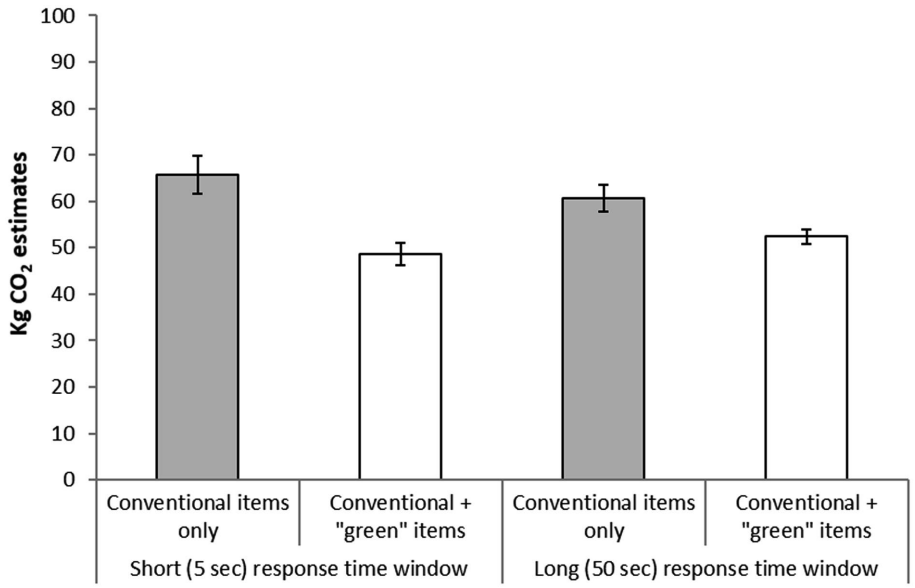



FIGURE 1
The figure shows mean estimates of kg $CO_2$ of sets of items either comprising conventional items only or comprising conventional items and "green" items in combination. Estimates were either made under high time pressure (5s) or under low time pressure (50s). Error bars represent standard error of means.

Finally, while past research has allowed the participants unlimited time to make their estimates, the current study shows that the illusion is also found when participants are required to make hasty responses. If anything, the illusion seems to be larger when hasty responses are required, in line with previous research suggesting that cognitive biases become exacerbated under time pressure (Roberts and Newton, 2001; Evans St. and Curtis-Holmes, 2005; Hilbig et al., 2012; Dekel and Sagi, 2020). Under time pressure, estimates arguably rely more heavily on intuitive thinking. Participants do not have time to carefully think it through and realize that a set of conventional items must cause fewer kg $CO_2$ than the very same set of conventional items plus another set of "green" items. Instead, they become more susceptible to the averaging bias.

## Limitations

One limitation of the current study is that these estimates were made under uncertainty. The negative footprint illusion may well be constrained to situations where people are asked to make estimates about something they do not have enough knowledge about to make accurate estimates. In the case reported here, participants were asked to estimate the amount of $CO_2$ that is generated by a number of houses. The general population (presumably) do not know the actual answer to this question. Future research could investigate if the illusion disappears with a higher level of certainty, by, for example, teaching participants about how much $CO_2$-emissions an average house produces. Participants may also be less susceptible to the negative footprint illusion when to-be-estimated items come from different categories, in particular, if the items belong to a category that participants are more knowledgeable about. There is empirical evidence that supports this idea. For example, Threadgold et al. (2022) found a negative footprint illusion in estimates of buildings and in estimates of cars but not in estimates of apples. It should be noted though, that the negative footprint illusion has been found in a sample comprising of experts (Holmgren et al., 2018b). This indicates that a higher level of knowledge in the judgmental domain does not necessarily make one immune to the effect, at least not when the estimates are made on intuitive rather than reflective thinking.

Another limitation that should be addressed is the loss of 18 participants from the full sample of 120 participants, due to a relatively high rate of participants not being fast enough to make all estimates within the given time window. A reason for this could be that the participants lacked proper task-related knowledge needed to make hasty responses. Regardless of the reason, the drop rate could have compromised the data in unpredictable ways. A further complication was that 17 participants reported 99 kg $CO_2$ as their estimates of all conventional only stimulus sets. However, with these participants removed from the analysis, the negative footprint illusion was still present in both response time window conditions. This is important since it shows that three of the main findings from the current study were not compromised by this issue: the fact that the negative footprint illusion is found with a ratio response scale, in a within-participants design and when estimates are made under high time pressure. Whether the negative footprint illusion is larger under high time pressure is less clear though.

## Conclusion

The negative footprint illusion is not a consequence of participants misinterpreting the response scale. The paradigm can be used as a reliable benchmark for the study of cognitive heuristics and biases underpinning environmentally significant behavior.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

## Author contributions

PS and MH designed the experiment. MH conducted the data collection and analysis of the data and wrote parts of the manuscript. PS wrote large parts of the manuscript. All authors contributed to the article and approved the submitted version.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References


Dekel, R., and Sagi, D. (2020). Perceptual bias is reduced with longer reaction times during visual discrimination. *Commun. Biol.* 3:59. doi: 10.1038/s42003-020-0786-7

Evans St., B. T., and Curtis-Holmes, J. (2005). Rapid responding increases belief bias: evidence for the dual-process theory of reasoning. *Think. Reason.* 11, 382–389. doi: 10.1080/13546780542000005

Gorissen, K., and Weijters, B. (2016). The negative footprint illusion: perceptual bias in sustainable food consumption. *J. Environ. Psychol.* 45, 50–65. doi: 10.1016/j.jenvp.2015.11.009

Hilbig, B. E., Erdfelder, E., and Pohl, R. F. (2012). A matter of time: antecedents of one-reason decision making based on recognition. *Acta Psychol.* 141, 9–16. doi: 10.1016/j.actpsy.2012.05.006

Holmgren, M., Andersson, H., Ball, L. J., and Marsh, J. E. (2021). Can the negative footprint illusion be eliminated by summative priming? *J. Cogn. Psychol.* 33, 337–356. doi: 10.1080/20445911.2021.1903012

Holmgren, M., Andersson, H., and Sörqvist, P. (2018a). Averaging bias in environmental impact estimates: evidence from the negative footprint illusion. *J. Environ. Psychol.* 55, 48–52. doi: 10.1016/j.jenvp.2017.12.005

Holmgren, M., Kabanshi, A., Marsh, J. E., and Sörqvist, P. (2018b). When a + B < a: cognitive bias in experts' judgment of environmental impact. *Front. Psychol.* 9:823. doi: 10.3389/fpsyg.2018.00823

Kim, B., and Schuldt, J. P. (2018). Judging the environmental impact of green consumption: evidence of quantity insensitivity. *J. Environ. Psychol.* 60, 122–127. doi: 10.1016/j.jenvp.2018.10.005

Kusch, S., and Fiebelkorn, F. (2019). Environmental impact judgments of meat, vegetarian, and insect burgers: unifying the negative footprint illusion and quantity insensitivity. *Food Qual. Prefer.* 78:103731. doi: 10.1016/j.foodqual.2019.103731

MacCutcheon, D., Holmgren, M., and Haga, A. (2020). Assuming the best: individual differences in compensatory "green" beliefs predict susceptibility to the negative footprint illusion. *Sustainability* 12:3414. doi: 10.3390/su12083414

Roberts, M. J., and Newton, E. J. (2001). Inspection times, the change task, and the rapid-response selection task. *Quart. J. Exp. Psychol. A.* 54, 1031–1048. doi: 10.1080/713756016

Sörqvist, P., Colding, J., and Marsh, J. E. (2020). Psychological obstacles to the efficacy of environmental footprint tools. *Environ. Res. Lett.* 15, 1–4. doi: 10.1088/1748-9326/ab9968

Sörqvist, P., Volna, I., Zhao, J., and Marsh, J. E. (2022). Irregular stimulus distribution increases the negative footprint illusion. *Scand. J. Psychol.* 530–535. doi: 10.1111/sjop.12829

Threadgold, E., Marsh, J. E., Holmgren, M., Andersson, A., Nelson, M., and Ball, J. L. (2022). Biased estimates of environmental impact in the negative footprint illusion: the nature of individual variation. *Front. Psychol.* 12:648328. doi: 10.3389/fpsyg.2021.648328

Weijters, B., Cabooter, E., and Schillewaert, N. (2010). The effect of rating scale format on response styles: the number of response categories and response category labels. *Int. J. Res. Mark.* 27, 236–247. doi: 10.1016/j.ijresmar.2010.02.004

frontiers | Frontiers in Psychology

TYPE Original Research
PUBLISHED 17 October 2022
DOI 10.3389/fpsyg.2022.940882



OPEN ACCESS

EDITED BY
Piera Centobelli,
University of Naples Federico II, Italy

REVIEWED BY
Elaheh Zareanshahraki,
Monash University,
Australia
Armin Azad,
University of Wollongong,
Australia

*CORRESPONDENCE
Hamidreza Sakhaei
sakhaihamidreza@gmail.com;
s_hamidreza@modares.ac.ir

;SPECIALTY SECTION
This article was submitted to Environmental Psychology, a section of the journal Frontiers in Psychology

RECEIVED 10 May 2022
ACCEPTED 26 September 2022
PUBLISHED 17 October 2022

CITATION
Sakhaei H, Biloria N and Azizmohammad Looha M (2022) Spatial stimuli in films: Uncovering the relationship between cognitive emotion and perceived environmental quality. *Front. Psychol.* 13:940882. doi: 10.3389/fpsyg.2022.940882



# Spatial stimuli in films: Uncovering the relationship between cognitive emotion and perceived environmental quality

Hamidreza Sakhaei[1]*, Nimish Biloria[2] and Mehdi Azizmohammad Looha[3]

[1]Architectural Design, Modeling, and Fabrication Lab, Department of Architecture, Tarbiat Modares University, Tehran, Iran, [2]Faculty of Design Architecture Building, University of Technology Sydney, Sydney, AUS, Australia, [3]Department of Biostatistics, Faculty of Paramedical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran

**Objectives:** The research paper establishes the impact of spatial stimulus on human cognition and emotion by studying environmental events as cues to understand how people perceive spatial qualities. The medium of film to implement visually disruptive events was used in the research to find the relationship between the subjective evaluation of space and emotional responses.

**Method:** Ninety participants participated in watching three films showcasing unexpected spatial stimuli, thus impacting their psychological state. Standard questionnaires involving Aesthetic chills and The Self-Assessment Manikin (SAM) model were used to capture emotional responses, and Normalized Accumulated Quality (NAQ) model was used to receive space quality assessments. The Pearson correlation coefficient was subsequently used to find the association of chills and The SAM with NAQ. Univariate and multivariate regression models were also conducted to find the impact of emotional responses on NAQ.

**Results:** A significant association of NAQ with chills ($p$-value: 0.001), pleasure ($p$-value <0.001), arousal ($p$-value: 0.016), and dominance (p-value: 0.015) was witnessed in film 1. In film 2, NAQ was significantly associated with pleasure ($p$-value <0.001), while in film 3, NAQ was highly associated with arousal ($p$-value: 0.043). According to the adjusted impact of variables on NAQ in film 1, significant impacts of chills ($p$-value: 0.028), arousal ($p$-value: 0.117), pleasure ($p$-value <0.001), and dominance ($p$-value: 0.113) on NAQ were observed. In film 2, pleasure ($p$-value <0.001) and dominance ($p$-value: 0.113) impacted NAQ using the univariate model, while only pleasure had an impact on NAQ in the multivariate model. In film 3, arousal was the only variable to impact NAQ ($p$-value: 0.043) in a univariate model. In regression analyses, higher slopes were witnessed for models in film 1.

**Conclusion:** The experiment highlighted that using affect-based video clips can help us capture the relationship between emotional responses and perceived quality of space. The appearance of spatial stimuli can engage learning, expectation, and attention, leading to a superior improvement of cognitive ability and mental health in space. This level of understanding can help design a more sustainable place.

KEYWORDS

cognition and emotion, spatial stimuli, normalized place quality, psychological responses, sustainable criteria

## Introduction

Architecture and human cognition are inseparable entities that shape the perceived quality of a designed space (Hakak et al., 2017). Understanding cognitive and psychological responses while being exposed to an architectural space can prove to be a vital area of investigation. This research accordingly focuses on studying people's environmental perception concerning cognitively storing situation-based events, their expectation or preemption of upcoming events, the extent to which these events attract their attention, and how these events impact their emotional state. Utilizing a cinematic context has proven reliable for observing the practice of a lived space (Penz, 2017). Through a film-based space screening experiment, we can thus analyze if architectural characteristics relate to emotional changes when people observe unexpected stimuli in space. Relying on the intersection of environmental design and space cognition will contribute to sustainable criteria. The perceived surrounding built space can be addressed to highlight mental health in human-environment interactions (Liddicoat et al., 2020; Buttazzoni et al., 2021; Guzman et al., 2021).

When a person's attention is drawn to a new environment (Sakhaei, 2020), the mind tries to contextualize it by gaining spatial understanding *via* categorizing cues (Bruner, 1973). After organizing specific space cues and ignoring the ones that disrupt perception, the mind tends to formulate a consistent projection of the perceived environment (Hakak et al., 2016). By implementing disruptive events, we can scrutinize if this consistency in projecting different environments will escalate and improve spatial cognition. In our research, we implement disruptive events as cues to elicit emotions. These unexpected events or stimuli change and deconstruct the structure of architectural elements that can plausibly impact emotions. Such events, in the conducted experiment, are formulated from spaces edited from different film spaces and aimed at stimulating the physical environment to aid observers in assessing architectural qualities. The evaluation based on film space can signify space qualities during the design process to escalate the experience of designing a more communicative and sustainable place. Thus, the related literature and theories concerning the intersection of spatial cognition, emotion, and built environments will be presented to establish their integrated role in human-environment behavior. Then, the role of the cinematic realm and film contents will be associated with the environmental perception to articulate this research's theoretical framework.

## Cognitive emotion and environmental perception

The environment we perceive affects us at cognitive and emotional levels (Sakhaei et al., 2022). The cognitive level involves mental processing and appraisal procedures, while the emotional level refers to the adaptive reaction to the gathered information (LeDoux, 1989; Higuera-Trujillo et al., 2021). Noting that cognitive and emotional levels work interrelatedly in mind, the human-space confrontation first requires activating sensory information to exhibit cognitive behavior. A substantial literature supports the relationship between human sensory information and environmental understanding (Grodal, 2009; Schacter et al., 2011; Izard, 2013; Coëgnarts, 2017). This sensory input that facilitates the entire perception process requires the active mental reestablishment of learning, memory, expectation, and attention (Bernstein, 2018).

The human mind should thus first perform cognitive tasks during the spatial learning process to perceive and assess a spatial configuration. The Cognitive Load Theory model (Paas and van Merriënboer, 1994) depicts the impact of physical characteristics of the environment as a crucial factor in studying human behavior (Tanner, 2000, 2008). Multiple studies have highlighted the learning process as necessary in cognitive tasks (Blackwood and Muir, 1990; Li et al., 2020), with factors such as volume, density, lighting, spatial arrangement, and the presence of other people being vital physical environment characteristics to enhance learning.

## Cinematic mediation and psychological reactions

Cinema has proven itself as a practical tool to present an illusion of the apparent reality of the built environment (Smith et al., 2012). There are two critical factors in films to induce the observer's feeling of reality: the appraisal of the film's relative realism to personal lived experiences and the factuality or plausibility of the observed events (Rooney and Hennessy, 2013). Through film induction, creating an apparent reality can capture emotional responses (Gross and Levenson, 1995; Schaefer et al., 2010; Xu et al., 2010). The dual awareness model (Tan, 2008) brings up two different domains called Entertainment Space and Executive Space while observing film scenes. As people engage with events in films, the entertainment space tries to infiltrate the mind as if they are real, while the executive space supports the constructed imagery of the entertainment space by evaluating the plausibility and reality of the observed scene compared to the real-world environment. Meanwhile, if the observer's attention is thoroughly drawn in by the event's realism, their minds will perceive this as apparent reality, leading to increased emotional arousal (Rooney et al., 2012).

The Limited Capacity Model (Lang, 2000) highlights that the interaction between the medium's content information (e.g., films), its structural information (e.g., sound effect), and the observer's characteristics (e.g., emotional arousal) are crucial to understanding cognitive allocation in human-film interactions. Evoking cognitive abilities through realistic film events can thus help to extract space characteristics and associated emotional feedback.

## Space quality and emotional responses

The quality of architectural space substantially impacts human perception (Zawidzki, 2016a). Multiple studies show that qualities like spatial openness (Hedge, 1982; Sundstrom et al., 1982) or enclosed and open spaces (Brennan et al., 2002) relate to mental contentment. Attractive, clean, and orderly spaces can indicate a high spatial quality among students in a learning environment (Gilmore et al., 2010). Architectural theorists further suggest that complexity (implicating diversity, entropy, richness) and order are also vital structures of architectural qualities (Weber, 1995). A previous study also showed that a balanced environment escalated creativity and cognitive function (Bruer, 1997).

There are two vital factors in assessing the quality of a space: Aesthetic judgments and Emotions. These factors have illustrated an interrelationship based on the Leder model (Leder et al., 2004). Accordingly, aesthetic judgment can lead to the chills responses in art perception, first studied as strong emotional responses by Goldstein (1980). Besides, feeling chills and goosebumps have been outlined as indicators of emotional arousal in other discussions (Salimpoor et al., 2009; Laeng et al., 2016). Sadness and joy are also emotional responses studied in the context of art-elicited chills (Panksepp, 1995; Nusbaum et al., 2014). The level of arousal, pleasure, and dominance responses have been studied in a PAD model as mediating between the built environment and behavior (Mehrabian and Russell, 1974; Gifford, 2007). The valence of the stimulus signifies the engaged motivational system, while arousal illustrates the activation level during the eliciting content exposure (Bradley et al., 2001; Lang and Bradley, 2010). The dominance is the emotional power of the content or the level of feeling dominated by the emotional activation (Osgood, 1966; Lang, 1979). Consequently, the four factors of chills, pleasure, arousal, and dominance can be critical emotional responses in assessing the qualities of architectural space.

## Assessing spatial quality and emotions in the cinematic context

Selecting affect-based video content to capture the mentioned emotional responses from spatial qualities require understanding the intensity and type of affect expected from the viewer (Soleymani et al., 2009). The valence-arousal space feature is an essential factor representing the appropriate affect in film content (Hanjalic and Xu, 2005). For instance, in a hierarchical movie content analysis study, film shots were divided into calm, average, and exciting to examine valence-arousal features (Xu et al., 2008). Another study depicted a substantial increase in participants' chills, feeling moved or touched, and goosebumps from an evoking film content (Schubert et al., 2018). Apart from emotional factors, film clips should also be controlled in terms of complexity, illumination, movements, the number of characters, and camera angle to achieve a homogenous emotional content in experiments. This control is vital since film contents can be effective in subjective assessments (Carvalho et al., 2012).

## Existing gaps and hypotheses

People react differently to their perceptions of the built environment (Küller et al., 2009). Zawidzki compiled a 20-item questionnaire to define a new subjective evaluation of a place based on normalized averaged values (Zawidzki, 2016a). Zawidzki's study mainly focused on spatial perception and geometric properties rather than a place's aesthetic aspects. After perusing Zawidzki's study, we found that the interrelationship between cognitive-emotional responses and subjective evaluation of spatial qualities can shed light on human-environment behavior analyses and expand the knowledge in this research area. We referred to numerous related studies and compiled the most related papers in Table 1. This table reviews prior research that assessed cognitive and emotional responses based on different stimuli, such as using films as a mediation technique to represent the real environment to capture cognitive loads or emotional behavior. However, no similar research has discussed the related emotional responses to this definition to analyze if a space's normalized accumulated quality correlates with or affects the normalized spatial quality assessments. Assessing the space qualities based on visual cognition can plausibly associate with the emotional states of individuals in the presence of a disruptive space-deconstructive stimulus.

In this research, we hypothesize that by ignoring unexpected events *via* the mediation of cinematic spaces, the mind would enhance its perception of the observed environment and improve mental health by assessing the quality of architectural space. We will also analyze if space-related events can change participants' emotional states. Additionally, we will scrutinize which psychological and emotional factors relate to or affect the quality and characteristics of space.

# Materials and methods

## Study population and sampling method

We selected 90 participants (half male, mean age 26, SD 2.69) of Iranian ethnicity who were university students or employees. The chosen demographic belonged to an age group of 20–30 to capture homogenous behavioral feedback from the experiment. This demographic control is primarily due to possible human personality changes (like past experiences) that can affect assessments of different age groups (Khaleghimoghaddam and Bala, 2018). Regarding the films' selection, we ensured that no individual had any experience of watching any of the movies previously to create a sense of novelty as regards space-related assessments. The participants were briefed regarding the procedural aspects of the experiment before the test began. This briefing included adequate resting time for each participant and

TABLE 1 Related research review.

| Author(s) | Discussion | Methods | Results |
|---|---|---|---|
| LeDoux (1989) | Studying interacting systems of the brain that mediate emotion and cognition | Conceptual framework reasoning | Stimulus representations, affect representations, and self-representations coincidence in working memory leads to emotional experiences |
| Gross and Levenson (1995) | Developing a set of films to elicit eight emotional states | Film screening assessment | Films successfully elicited amusement, anger, contentment, disgust, sadness, surprise, neutral state, and fear |
| Wang and Cheong (2006) | Developing a systematic approach in psychology and cinematography to address affective understanding | Extracting affective information from audio streams and films into categories | Results validate the efficacy of the audiovisual cues |
| Xu et al. (2008) | Analyzing films' emotion intensity and emotion type using arousal and valence-related features hierarchically | Experimental assessments | Results show that viewers prefer to access movie content by emotion intensity levels while satisfied with the emotion detection |
| Dijkstra et al. (2008) | The importance of individual differences in sensitivity toward colors in healthcare environments | Stimulus screening assessments | The effects of environmental coloring on stress, arousal, and cognitive appraisal were significant from different subject scores |
| Schaefer et al. (2010) | Testing and developing the effectiveness of a new and comprehensive set of emotional film excerpts | Subjective assessments from the film screening | Film clips were effective in emotional discreteness, arousal, and positive and negative affect |
| Smith et al. (2012) | Reviewing the history of empirical investigations into movie perception from various methods | Review | Sensory-motor processing differences between movies and reality help perceive continuity in the real world |
| AL-Ayash et al. (2016) | Learning, physiological and emotional states can be affected by colors in private study spaces | Analysis of emotional and physiological responses | Changes in colors have a significant impact on psychophysiological properties in study environments |
| Hakak et al. (2016) | The role of the pre-central gyrus in perceiving abstract spatial environments | Questionnaire reports from experimental environments | Correlation between designed environments and already experienced physical world |
| Higuera-Trujillo et al. (2021) | Impacts of neural activity during exposure to environmental situations | Scoping review | There is great potential in the neuroarchitecture approach for future design and studies |
| Sakhaei et al. (2022) | Examining if film stimuli help perceive architectural qualities to highlight mental health and improved cognitive tasks | Psychophysiological assessments | The intensive disruption of architectural elements indicates improved cognitive perception of spatial qualities, and enhanced interaction and can signify sustainable design criteria |

having a meal before the experiment began. All of the participants reported as healthy with no mental or physical difficulty. Participants were also asked to avoid smoking, drinking alcohol, or caffeine at least 4 h before the test to avoid over-stimulation. The experiment protocol was validated and conducted under the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

## Editing film sequences

Three film clips from cinematic movies were edited in a shorter format for this experiment based on two criteria. The first criterion for selecting the films was *space narration*, implying that the screened space in each clip and the depicted architectural elements therein would potentially influence the observers' attention irrespective of the film's script. The second criterion involved the presence of a *disruptive and evoking event* in all three film spaces such that the architectural elements therein were deconstructed. By weakening the influence of the script per clip (to avoid critical storyline and dialogs), the architecture of featured spaces within the clips was prioritized to influence the audience's perception.

To fulfill these two criteria, we focused on particular scenes in which a one-point perspective and point-of-view or eye-level-view shots were featured in the clips. Accordingly, the film form analysis

system (Bordwell et al., 1993) was regarded as a reference to extract standard scenes to depict the best affective experience of observing film spaces and space configurations. This camera height and angle choice could help our depicted spaces impart an illusion of being present within the visualized spaces. Face validity of the film clips' final editing was examined by sending the final films to experts and academics in the fields of architecture and cinema to identify problems with the clarity of film contents to appropriately deliver the architectural space qualities based on our criteria. The video contents were then revisited and finalized based on experts' feedback.

Thus, three film clips with an average of 5 min duration and a total of 15 min were edited for the experiment. The first and last 2 min of each film narrate a classic cozy home space, while the middle one and a half minutes show evoking events that change the physical shape of architectural elements. The house space was chosen to arouse a sense of familiarity within the participants.

Each clip is split into three parts; the ordinary scene in the first part shown to subjects allows them to be immersed in the space, thus allowing them to get acquainted with spatial characteristics. The middle section illustrates the event scene in which the previously shown architectural elements get destroyed and lose their function. In the third or final part of each movie following the event scene, subjects watched the same first part of the clip (Figure 1). They watched the repeated scene so that we could assess their cognitive responses and emotions that could have been possibly affected by the middle scene's disruptive events. Participants' perception of spatial quality and emotions were assessed by conducting three questionnaires-based surveys during the screenings.

## Film plot summaries and details

Table 2 describes plot summaries and scenes' details of the three films.

## Data collection of biofeedback and psychological measurements

We tried to conduct the research in the same timeline every day to create a more homogenous psychological atmosphere for participants. The experiment was performed between 11 a.m. and 2 p.m. in the same room with a constant temperature of 25 degrees Celsius for all subjects. We chose this timeline as people's consciousness level could be appropriate enough to observe the films and evaluate the spaces. We tried to perform data collection in a single season of the year to preserve the homogeneous mental situation of participants that could be related to weather conditions. Accordingly, the tests were performed from September to December, which is the Autumn season in the experiment's location.

Three standard questionnaire-based surveys were conducted to capture psychological changes during the film screenings. Questionnaires including Aesthetic Chills, The Self-assessment Manikin, and Normalized Accumulated Quality were filled out in paper and pencil format to assess emotional responses. The Aesthetic Chills (chills) questionnaire consisted of 10 questions about emotional reactions from the films' observations. According to Silvia and Nusbaum (2011), the chills test could serve as a standard assessment test wherein people engage with art forms such as movie content. Participants can also write down in detail their self-description of emotional state for each questionnaire's item. The Self-Assessment Manikin test (SAM) involved gathering information pertaining to the participant's feelings of pleasure, arousal, and dominance using a 9-point scale. The SAM test describes individuals' emotional feelings regarding three independent characteristics: pleasure, arousal, and dominance (Bradley and Lang, 1994). In this model, pleasure represents a continuous feeling ranging from severe sadness to extreme joy when watching different film sequences. Arousal illustrates the mental activity ranging from feeling asleep to an unpleasant thrill. Dominance is related to the sense of being controlled and limited when exposed to various events in the movies (Mehrabian and Russell, 1974). The Normalized Accumulated Quality (NAQ) involves a human subjective evaluation of geometrical characteristics in space (Zawidzki, 2016a). The NAQ is focused on assessing spatial perception as opposed to aesthetic features of a space.

After letting the participants feel relaxed and calm in the room where the experiment was conducted, the participants were briefed regarding the experiment procedure. The candidates were specifically instructed to assess the observed architectural details and spatial features thoroughly. The participants sat in front of a 15-inch laptop with loudspeaker audio to view the movie contents. After they watched the ordinary sequence, we paused the clip and asked them to fill out the chills, SAM, and NAQ questionnaires related to the first 2-min scene. Upon completing the three questionnaires, we continued screening the second scene with disruptive events alongside the ordinary scene without a pause in between. This was followed by the ordinary scene that was precisely the one screened in the first part of the movie. The film clip was not paused while transitioning from the second scene to the third scene, thus allowing the participants to assess the ordinary space based on the psychological changes that affected their emotions in the middle of the movie. Post this exposure, the participants were asked to complete the same chills, SAM, and NAQ survey again; Data was thus gathered for two distinct phases: pre-event and post-event, with two entirely identical scenes (scenes 1 and 3) with the latter one hypothesized to have been impacted by cognitive stimuli. This protocol was executed for all films. The participants were separated into three groups of thirty people per group for each movie. Additionally, we captured a video from each subject during their film screenings to report an observational analysis of apparent psychophysiological changes.

## Statistical analyses

The Pearson correlation coefficient was performed to evaluate the association between NAQ and variables including

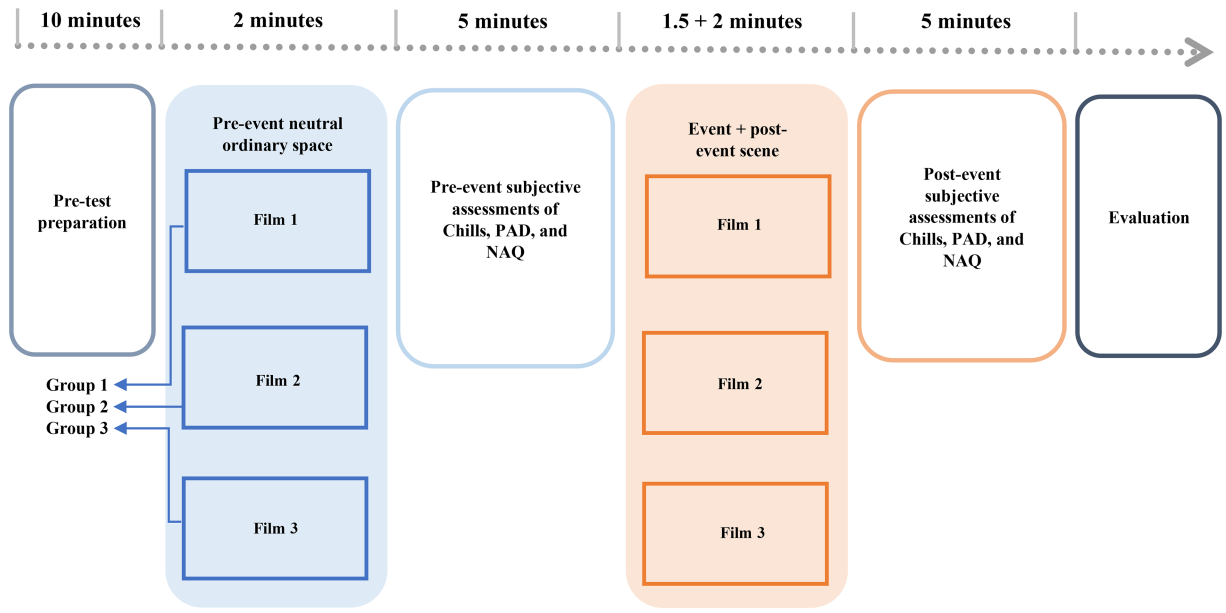



FIGURE 1
Research design.

chills, pleasure, arousal, and dominance in different films. The impact of chills, pleasure, arousal, and dominance on NAQ was evaluated using the univariate regression model. The adjusted impact of variables on NAQ was assessed using a multivariate regression model by different films, meaning that the adjusted impacts of chills, pleasure, arousal, and dominance on NAQ were compared between the three films. R-squared was reported to measure the proportion of the variance for a NAQ explained by an independent variable. The variance inflammatory factor (VIF) was used as an indicator of multicollinearity, which is a statistical concept where several independent variables in a model are correlated. Two variables are assumed to be significantly collinear if their correlation coefficient is ±1.0. All analyses were conducted using R (version 4.0.2) and SPSS (version 26). *p*-values <0.05 were regarded as statistically significant.

## Results

Analyzing the NAQ components resulted in identifying that the 'Harsh' factor showed the highest fluctuation between pre-event and post-event evaluations (−3.00 for Film 1, −3.10 for Film 2, and −3.60 for Film 3). The 'Chaotic' (−2.80 for Film 1, −2.80 for Film 2, and −3.10 for Film 3) and 'Artificial' (−1.80 for Film 1, −1.30 for Film 2, and −3.00 for Film 3) factors also had the highest negative impacts on assessing of space qualities. Events had the most positive impact on the Diverse factor of NAQ (−0.50 for Film 1, +0.90 for Film 2, and +0.50 for Film 3). Overall, the Film 3 event had the highest impact on understanding the NAQ among the three film spaces.

The association between NAQ and variables such as chills, pleasure, arousal, and dominance are reported in Table 3. In film 1, NAQ was significantly associated with chills (0.56; 95% CI: 0.25, 0.76), pleasure (0.87; 95% CI: 0.73, 0.93), arousal (0.4; 95% CI: 0.08, 0.69), and dominance (0.44; 95% CI: 0.09, 0.69). This report illustrates that participants' emotional states were significantly related to understanding the quality of space. The disruptive events in film 1 led to a substantial difference in evaluating normalized spatial qualities between pre-event and post-event scenes and highlighted a meaningful relationship with emotional feelings. There was also a significant positive relationship between NAQ and pleasure (0.72; 95% CI: 0.47, 0.85) in film 2. In film 3, however, the correlation between NAQ and arousal was observed to be positive and significant (0.37; 95% CI: 0.01, 0.64). The overall association of emotional feelings with normalized space quality depicts that the subjective assessments of space qualities could significantly impact the level of feeling pleasure and arousal. In some scenes, the high correlations of chills and dominance with assessing the space quality were observed.

Table 4 shows the crude and adjusted impact of variables on the NAQ across different films. According to the results of film 1, the average NAQ was raised for each unit increase in the chills (0.73; 95% CI: 0.32, 1.4), dominance (0.17; 95% CI: 0.04, 0.31), arousal (0.20; 95% CI: 0.04, 0.36) and pleasure (0.28; 95% CI: 0.22, 0.35) factors. A significant impact was also found on NAQ for adjusted chills (0.37; 95% CI: 0.04, 0.70) and pleasure (0.31; 95% CI: 0.23, 0.39) factors. Accordingly, the emotional changes in participants illustrated a reasonable trend with changes in perception of spatial qualities. Subjects' emotional changes from film 1's space-related stimuli illustrated an impact on architectural

TABLE 2 Plot summaries and space-related features in the film clips.

| Film name | Plot summary | Pre-event scene details | Event scene details |
|---|---|---|---|
| Film 1: *The Money Pit (1986)* | A young couple pays a visit to a classic architecture house to buy the place. As the house needs renovation to satisfy their desires, however, unpredictable accidents devastate the couple's renovation process | The young couple checks the house to conclude if it is proper to buy. They start the renovation together to make it suitable to live for their future | The front door falls during the renovation, and the interior main stairs collapse. The electrical wiring in the kitchen catches fire while the tiles shatter. The chimney in the bedroom gets demolished when they lit the fire |
| Film 2: *Zathura: A Space Adventure (2005)* | Two young kids live with their father. As soon as their father leaves the house for a business, the lonely kids face strange events inside the house while playing a board game | An ordinary father-son play inside the house depicts a happy weekend in a family. The kids use the living room, stairs, and kitchen as playgrounds | The house gets hit by multiple fireballs that pierced the roof, the interior walls, and the ceiling and frightened the children. The kids run away for shelter as they watch their house gets demolished |
| Film 3: *I, Robot (2004)* | Robots will work as human servants in the future. While there are strict rules to control them, a detective has to determine if a robot has violated the regulations and murdered a person | The detective walks into a vacant house for investigation. He suspiciously walks into the corridor, uses the stairs, and searches the private room for clues. At least for a while, he finds no unusual activity | A giant robot starts to invade the house from the outside. It destroys the walls and continues the demolishment until the place turns to ashes. The detective runs away to save his life during the invasion |

quality assessments when we adjusted the impact of each variable on normalized space quality. In film 2, the significant impact of dominance (0.13; 95% CI: 0.00, 0.26) and pleasure (0.23; 95% CI: 0.14, 0.32) factors on NAQ was observed using the univariate model, whereas only the adjusted effect of pleasure factor on NAQ remained significant throughout the multivariate model (0.23; 95% CI: 0.15, 0.31). This report shows that feeling dominated and pleased among emotional responses in film 2 could influence normalized space quality judgments more than chills and arousal. According to film 3 and the univariate model, arousal was the only variable that significantly impacted the NAQ (0.12; 95% CI: 0.00, 0.23). The adjusted R-squared for films 1, 2, and 3 was 0.78, 0.59, and 0.05, respectively. VIFs were <5 for all variables. As shown in Figure 2, the linear regression was fitted for NAQ and other variables. Higher slopes were illustrated for models in film 1, showing a more significant impact of emotional responses on perceiving normalized space quality than events in films 2 and 3.

## Discussion

This research tried to understand the impact of emotion-eliciting stimuli in space on environmental perception. Since environmental quality is beneficial to achieving a sustainable and communicative design (Li et al., 2021), we relied on human subjective evaluation (HSE) of space, previously developed by Zawidzki (2016b), to capture the association of normalized factors of spatial quality with chills, pleasure, arousal, and dominance in three films. Besides this, significant psychological feedback was also extracted by editing affect-based video clips with a potential valence-arousal feature (Soleymani et al., 2009). Based on previous experiments by Xu et al. that categorized a film's content into calm, average, and exciting (Xu et al., 2008), we divided our scenes into pre-event, event, and post-event in order to systematically compile the feedback from the participants. We also standardized the camera angle, movements, and other space-related factors to control the experiment, as mentioned in an earlier study (Carvalho et al., 2012).

Our assessment revealed that the participants' expectations changed from the pre-event scenario where they tried to memorize the environment to the event scene. It was also observed that during the event scene, participants' attention to architectural qualities had been substantially elevated and hence, impacted their post-event responses. This could have also impacted the assignment of a superior form of attention to the disruptive events when they scored the post-event scene's assessments. As previously validated by Bernstein (2018), this process can highlight the critical role of sensory information in determining cognitive behavior (Smith et al., 2012). During the event scene, significant alterations to the physical environments occurred in spatial arrangements, lighting, and the forms of architectural elements. While changes in the physical environment's elements improved the overall spatial perception of participants, the experiment can validate the Cognitive Load Theory, which discussed the impact of spatial characteristics on environmental learning improvement. As discussed in the literature, order, diversity, and a balanced environment influence the perception of space and cognitive function. Likewise, after participants' subjective evaluation of space in the three films, NAQ's negative factors of Harsh, Chaotic, and Artificial were the most influential items impacted by post-event evaluation. On the contrary, the positive factor of "Diverse" was the most noticeable item affected by the events.

In the experiment, almost all emotional responses correlated significantly with the subjective evaluation of space. Among chills and PAD variables, both pleasure and arousal highlighted their substantial association with the evaluation of space. Similar studies also validated that utilizing film content stimuli elicited emotional feelings in participants (Gross and Levenson, 1995;

Schaefer et al., 2010). Higher correlation and impact of emotional arousal with space quality assessments indicate that the spatial stimuli could possibly represent categorized cues (Bruner, 1973). Subjects' broader attention to architectural details may illustrate the role of spatial stimuli in creating a transcendent projection of the environment compared to the normal situation. The emotional arousal can indicate that the events in the films might have helped establish an apparent reality by shifting from entertainment space to executive space discussed in Dual Awareness Theory (Tan, 2008). Participants' engagement with the movie contents alongside emotional behavior elevated after the event scene, indicating their strong interaction with the scenes' content and structural information as explained in the Limited Capacity Model. In Lang's LCM model (Lang, 2000), changes in space structure and the deconstruction of elements are integrated with the viewer's emotional states. As a result, we tried to focus on mental and cognitive aspects of space to demonstrate the importance of enhanced perception in sustainable design thinking.

The high association of chills and arousal with NAQ may also show that our experiment may explain the interrelationship between aesthetic judgments and emotion in space evaluation mentioned in the Leder model (Leder et al., 2004). Accordingly, the art-eliciting judgments in our experiment were followed by chills and goosebumps (Salimpoor et al., 2009; Laeng et al., 2016), feeling joy (Panksepp, 1995; Nusbaum et al., 2014), and PAD (Mehrabian and Russell, 1974; Gifford, 2007). The highest slopes of regression graphs were reported for the impact of chills and PAD on NAQ in film 1. The factors of chills and PAD as predictors for NAQ also showed high slopes for films two and three, demonstrating a meaningful relationship with NAQ. To validate the psychological reports of participants from observational data collection, we relied on the video-recorded data from their apparent psychophysiological changes and discovered minor alterations in pupils' size, skin tone color, and even slight goosebumps during the event scenes. In addition, some individuals reported being aroused and overwhelmed by the space stimuli. Conversely, subjects reported being more relaxed with no apparent arousal in their body or face during the pre-event scenes. This observational study can demonstrate a sufficient alignment between psychophysiological responses and observational analyses.

According to our results, the adjusted impact of chills and PAD variables on the space quality assessments depicted a meaningful increasing trend as the average NAQ increased with elevated emotional arousal. However, among the three films, film 1's post-event evaluation signified a stronger relationship between emotional responses and NAQ assessments both in correlation and regression analyses. In film three analyses, the arousal factor was mainly associated with the NAQ compared to

TABLE 3 The association between NAQ score and variables including chills, pleasure, arousal, and dominance.

| Film name | Variables | Pearson correlation (95% CI) | Value of *p* |
|---|---|---|---|
| 1 | NAQ – Chills | 0.56 (0.25, 0.76) | 0.001 |
| | NAQ – Pleasure | 0.87 (0.73, 0.93) | <0.001 |
| | NAQ – Arousal | 0.44 (0.08, 0.69) | 0.016 |
| | NAQ – Dominance | 0.44 (0.09, 0.69) | 0.015 |
| 2 | NAQ – Chills | 0.26 (−0.11, 0.57) | 0.164 |
| | NAQ – Pleasure | 0.72 (0.47, 0.85) | <0.001 |
| | NAQ – Arousal | −0.12 (−0.46, 0.26) | 0.541 |
| | NAQ – Dominance | 0.36 (−0.01, 0.64) | 0.050 |
| 3 | NAQ – Chills | 0.17 (−0.20, 0.50) | 0.362 |
| | NAQ – Pleasure | 0.18 (−0.20, 0.50) | 0.354 |
| | NAQ – Arousal | 0.37 (0.01, 0.64) | 0.043 |
| | NAQ – Dominance | 0.32 (−0.05, 0.61) | 0.087 |

The 95% CI was calculated for bivariate correlation variables considering the bias adjustment.

TABLE 4 The crude and adjusted impact of dominance, arousal, and pleasure on the NAQ by film name.

| Film name | Variables | Univariate regression | | | Multivariate regression | | | |
|---|---|---|---|---|---|---|---|---|
| | | Coefficient (95% CI) | Value of *p* | $R^2$ | Coefficient (95% CI) | Value of *p* | Adjusted $R^2$ | VIF |
| 1 | Chills | 0.73 (0.32, 1.4) | **0.001** | 0.32 | 0.37 (0.04, 0.70) | 0.028 | 0.78 | 2.03 |
| | Dominance | 0.17 (0.04, 0.31) | **0.015** | 0.20 | −0.08 (−0.18, 0.02) | 0.113 | | 1.93 |
| | Arousal | 0.20 (0.04, 0.36) | **0.016** | 0.19 | −0.09 (−0.21, 0.03) | 0.117 | | 2.13 |
| | Pleasure | 0.28 (0.22, 0.35) | **<0.001** | 0.75 | 0.31 (0.23, 0.39) | <0.001 | | 1.93 |
| 2 | Chills | 0.28 (−0.12, 0.67) | 0.164 | 0.07 | 0.19 (−0.13, 0.51) | 0.236 | 0.59 | 1.55 |
| | Dominance | 0.13 (0.00, 0.26) | **0.050** | 0.13 | 0.09 (−0.02, 0.20) | 0.113 | | 1.52 |
| | Arousal | −0.06 (−0.27, 0.14) | 0.541 | 0.12 | −0.01 (−0.15, 0.13) | 0.883 | | 1.14 |
| | Pleasure | 0.23 (0.14, 0.32) | **<0.001** | 0.51 | 0.23 (0.15, 0.31) | <0.001 | | 1.08 |
| 3 | Chills | 0.12 (−0.14, 0.378) | 0.362 | 0.03 | 0.06 (−0.36, 0.47) | 0.789 | 0.05 | 2.75 |
| | Dominance | 0.12 (−0.02, 0.26) | 0.087 | 0.10 | 0.09 (−0.11, 0.29) | 0.371 | | 2.10 |
| | Arousal | 0.12 (0.00, 0.23) | **0.043** | 0.14 | 0.05 (−0.18, 0.28) | 0.662 | | 4.04 |
| | Pleasure | 0.09 (−0.11, 0.29) | 0.354 | 0.03 | 0.09 (−0.14, 0.32) | 0.418 | | 1.40 |

NAQ is the dependent variable; VIF, Variance Inflammatory Factor. Bold values show that they are significant.

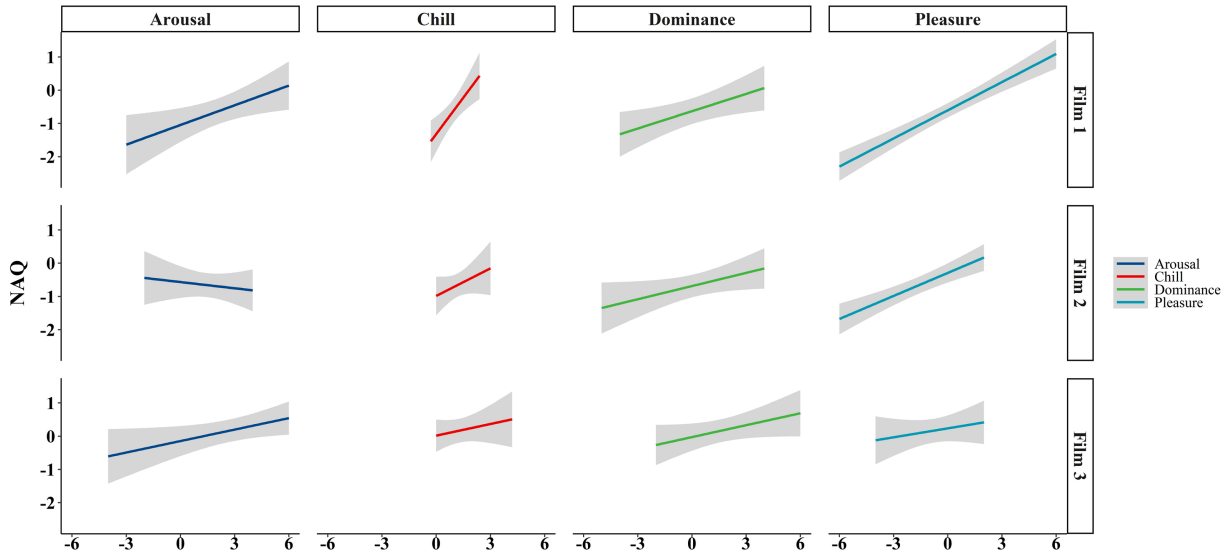



FIGURE 2
Scatter plot showcasing the arousal, chills, dominance, and pleasure variables as the predictors of NAQ.

other variables, meaning that the events of film three highly intensified the level of arousal than in the other two films. It can be construed that the structure of the events in film 1 was more indicative of apparent reality than in the other films. In film 1, real architecture elements shatter without significant visual effects. In the second and third films, subjects witness the same deconstruction of architectural elements but with moderate visual effects that intensify the events. The lower association of emotional responses during spatial assessments in films 2 and 3 may prove that the higher level of assuming the environment as an Entertainment Space can impact the judgment of spatial character. As mentioned in the dual awareness theory (Tan, 2008), in the second and third films, the lower level of engagement with events led to perceiving the environment only as an entertainment space. In contrast, film 1's events could possibly lead the Executive Space to support the constructed imagery of the Entertainment Space by creating a higher association of emotional responses with the perception of spatial qualities. Capturing the association between psychological aspects of space and environmental qualities helped us notice the interrelation between sustainable design thinking and environmental research.

The overall association of chill and PAD with subjective evaluation of space demonstrated that normalized accumulated quality could be related to emotional states of feeling goosebumps, enjoyment or sadness, aroused, and dominated. We tried to establish a standard and controlled experiment to simulate real physical environments through the mediation of film context to capture the association between normalized space quality perception and emotional arousal. This mediation of cinematic context can help us understand how the human mind learns, memorizes, and judges its surroundings. Hence, we will be able to improve our built environment by enhancing spatial cognition and environmental interactions. This improvement can validate more sustainable and communicative space criteria in an interactive environment by influencing designers to highly regard cognitive emotions and space qualities within the communication discussion.

## Conclusion

This study highlighted that using affect-based video clips focusing on space-related stimuli can be an operational approach to capture the association of psychological responses with the perceived quality of a normalized place. By introducing spatial stimuli in a conventional spatial environment, the mind's cognitive ability can be enhanced by improving the learning process and categorizing events as cues to improve environmental perception. The impact of events on emotional changes can help understand the intensity of cognitive load to assess spatial qualities. Capturing the psychological states of individuals and their relationship with spatial judgments, especially when people are exposed to environmental stimuli, can contribute to designing a highly sustainable place.

## Limitations and future research

In this study, we focused on the affective responses from different groups of participants from the same culture. However, the affective responses can vary from person to person and culture to culture. An affect representation of particular individuals could be controversial and generalized to a broad population (Wang and

Cheong, 2006). We propose that this study be conducted for a broader group of people with different nationalities or experiences to consider people's preferences and variety, thus promoting efficient affect analyses of space stimuli. Another important matter that requires critical attention for future research is controlling the film content parameters. Accordingly, the environmental stimulation in films may differ from the real environment and lead to the result distortions. This important criterion should be highly noted when the self-evaluations are prone to bias since they mainly assess the conscious human responses to the space (Schwarz and Strack, 1999). We suggest that future similar studies reflect the possible unconscious aspects when measuring individuals' cognitive activities in mediated environments like films by noting that most emotional states appear at the unconscious level (Zaltman, 2003).

## Data availability statement

The original contributions presented in the study are included in the article/supplementary files, further inquiries can be directed to the corresponding author.

## Ethics statement

The studies involving human participants were reviewed and approved by Department of Physiology, Tarbiat Modares University. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

## Author contributions

HS and NB: conceptualization, methodology, software, visualization, funding acquisition, investigation, review, editing, validation, project administration, and supervision. HS and ML writing original draft, data curation, and formal analysis. All authors contributed to the article and approved the submitted version.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References


AL-Ayash, A., Kane, R. T., Smith, D., and Green-Armytage, P. (2016). The influence of color on student emotion, heart rate, and performance in learning environments. *Color Res. Appl.* 41, 196–205. doi: 10.1002/col.21949

Bernstein, D. (2018). *Essentials of Psychology.* Boston, USA: Cengage Learning.

Blackwood, D. H. R., and Muir, W. J. (1990). Cognitive brain potentials and their application. *Br. J. Psychiatry* 157, 96–101. doi: 10.1192/S0007125000291897

Bordwell, D., Thompson, K., and Smith, J., (1993). *Film Art: An Introduction*. New York, NY McGraw-Hill.

Bradley, M. M., Codispoti, M., Cuthbert, B. N., and Lang, P. J. (2001). Emotion and motivation I: defensive and appetitive reactions in picture processing. *Emotion* 1:276, –298. doi: 10.1037/1528-3542.1.3.276

Bradley, M. M., and Lang, P. J. (1994). Measuring emotion: the self-assessment manikin and the semantic differential. *J. Behav. Ther. Exp. Psychiatry.* 25, 49–59. doi: 10.1016/0005-7916(94)90063-9

Brennan, A., Chugh, J. S., and Kline, T. (2002). Traditional versus open office design: a longitudinal field study. *Environ. Behav.* 34, 279–299. doi: 10.1177/0013916502034003001

Bruer, J. T. (1997). Education and the brain: a bridge too far. *Educ. Res.* 26, 4–16. doi: 10.3102/0013189X026008004

Bruner, J. S. (1973). *Beyond the Information Given: Studies in the Psychology of Knowing.* Washington DC, USA: WW Norton.

Buttazzoni, A., Parker, A., and Minaker, L. (2021). Investigating the mental health implications of urban environments with neuroscientific methods and mobile technologies: a systematic literature review. *Health Place* 70:102597. doi: 10.1016/j.healthplace.2021.102597

Carvalho, S., Leite, J., Galdo-Álvarez, S., and Gonçalves, O. F. (2012). The emotional movie database (EMDB): a self-report and psychophysiological study. *Appl. Psychophysiol. Biofeedback* 37, 279–294. doi: 10.1007/s10484-012-9201-6

Coëgnarts, M. (2017). Cinema and the embodied mind: metaphor and simulation in understanding meaning in films. *Palgrave Commun.* 3, 1–15. doi: 10.1057/palcomms.2017.67

Dijkstra, K., Pieterse, M. E., and Pruyn, A. T. H. (2008). Individual differences in reactions towards color in simulated healthcare environments: the role of stimulus screening ability. *J. Environ. Psychol.* 28, 268–277. doi: 10.1016/j.jenvp.2008.02.007

Gifford, R., (2007). *Environmental Psychology: Principles and Practice*. Optimal Books Colville, WA.

Gilmore, C. S., Malone, S. M., Bernat, E. M., and Iacono, W. G. (2010). Relationship between the P3 event-related potential, its associated time-frequency components, and externalizing psychopathology. *Psychophysiology* 47, 123–132. doi: 10.1111/j.1469-8986.2009.00876.x

Goldstein, A. (1980). Thrills in response to music and other stimuli. *Physiol. Psychol.* 8, 126–129. doi: 10.3758/BF03326460

Grodal, T. (2009). *Embodied Visions: Evolution, Emotion, Culture, and Film.* Oxford, UK: Oxford University Press.

Gross, J. J., and Levenson, R. W. (1995). Emotion elicitation using films. *Cogn. Emot.* 9, 87–108. doi: 10.1080/02699939508408966

Guzman, V., Garrido-Cumbrera, M., Braçe, O., Hewlett, D., and Foley, R. (2021). Associations of the natural and built environment with mental health and wellbeing during COVID-19: Irish perspectives from the GreenCOVID study. *Lancet Glob. Health* 9:S20. doi: 10.1016/S2214-109X(21)00128-5

Hakak, A. M., Bhattacharya, J., Biloria, N., de Kleijn, R., and Shah-Mohammadi, F. (2016). Navigating abstract virtual environment: an eeg study. *Cogn. Neurodyn.* 10, 471–480. doi: 10.1007/s11571-016-9395-z

Hakak, A. M., Biloria, N., Dabbagh, A., and Venhari, A. A. (2017). 2D vs. 3D: starting the design process from a higher dimension. *A+ BE|Archit. Built Environ.* 7, 47–62. doi: 10.7480/abe.2017.7.3632

Hanjalic, A., and Xu, L.-Q. (2005). Affective video content representation and modeling. *IEEE Trans. Multimedia* 7, 143–154. doi: 10.1109/TMM.2004.840618

Hedge, A. (1982). The open-plan office: a systematic investigation of employee reactions to their work environment. *Environ. Behav.* 14, 519–542. doi: 10.1177/0013916582145002

Higuera-Trujillo, J. L., Llinares, C., and Macagno, E. (2021). The cognitive-emotional design and study of architectural space: a scoping review of neuroarchitecture and its precursor approaches. *Sensors* 21:2193. doi: 10.3390/s21062193

Izard, C. E. (2013). *Human Emotions.* New York, USA: Springer Science & Business Media.

Khaleghimoghaddam, N., and Bala, H. A. (2018). The impact of environmental and architectural design on users' affective experience. *YBL J. Built Environ.* 6, 5–19. doi: 10.2478/jbe-2018-0001

Küller, R., Mikellides, B., and Janssens, J. (2009). Color, arousal, and performance-a comparison of three experiments. *Color Res. Appl.* 34, 141–152. doi: 10.1002/col.20476

Laeng, B., Eidet, L. M., Sulutvedt, U., and Panksepp, J. (2016). Music chills: the eye pupil as a mirror to music's soul. *Conscious. Cogn.* 44, 161–178. doi: 10.1016/j.concog.2016.07.009

Lang, P. J. (1979). A bio-informational theory of emotional imagery. *Psychophysiology* 16, 495–512. PMID: 515293

Lang, A. (2000). The limited capacity model of mediated message processing. *J. Commun.* 50, 46–70. doi: 10.1111/j.1460-2466.2000.tb02833.x

Lang, P. J., and Bradley, M. M. (2010). Emotion and the motivational brain. *Biol. Psychol.* 84, 437–450. doi: 10.1016/j.biopsycho.2009.10.007

Leder, H., Belke, B., Oeberst, A., and Augustin, D. (2004). A model of aesthetic appreciation and aesthetic judgments. *Br. J. Psychol.* 95, 489–508. doi: 10.1348/0007126042369811

LeDoux, J. E. (1989). Cognitive-emotional interactions in the brain. *Cognit. Emot.* 3, 267–289. doi: 10.1080/02699938908412709

Li, Z., Ba, M., and Kang, J. (2021). Physiological indicators and subjective restorativeness with audio-visual interactions in urban soundscapes. *Sustain. Cities Soc.* 75:103360. doi: 10.1016/J.SCS.2021.103360

Li, J., Jin, Y., Lu, S., Wu, W., and Wang, P. (2020). Building environment information and human perceptual feedback collected through a combined virtual reality (VR) and electroencephalogram (EEG) method. *Energ. Buildings* 224:110259. doi: 10.1016/j.enbuild.2020.110259

Liddicoat, S., Badcock, P., and Killackey, E. (2020). Principles for designing the built environment of mental health services. *Lancet Psychiatry* 7, 915–920. doi: 10.1016/S2215-0366(20)30038-9

Mehrabian, A., and Russell, J. A. (1974). *An Approach to Environmental Psychology*. Cambridge MA, USA: The MIT Press.

Nusbaum, E. C., Silvia, P. J., Beaty, R. E., Burgin, C. J., Hodges, D. A., and Kwapil, T. R. (2014). Listening between the notes: aesthetic chills in everyday music listening. *Psychol. Aesthet. Creat. Arts* 8, 104–109. doi: 10.1037/a0034867

Osgood, C. E. (1966). Dimensionality of the semantic space for communication via facial expressions. *Scand. J. Psychol.* 7, 1–30. doi: 10.1111/j.1467-9450.1966.tb01334.x

Paas, F. G. W. C., and van Merriënboer, J. J. G. (1994). Variability of worked examples and transfer of geometrical problem-solving skills: a cognitive-load approach. *J. Educ. Psychol.* 86, 122–133. doi: 10.1037/0022-0663.86.1.122

Panksepp, J. (1995). The emotional sources of" chills" induced by music. *Music. Percept.* 13, 171–207. doi: 10.2307/40285693

Penz, F. (2017). *Cinematic Aided Design: An Everyday Life Approach to Architecture.* London, UK: Routledge.

Rooney, B., Benson, C., and Hennessy, E. (2012). The apparent reality of movies and emotional arousal: a study using physiological and self-report measures. *Poetics* 40, 405–422. doi: 10.1016/j.poetic.2012.07.004

Rooney, B., and Hennessy, E. (2013). Actually in the cinema: a field study comparing real 3D and 2D movie patrons' attention, emotion, and film satisfaction. *Media Psychol.* 16, 441–460. doi: 10.1080/15213269.2013.838905

Sakhaei, H. (2020). Interactive kinetic canopy with industrial architecture legacy preservation approach. *J. Archit. Res. Dev* 4:4. doi: 10.26689/jard.v4i2.1033

Sakhaei, H., Yeganeh, M., and Afhami, R. (2022). Quantifying stimulus-affected cinematic spaces using psychophysiological assessments to indicate enhanced cognition and sustainable design criteria. *Front. Environ. Sci.* 10:832537. doi: 10.3389/fenvs.2022.832537

Salimpoor, V. N., Benovoy, M., Longo, G., Cooperstock, J. R., and Zatorre, R. J. (2009). The rewarding aspects of music listening are related to degree of emotional arousal. *PLoS One* 4:e7487. doi: 10.1371/journal.pone.0007487

Schacter, D., Gilbert, D., and Wegner, D. (2011). *Sensation and Perception.* London, UK: Charles Linsmeiser Psychology Worth Publishers, 158–159.

Schaefer, A., Nils, F., Sanchez, X., and Philippot, P. (2010). Assessing the effectiveness of a large database of emotion-eliciting films: a new tool for emotion researchers. *Cognit. Emot.* 24, 1153–1172. doi: 10.1080/02699930903274322

Schubert, T. W., Zickfeld, J. H., Seibt, B., and Fiske, A. P. (2018). Moment-to-moment changes in feeling moved match changes in closeness, tears, goosebumps, and warmth: time series analyses. *Cognit. Emot.* 32, 174–184. doi: 10.1080/02699931.2016.1268998

Schwarz, N., and Strack, F. (1999). Reports of subjective well-being: judgmental processes and their methodological implications. *Well-being: Found. Hedonic Psychol.* 7, 61–84.

Silvia, P. J., and Nusbaum, E. C. (2011). On personality and piloerection: individual differences in aesthetic chills and other unusual aesthetic experiences. *Psychol. Aesthet. Creat. Arts* 5, 208–214. doi: 10.1037/a0021914

Smith, T. J., Levin, D., and Cutting, J. E. (2012). A window on reality: perceiving edited moving images. *Curr. Dir. Psychol. Sci.* 21, 107–113. doi: 10.1177/0963721412437407

Soleymani, M., Chanel, G., Kierkels, J. J. M., and Pun, T. (2009). Affective characterization of movie scenes based on content analysis and physiological changes. *Int. J. Semantic Comput.* 3, 235–254. doi: 10.1142/S1793351X09000744

Sundstrom, E., Town, J. P., Brown, D. W., Forman, A., and Mcgee, C. (1982). Physical enclosure, type of job, and privacy in the office. *Environ. Behav.* 14, 543–559. doi: 10.1177/0013916582145003

Tan, E. S.-H. (2008). Entertainment is emotion: the functional architecture of the entertainment experience. *Media Psychol.* 11, 28–51. doi: 10.1080/15213260701853161

Tanner, C. K. (2000). The influence of school architecture on academic achievement. *J. Educ. Adm.* 38, 309–330. doi: 10.1108/09578230010373598

Tanner, C. K. (2008). Explaining relationships among student outcomes and the school's physical environment. *J. Adv. Acad.* 19, 444–471. doi: 10.4219/jaa-2008-812

Wang, H. L., and Cheong, L.-F. (2006). Affective understanding in film. *IEEE Trans. Circuits Syst. Video Technol.* 16, 689–704. doi: 10.1109/TCSVT.2006.873781

Weber, R. (1995). *On the Aesthetics of Architecture a Psychological Approach to the Structure and the Order of Perceived Architectural Space*. USA: Brookfield.

Xu, P., Huang, Y., and Luo, Y. (2010). Preliminary compilation and evaluation of Chinese emotional image library. *Chin. J. Mental Health* 24, 551–554.

Xu, M., Jin, J. S., Luo, S., and Duan, L. (2008). "Hierarchical movie affective content analysis based on arousal and valence features" in *Proceedings of the 16th ACM International Conference on Multimedia*, 677–680.

Zaltman, G. (2003). *How Customers Think: Essential Insights into the Mind of the Market.* Boston MA, USA: Harvard Business Press.

Zawidzki, M. (2016a). Automated geometrical evaluation of a plaza (town square). *Adv. Eng. Softw.* 96, 58–69. doi: 10.1016/j.advengsoft.2016.01.018

Zawidzki, M. (2016b). "Evaluation of the quality of an Urban Square," in *Discrete Optimization in Architecture.* (Singapore: Springer), 35–50.

frontiers | Frontiers in Psychology

TYPE Original Research
PUBLISHED 01 December 2022
DOI 10.3389/fpsyg.2022.1044697



OPEN ACCESS

EDITED BY
César O. Tapia-Fonllem,
University of Sonora, Mexico

REVIEWED BY
Amal Saad-Hussein,
National Research Centre, Egypt
Ricardo Ernesto Pérez Ibarra,
Instituto Tecnológico de Sonora (ITSON), Mexico

*CORRESPONDENCE
Boshra A. Arnout
prof.arnout74@gmail.com

SPECIALTY SECTION
This article was submitted to Environmental Psychology, a section of the journal Frontiers in Psychology

RECEIVED 21 September 2022
ACCEPTED 15 November 2022
PUBLISHED 01 December 2022

CITATION
Arnout BA (2022) Climate values as predictor of climate change perception in the Kingdom of Saudi Arabia.
*Front. Psychol.* 13:1044697.
doi: 10.3389/fpsyg.2022.1044697



# Climate values as predictor of climate change perception in the Kingdom of Saudi Arabia

Boshra A. Arnout[1,2]*

[1]Department of Psychology, King Khalid University, Abha, Saudi Arabia, [2]Department of Psychology, Zagazig University, Zagazig, Egypt

**Background:** Understanding public perceptions of climate change and how individuals perceive it is critical to developing effective communication strategies, policies, and socially robust technologies to relieve the risks of climate change. Despite the growing literature on climate change, until now, researchers in Arab countries have not been interested in studying citizens' perceptions of climate change or identifying the factors that predict it. This study aimed to identify and understand the nature and dynamics of public perceptions of climate change among Arab citizens and detect the level of climate change perception (CCP) and climate values (CV). Also, to detect the predictability of CCP from CV. As well as to reveal the differences between CCP and CV.

**Methods:** A random sample consisted of 465 participants (236 male and 229 female), residents of the Kingdom of Saudi Arabia; their ages ranged from 30 years and over. The Climate Change Perception Questionnaire (CCPQ) and Climate Values Questionnaire (CVQ) were applied online.

**Results:** The results found average levels of CCP and CV among the study sample. The results also revealed significant statistical differences in the CCP and CV due to gender in favor of females. As well as, there were significant statistical differences in the CCP due to the career field in favor of agriculture, engineering, and construction workers. Also, there were statistical differences in the emotional subscale of climate perception and CV due to age groups in favor of individuals whose ages ranged from 30 to 45 years. The results also found that the CV were a statistically significant predictor (1.2% of total variance) of climate perception.

**Conclusion:** The current study showed an average level of CCP and CV among individuals in the Kingdom of Saudi Arabian. The findings also concluded that individuals' perceptions of climate change are an individual response determined by the individual's gender, age, and career field and are affected by his values about climate. These findings shed light on the need for climate communications to increase the level of CCP and CV, especially among males and individuals in the age group over

45 years and individuals working in various career fields, whether education, engineering and construction, and commerce and business, etc.; to improve the engagement in mitigation and adaptation measures to climate change.

KEYWORDS

climate change, climate perception, climate values, Self-transcendence values, self-enhancement, hedonic values, egoism, altruism

## Theoretical background

The perception of climate change has grown significantly over the last few decades, while the level of concern has varied through time and worldwide. Though it developed in several Western nations in the late 2000s, skepticism regarding the existence and severity of climate change is mainly low among the general population worldwide (Clarke et al., 2012; Hansen et al., 2012; Altea, 2020).

To encourage widespread public participation and to create successful communication and educational strategies to encourage climate mindfulness and citizenship, it is essential to understand how the general public views climate change. Understanding how people feel about climate change and how it should be addressed is necessary for developing and implementing viable policies and technology that will help us reduce and adapt to it (de Matos Carlos et al., 2020; Fourment et al., 2020; Arnout, 2022a). Various psychological elements, such as information, beliefs, attitudes, anxiety, influence, and perceived threats associated with climate change, have all been called "climate change perceptions (CCP)." The term "perceptions" refers to people's internal representations of the problem of climate change, including their cognitive (e.g., knowledge), emotional (e.g., feelings), and evaluative (e.g., perceived risks) dimensions. However, we understand that these representations are influenced by social processes and cultural context (Kahan, 2015; Lehner and Stocker, 2015; Clayton and Manning, 2018).

Since the early 1980s, research on public perceptions of climate change has increased. Clayton and Manning (2018) mentioned that surveys have shown that perception and subjective knowledge about climate change have grown during the previous three decades. However, a cross-country study conducted in 2014 in three European nations, China, the United States, and Canada, showed that general respondents were primarily well-informed about climate change (Basannagari and Kala, 2013; Singh et al., 2017; Soliman et al., 2018; Kim and Ahn, 2019).

Climate change perceptions are shaped by cognitive processes (such as information assimilation) and social interaction within a given cultural context. Climate change is recognized primarily through mass communication, interpersonal communication, formal education, and other channels (Sterman and Sweeney, 2007; Spence et al., 2012; Clayton and Manning, 2018). As a result, media like newspapers and television have been essential in shaping public perceptions of climate change, particularly by highlighting debate over the topic and connecting it to pertinent social and political developments (Clayton and Manning, 2018).

According to a qualitative study on climate perceptions, people's direct associations with climate change are based on recurring themes such as weather changes and potential climate impacts, the causal role of human activities and natural cycles, and the connection between climate change and consumer society. Other studies have revealed that rather than being seen as a standalone problem, the public percept climate change as a component of a larger group of social and environmental problems, including air pollution, industrialization, consumption, and population increase (Milfont, 2012; Spence et al., 2012; Busse and Menzel, 2014).

Consequently, this conceptual link reflects media coverage that frequently discusses climate change in the context of local weather stories, like floods in the UK, as well as a fundamental understanding of nature and natural processes, such as how they are cyclical or continuously changing. It's also likely that people's mental associations are brought on by how climate change is perceived as a novel idea about well-known concepts and events, a phenomenon known as "fixation" in the psychosocial literature. This embedded perspective on climate change implies that surveys and interviews will ostensibly reveal "misconceptions" about how various environmental and social issues are related to climate change. Instead of attempting to communicate abstract scientific "facts" that may have little application to everyday life, officials can use such socially rooted narratives to engage the public in climate change actively (Hansen et al., 2012; Gurgiser et al., 2016; Clayton and Manning, 2018; de Matos Carlos et al., 2020).

Numerous studies have shown that people's views on climate change vary significantly within and within countries. People's opinions of climate change varied widely around the world, with Latin America and developed Asia displaying relatively high levels of fear compared to other regions. This is probably attributable to the higher risk exposure, cultural values (such as a greater emphasis on environmental protection), political

climate (such as left-wing politics), and media coverage style. Studies also show diverse attitudes, from the most engaged and concerned doubters to the ones who are merely apathetic or uninterested (Sánchez-Cortés and Lazos, 2011; Hansen et al., 2012; Lehner and Stocker, 2015; Stoknes, 2015).

Belief and concern about climate change vary according to a range of factors, such as gender and age (specifically, men and the elderly tend to be more skeptical and less concerned about climate change, although the results of studies find that variables of values, an individual's view of the world and ideology are substantial and statistically significant predictors of demographic, cognitive, or other factors (Daniel et al., 2001; Milfont, 2012; Kahan, 2015; Clayton and Manning, 2018).

Bauman et al. (2018) mentioned that individuals think and behave in line with their endorsed values; this means that if an individual endorses biospheric and altruistic values, his behavior is more pro-environmentally. While the individual who endorse egoistic and hedonic values their behaviors less pro-environmentally.

According to Hicks et al. (2015) about environmental values and the suggested framework by Marshall et al. (2018) about human-environment cultural values, there are two types of environmental values: self-transcendence values contain biospheric and altruistic values; and two self-enhancement values include egoistic and hedonic values (Hicks et al., 2015; Bauman et al., 2018; Marshall et al., 2018). Hicks et al. (2015) found that these environmental values correlated and shaped a consistent pattern in line with human values theory. Marshall et al. (2019) found that environmental value orientations significantly affect the response to climate change, especially biospheric and altruism, while egoism influences grief response. Thus, Marshall et al. (2019) concluded that values might be a valuable communication method for climate change.

The current study aims to reveal the possibility of these values predicting individuals' perceptions of climate change since the Arab researchers did not focus on studying the psychological explanation of individuals' perceptions of climate change and what factors contribute to predicting CCP.

# Materials and methods

## Design and participants

This study used a cross-sectional descriptive design to assess the levels of perception of climate change. A comparative design was used to examine CCP and CV in the Kingdom of Saudi Arabia to identify variations in CP and climate values (CV) caused by demographic factors. The researcher selected randomly (465) residents in the Kingdom of Saudi Arabia, divided into subgroups according to demographic variables: gender (male $n$ = 236, 50.75%; female $n$ = 229, 49.25%), career field (education $n$ = 134, 28.82%, commerce, and business $n$ = 104, 22.36%, engineering, and construction $n$ = 117, 25.16% and agriculture $n$ = 110, 23.66%), and also divided to three age subgroups (from 30 to 45-year $n$ = 147, 31.61%, 46-to-60-year $n$ = 232, 49.90%, and up to 61-year $n$ = 86, 18.49%).

## Data collection instrument

The researcher developed the Climate Change Perception Questionnaire (CCPQ) and Climate Values Questionnaire (CVQ) and applied them online using Google Forms. The online link was sent to many individuals in the Kingdom of Saudi Arabia. The CCPQ (**Supplementary Appendix 1**) consists of 21 items divided into three aspects of CCP: cognitive, emotional, and evaluation. Answers are given using a 5-point Likert questionnaire (never = 1 to very much = 5). And the CVQ (**Supplementary Appendix 2**) also consisted of 10 items; individuals can answer by choosing one of the 5-point Likert (never = 1 to very much = 5).

## Climate change perception questionnaire validity

Before conducting the exploratory factor analysis (EFA) analysis on the CCPQ, the researcher conducted Bartlett's test of Sphericity and the Kaiser–Meyer–Olkin measurement of sampling adequacy (KMO) to verify that the sample was adequate for conducting this analysis. Bartlett's test of Sphericity for CCPQ was significant ($\chi^2$ = 8,883.753, df = 210, $p < 0.001$), and the KMO value was acceptable at 0.925. CCPQ items' component load ranged from 0.510 to 0.914. The EFA results suggest that CCPQ consisted of the 3-dimensional construct (**Table 1**).

The CCPQ also exhibits good reliability since Cronbach's alpha coefficients for the three subscales and total CCP were (0.966, 0.900, 0.70, 0.930, respectively) high. Also, the correlations between the items and the total score of the subscales were high, ranging between 0.540 and 0.924.

## Climate values questionnaire validity

The results of Bartlett's test of Sphericity and the KMO revealed that the sample was adequate for conducting this analysis. Bartlett's test of Sphericity for CVQ was significant ($\chi^2$ = 3,183.952, df = 45, $p < 0.001$), and the KMO value was acceptable at 0.923. CVQ items component load ranged from 0.766 to 0.825. The EFA results showed that CCPQ consisted of the one-dimensional construct (**Table 2**).

The CVQ also exhibits good reliability since Cronbach's alpha coefficient was (0.935) high. Also, the correlations between the items and the total score of the subscales were high, ranging between 0.770 and 0.823.

TABLE 1 Saturations of the items of the climate change perception (CCP) questionnaire by factors after the rotated component matrix.

| Items | Emotional | Appraisal | Cognitive |
|---|---|---|---|
| 1 | 0.807 | | |
| 2 | 0.913 | | |
| 3 | 0.881 | | |
| 4 | 0.914 | | |
| 5 | 0.853 | | |
| 6 | 0.836 | | |
| 7 | 0.903 | | |
| 8 | 0.867 | | |
| 9 | 0.859 | | |
| 10 | 0.873 | | |
| 11 | | 0.817 | |
| 12 | | 0.816 | |
| 13 | | 0.785 | |
| 14 | | 0.827 | |
| 15 | | 0.807 | |
| 16 | | 0.820 | |
| 17 | | 0.769 | |
| 18 | | 0.857 | |
| 19 | | | 0.805 |
| 20 | | | 0.809 |
| 21 | | | 0.510 |
| Total | 7.979 | 5.830 | 1.552 |
| % Of Variance | 37.997 | 27.760 | 7.390 |
| Cumulative% | 37.997 | 65.757 | 73.146 |

Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization.

TABLE 2 Saturations of the items of the climate values (CV) questionnaire by principal component analysis.

| Items | 1 |
|---|---|
| 1 | 0.781 |
| 2 | 0.807 |
| 3 | 0.766 |
| 4 | 0.818 |
| 5 | 0.799 |
| 6 | 0.789 |
| 7 | 0.774 |
| 8 | 0.819 |
| 9 | 0.825 |
| 10 | 0.787 |
| Total | 6.348 |
| % of Variance | 63.477 |
| Cumulative% | 63.477 |

## Data analysis

Using IBM SPSS Statistics, Version 25, the data was statistically examined. The researcher used descriptive statistics, including percentages, frequencies, and the mean, and standard deviation for sociodemographic variables, to gauge how much the study sample perceived and valued climate change. The Kolmogorov–Smirnov test was employed to determine whether the data distribution was normal. The researcher calculated the correlations between scale items and subscales using Pearson's correlation coefficient. Additionally, Cronbach's alpha coefficients were utilized to confirm the CCPQ and CVQ's internal consistency. The factor structure of the CCPQ and CVQ was examined using EFA. Independent samples *T*-test and one-way ANOVA between-groups comparisons were used to detect the differences due to demographic variables, and $p < 0.05$ statistical significance level was approved, and a Scheffe test was used to identify the direction of the differences. Also, a linear regression was applied to examine the predictability of CCP from CV.

# Results

## Climate change perception and climate values scores

To determine the level of CCP and CV, the individuals were classified into three levels of CCP, as follows: low level from (21 to 49), medium level from (50 to 77), and high level from (78 to 105). In the same way, the individuals were classified into three levels of subscales (for example, the emotional subscale of CCP: low level from (10 to 23.33); medium from (23.34 to 36.67); and high level from (36.68 to 50). Also, CV scores are classified into three levels: Low level from 10 to 23.33, medium level from 23.34 to 36.67, and high level from 36.68 to 50. The results in Table 3 indicated an average level of CCP and CV.

## Means and standard deviation of the climate change perception and climate values and their level

### Differences in climate change perception and climate values due to demographic variables

The statistical analysis results showed in Table 4 indicated that there were statistically significant differences in CCP total score, emotional subscale, and CV ($t$ = 6.364, 2.087, and 2.539, $p < 0.05$, respectively) due to gender. While there were no statistically significant differences in cognitive and evaluation subscales of CCP due to gender ($t$ = 0.434 and 0.829, $p > 0.05$, respectively).

There were statistically significant differences in the emotional subscale of CCP and the total score of CCP due to career field. One-way ANOVA was calculated to detect the differences between career field subgroups. The findings in

TABLE 3 Means, standard deviation, and levels of the CCP and CV of the sample study scores.

| Measurements | *M* | St. deviation | Level |
|---|---|---|---|
| Emotional | 31.077 | 10.049 | Average |
| Appraisal | 25.443 | 6.759 | Average |
| Cognitive | 9.750 | 2.375 | Average |
| CCP total score | 60.759 | 8.920 | Average |
| CV total score | 30.142 | 9.205 | Average |

CCP, climate change perception; CV, climate values.

Tables 5, 6 indicated significant statistical differences due to career field in the emotional subscale of CCP and the total score ($F$ = 4.456 and 3.935, $p < 0.05$). At the same time, there were no differences in cognitive, evaluation, and CV ($F$ = 2.551 and 1.185, $p > 0.05$).

To determine the direction of these differences, a Scheffe test was applied, and the results are concluded as follows:

The results shown in Table 7 about the direction of the differences between career field subgroups indicated that the emotional subscale of CCP was high among workers in the field of agriculture rather than workers in the field of education (mean difference = 4.379, $p < 0.05$), also the workers in the field of engineering and construction higher than the workers of education field in the total score of CCP (mean difference = 7.803 $p < 0.05$).

There were differences in the emotional subscale of CCP and CV due to age group. One-way ANOVA was calculated to detect the differences between age subgroups. The findings in Tables 8, 9 indicated significant statistical differences due to age group in the emotional subscale of CCP and CV ($F$ = 3.565 and 3.524, $p < 0.05$). At the same time, there were no differences in cognitive, evaluation, and total score of CCP ($F$ = 0.253, 1.105, and 1.559, $p > 0.05$).

To determine the direction of these differences, a Scheffe test was applied, and the results are concluded as follows:

The results shown in Table 10 about the direction of the differences between age subgroups indicated that the emotional subscale of CCP and CV were high among individuals whose ages ranged from 30 to 45 subgroup rather than 46–60 years old subgroup (mean difference = 2.799 and 2.92, $p < 0.05$, respectively).

### Predict climate change perception from climate values

The researcher used a simple linear regression to detect the ability to predict CCP from CV. The simple regression model predicting CCP total score proved to be statistically significant ($F$ = 5.392, $p < 0.021$). The results in Table 11 indicated that the CV could predict CCP statistically significant; CV total score explains 1.2% of the variance in total CCP (Beta [β] = 0.107; 95% Confidence Interval: [18.080, 2.322]; $p < 0.05$). We can predict the CCP total score from this prediction equation: CCP = 54.112 + 0.221× CV.

## Discussion

The study findings showed an average level of CCP (total score and subscales). The result of the current study is consistent with the findings of the study by Hussein et al. (2019) that only a small percentage of citizens in Lebanon have a high level of awareness of climate change and their intentions to reduce the carbon lifestyle. Clayton and Manning (2018) stated individuals percept climate change as part of a broader set of social and environmental problems, such as air pollution, industrialization, consumption, and population increase, rather than as a stand-alone problem. Therefore, the study sample's perception of climate change was average. Also, the results found an average level of climate value. This finding can be interpreted as weather events are not percept as evidence of climate change unless one believes in climate change. Therefore, the level of CCP and CV were average among the study sample. Because, in general, climate change is viewed as an issue of low importance to all other issues and challenges facing society, such as economic development, global political

TABLE 4 Differences in climate change perception and climate values due to gender (male/female) variable.

| Measurement | Gender | *N* | Mean | Std. deviation | *t*-test | Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| Emotional | Male | 236 | 30.123 | 9.302 | 2.087 | 0.037 |
| | Female | 229 | 32.061 | 10.697 | | |
| Appraisal | Male | 236 | 25.699 | 6.116 | 0.829 | 0.407 |
| | Female | 229 | 25.179 | 7.369 | | |
| Cognitive | Male | 236 | 9.703 | 2.398 | 0.434 | 0.664 |
| | Female | 229 | 9.799 | 2.355 | | |
| CCP total score | Male | 236 | 55.479 | 18.595 | 6.364 | 0.000 |
| | Female | 229 | 66.201 | 17.707 | | |
| CV total score | Male | 236 | 29.080 | 9.266 | 2.539 | 0.01 |
| | Female | 229 | 31.236 | 9.32 | | |

TABLE 5 Differences in climate change perception (CCP) and climate values (CV) due to career field variable.

| Measurement | Career field subgroups | *N* | Mean | Std. deviation |
|---|---|---|---|---|
| Emotional | Engineering and construction field | 134 | 31.948 | 10.308 |
| | Commerce and business field | 104 | 29.952 | 10.355 |
| | Education field | 117 | 28.957 | 9.356 |
| | Agriculture field | 110 | 33.336 | 9.675 |
| | Total | 465 | 31.077 | 10.049 |
| Cognitive | Engineering and construction field | 134 | 9.955 | 2.399 |
| | Commerce and business field | 104 | 9.596 | 2.518 |
| | Education field | 117 | 9.325 | 2.173 |
| | Agriculture field | 110 | 10.100 | 2.362 |
| | Total | 465 | 9.750 | 2.375 |
| Appraisal | Engineering and construction field | 134 | 25.694 | 7.097 |
| | Commerce and business field | 104 | 25.298 | 7.567 |
| | Education field | 117 | 24.573 | 6.347 |
| | Agriculture field | 110 | 26.200 | 5.882 |
| | Total | 465 | 25.443 | 6.759 |
| Climate perception | Engineering and construction field | 134 | 65.179 | 18.177 |
| | Commerce and business field | 104 | 59.615 | 19.869 |
| | Education field | 117 | 57.376 | 18.724 |
| | Agriculture field | 110 | 60.054 | 18.344 |
| | Total | 465 | 60.759 | 18.920 |
| Climate values | Engineering and construction field | 134 | 29.716 | 9.012 |
| | Commerce and business field | 104 | 30.173 | 9.834 |
| | Education field | 117 | 29.932 | 8.7116 |
| | Agriculture field | 110 | 30.854 | 9.417 |
| | Total | 465 | 30.142 | 9.205 |

TABLE 6 Results of group differences in climate change perception (CCP) and climate values (CV) due to a career field variable.

| Variables | Groups | Sum of squares | df | Mean square | *F* | Sig. |
|---|---|---|---|---|---|---|
| Emotional | Between groups | 1,320.478 | 3 | 440.159 | 4.456 | 0.004 |
| | Within groups | 45,536.735 | 461 | 98.778 | | |
| | Total | 46,857.213 | 464 | | | |
| Appraisal | Between groups | 42.734 | 3 | 14.245 | 1.185 | 0.315 |
| | Within groups | 2,574.328 | 461 | 5.584 | | |
| | Total | 2,617.062 | 464 | | | |
| Cognitive | Between groups | 162.292 | 3 | 54.097 | 2.551 | 0.055 |
| | Within groups | 21,040.447 | 461 | 45.641 | | |
| | Total | 21,202.740 | 464 | | | |
| CCP total score | Between groups | 4,147.581 | 3 | 1,382.527 | 3.935 | 0.01 |
| | Within groups | 161,955.443 | 461 | 351.313 | | |
| | Total | 166,103.024 | 464 | | | |
| CV total score | Between groups | 85.398 | 3 | 28.466 | 0.334 | 0.800 |
| | Within groups | 39,231.234 | 461 | 85.100 | | |
| | Total | 39,316.632 | 464 | | | |

Significant at 0.05 level.

instability, public health, and other environmental problems. As well as the deep cultural conflict that exists over this issue (Sterman and Sweeney, 2007).

Gifford (2011) hypothesized that 30 factors might act as barriers to individuals' perceptions of climate change and changing their behaviors, including limited awareness, old

TABLE 7 Multiple comparisons in the emotional subscale of climate change perception (CCP) and CCP total score due to career field variable.

| Measurement | Career field | Agriculture field | Engineering and construction field | Education field |
|---|---|---|---|---|
| Emotional | Agriculture field | – | 4.379* | |
| | Engineering and construction field | −4.379* | – | |
| Climate change perception | Engineering and construction field | | – | −7.803* |
| | Education field | | 7.803* | |

*Mean differences were significant ($p$-value $< 0.05$).

brain, ignorance, environmental numbness, mistrust, reduced judgment of risk, unrealistic/biased optimism, and lack of perceived behavioral control, ideology, superhuman powers, technological revolution, others of importance, social norms, social comparison, perceived injustice, behavioral momentum, the strength of habits, resistance, and denial.

These results about the average level of perception of climate change and CV can interpret using the framework of values of Schwartz (1994), as it has been shown in many studies that support the values of the "transcendent self,"—which includes a focus on protecting and caring for others—is linked to acceptance of the reality of climate change, and level of concern about the issue, as well as support for policies designed to relief climate change and a willingness to act in an environmentally friendly manner. Drawing on an alternative concept of the "Schwartz" framework, others have suggested the importance of other-oriented values such as selfishness, altruism, and the biosphere as negative influences on climate change recognition, policy support, and pro-environmental behavior. Selfishness negatively affects recognition of the problem of climate change and support for policies designed to address climate change, while altruism and biosphere influence positively. Studies showed that other-oriented values (such as altruism) are associated with environmental concerns (including climate change) and support for climate change policies and pro-environmental actions.

These findings are also due to the role of the media as the primary source of public information on climate change. Unsurprisingly, the media play a crucial role in shaping public attitudes, responses, and perceptions of climate change. The study by Carmichael and Brulle (2017) showed a clear impact of media on public anxiety about climate change and their perception of it. Clayton and Manning (2018) argue that humans live in a bubble of self-deception and a false sense that climate change is a problem for the future rather than an urgent crisis that must be addressed to secure life on Earth.

These findings can also be explained in terms of the perception of climate change through construal level theory (CLT), which indicates that objects, events, and structures can be thought of in somewhat abstract terms depending on the psychological distance between them. CLT theory showed a relationship between psychological distance and people's response to a particular event. Psychological distance consists of four dimensions: spatial, social, temporal, and virtual. Each dimension is related to the others, although there are no common denominators. Psychological distance is one of the main psychological structures that explain the more realistic or abstract perception of objects and events around people. An event is viewed as near or far from a psychological point of view. When viewed as psychologically close, the representation is more realistic, while the representation is more abstract when viewed as psychologically distant. Thus, people perceive climate change more realistically when they see it up close; and as a result, there may be an increased willingness to engage in pro-environmental and resilient behaviors. When people have a more abstract representation of the event, climate change is seen as far from occurring. We can conclude that psychological distance determines an individual's perception of climate change. The results of studies such (Spence et al., 2012; Busse and Menzel, 2014; Carmi and Kimhi, 2015; Jones et al., 2017; Singh et al., 2017; Soliman et al., 2018; Kim and Ahn, 2019; Kyselá et al., 2019) found an effect of psychological distance on

TABLE 8 Differences in climate change perception (CCP) and climate values (CV) due to age group variable.

| Measurement | Age subgroups | *N* | Mean | Std. deviation |
|---|---|---|---|---|
| Emotional | 30–45 years | 147 | 32.8503 | 10.99399 |
| | 46–61 years | 232 | 30.0517 | 9.73443 |
| | Up to 61 years | 86 | 30.8140 | 8.81778 |
| | Total | 465 | 31.0774 | 10.04915 |
| Cognitive | 30–45 years | 147 | 9.7823 | 2.22229 |
| | 46–61 years | 232 | 9.6164 | 2.38216 |
| | Up to 61 years | 86 | 10.0581 | 2.59572 |
| | Total | 465 | 9.7505 | 2.37491 |
| Appraisal | 30–45 years | 147 | 25.6803 | 7.26880 |
| | 46–61 years | 232 | 25.2198 | 6.78609 |
| | Up to 61 years | 86 | 25.6395 | 5.76789 |
| | Total | 465 | 25.4430 | 6.75985 |
| Climate perception | 30–45 years | 147 | 63.0204 | 20.17101 |
| | 46–61 years | 232 | 59.8448 | 17.78861 |
| | Up to 61 years | 86 | 59.3605 | 19.55079 |
| | Total | 465 | 60.7591 | 18.92038 |
| Climate values | 30–45 years | 147 | 31.3061 | 9.46704 |
| | 46–61 years | 232 | 29.0129 | 8.99903 |
| | Up to 61 years | 86 | 31.1977 | 9.03173 |
| | Total | 465 | 30.1419 | 9.20511 |

TABLE 9 Results of group differences in climate change perception (CCP) and climate values (CV) due to age group variable.

| Variables | Groups | Sum of squares | df | Mean square | *F* | Sig. |
|---|---|---|---|---|---|---|
| Emotional | Between groups | 712.103 | 2 | 356.051 | 3.565 | 0.029 |
| | Within groups | 46,145.110 | 462 | 99.881 | | |
| | Total | 46,857.213 | 464 | | | |
| Appraisal | Between groups | 12.461 | 2 | 6.231 | 0.253 | 0.777 |
| | Within groups | 2,604.601 | 462 | 5.638 | | |
| | Total | 2,617.062 | 464 | | | |
| Cognitive | Between groups | 23.153 | 2 | 11.576 | 1.105 | 0.332 |
| | Within groups | 21,179.587 | 462 | 45.843 | | |
| | Total | 21,202.740 | 464 | | | |
| CCP total score | Between groups | 1,113.846 | 2 | 556.923 | 1.559 | 0.211 |
| | Within groups | 164,989.178 | 462 | 357.119 | | |
| | Total | 166,103.024 | 464 | | | |
| CV total score | Between groups | 590.807 | 2 | 295.404 | 3.524 | 0.030 |
| | Within groups | 38,725.825 | 462 | 83.822 | | |
| | Total | 39,316.632 | 464 | | | |

Significant at 0.05 level.

individuals' perception of climate change and engagement in pro-environmental behaviors.

From a cognitive psychology perspective, the perception of climate change refers to how we think and how the brain processes information. Perception is an individual process determined in light of the personality traits and the habits and traditions of the society in which he lives. The perception process is affected by many situational and personal factors, and the individual's attitudes may effectively impact his perception of stimuli. The attitudes of individuals toward climate change consist of three main components: a cognitive component that includes ideas, knowledge, and beliefs that stem from memory when paying attention to the issue of climate change, an emotional component, which refers to the feeling associated with an object or event, and then a behavioral component, includes the type of action or readiness for behavior inherent in the situation. The attitude toward climate change is strong and consistent if these three components are compatible. According to the strength of the emotional component toward the issue of climate change, the strength and quality of our actions and responses are determined by whether we will make an effort to combat climate change or will we fail to act and not seek to make any effort, but instead deny the issue in its entirety and fight its supporters. In light of this, the individual's perception and values about climatic changes are determined. Hence, individuals differ in their awareness of climate change and their CV according to their characteristics, customs, and traditions of society and their attitudes toward climate change.

TABLE 10 Multiple comparisons in the emotional subscale of climate change perception (CCP) and climate values (CV) due to age group variable.

| Measurement | Age subgroups | 30–45 years | 46–61 years |
|---|---|---|---|
| Emotional | 30–45 years | – | 2.799* |
| | 46–61 years | −2.799* | – |
| Climate values | 30–45 years | – | 2.292* |
| | 46–61 years | −2.292* | – |

*Mean differences were significant ($p$-value $< 0.05$).

Clayton and Manning (2018) reported that perception of climate change varies according to various factors, such as gender and age (specifically, men and older people tend to be more aware and less anxious about climate change). However, studies find that variables of values, an individual's view of the world, and ideology are strong and statistically significant predictors of CCP rather than demographic, cognitive, or other factors. Also, the results found differences between males and females in the emotional subscale of CCP, the total score of CCP, and CV in the favorite of females. This result is due to females' lack of social and economic power; they tend to have fewer economic resources than men. Also, females find it difficult to access assistance services in disasters such as climate change. Thus, females are more aware of climate change and have higher CV and participation in mitigation measures.

Results also revealed significant statistical differences due to the career field in the emotional subscale of CCP and total score of CCP in favorite of workers in the agriculture and engineering and construction fields rather than career workers field subgroups. Clayton and Manning (2018) mentioned that societies whose livelihoods are directly linked to local climatic conditions, such as farmers in developing countries, may recognize climate change closer. Basannagari and Kala (2013) provides evidence that apple farmers in the Indian Himalayas percept climate change as having led to modifications in their farm use practices, delays in

TABLE 11 Results of regression analysis of climate values (CV) on climate change perception (CCP).

| Model | $R^2$ | Durbin–Watson | $F$ | Independent variables | Unstandardized coefficients | | Standardized coefficient | $t$ | Sig. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | B | SE | Beta | | |
| 1 | 0.012 | 0.805 | 5.392 | Constant | 54.112 | 2.993 | | 18.080 | 0.000 |
| | | | | Climate values | 0.221 | 0.095 | 0.107 | 2.322 | 0.021 |

harvest periods, and adverse effects on fruit quality. Also, in Mexico, Sánchez-Cortés and Lazos (2011) similarly found that in addition to being aware of changes in rainfall and temperature, farmers responded to these changing conditions by introducing the seeding season for corn and planting new crops.

The findings also found differences between age subgroups in the emotional subscale of CCP and CV in favorite of individuals in the 30–45-year subgroup. This difference is because, according to the ages of individuals, their attitudes toward climate change differ from acknowledgment or denial of the occurrence of climate change to either interest in combating climate change or denial and resistance. In light of this, the individual's perception and values regarding climate change differ. The age subgroup from 30 to 45 years old, we find their attitude toward environmental issues stronger and open to weather news around the world and good readers of environmental issues, climate and global agreements on climate change and integrated into daily life with its problems to a greater degree than the elderly who are gradually isolated and do not care about news about the world but instead they may not care about the environment and climate issues. Weber (2016) stated that men are more skeptical of climate change than women and that younger adults have demonstrated stronger attitudes toward the environment and climate than older adults.

The differences in CCP and CV are compatible with the results of several studies that showed that individuals are highly heterogeneous in their perception of climate change—both within and between countries (Arnout, 2022b). There is a wide variation in people's perceptions of climate change, with Latin America and developed countries in Asia showing relatively high levels of anxiety compared to other parts of the world. This is likely due to increased exposure to risks, cultural values, political context, and the nature of media coverage. Studies also point to distinct sets of attitudes, ranging from the most active and concerned about climate change to the uninterested or passive deniers.

In light of the theory of the five D barriers developed by Stoknes (2015), we can explain the differences between CCP and CV in the study sample. These five D barriers are Distance, Doom, Dissonance, Denial, and iDentity; they are interconnected and act as invisible barriers within the individual that prevent them from perceiving climate change or engaging in mitigation measures and pro-environmental behavior. These 5 D barrier levels differed between individuals; hence, their levels of CCP and CV differ. Kahan (2015) added that individuals have a strong incentive to form perceptions of risks in general, including those related to climate change, that support their overall sense of who they are, that is, that reinforces their identity. Since our identities are closely linked to our social groups and our preferences for how society is organized, the drive to protect one's identity can lead to different groups of people coming to percept particular risks or issues, such as climate change, in very different ways.

Also, the results of the current study indicated that the CV have statistically significant predictability of CCP. This result is in line with the study of Marshall et al. (2019), which found that environmental value orientations influenced the individual response to climate change. Ajzen (2005, 2012) mentioned that people form their attitudes toward events (such as climate change) through their fundamental values and beliefs. Therefore, values predict individuals' perceptions of climate change, attitudes toward this issue, and the decisions that lead to behavior. Daniel et al. (2001) reported that values are essential in building an individual's personality and affect his attitudes, decisions, and behaviors. Ajzen (2012) refereed those values raise the individual's awareness of himself and the climatic changes that occur around him and adapt to them with free will and mindfulness. Through the values that the individual adopts, he will be able to face all challenges in his life, deal with crises, and urge him to think about them (including the climate change crisis).

Many theories explain the role of values in perception, attitude, and behavior. Values and beliefs (VBN) theory has explained that environmental behavior is the indirect result of following an individual's deeply held values, usually, those that demonstrate an interest beyond the individual's immediate self-interest and include altruism toward other human beings as altruism toward the environment. Theories of values have been developed to influence global views about the relationship between humans and nature, influencing specific beliefs about the consequences of environmental problems and actions, including climate change. The theory of planning behavior (TPB) also suggests that intentions engage in behavior result from three factors: attitudes about the behavior, subjective norms, and perceived control. Each of these factors, in turn,

is influenced by the specific beliefs of the individual. Attitudes are formed in response to beliefs about the consequences of behavior. The TPB theory of planned behavior successfully explains climate-related intentions and behavior variations.

## Conclusion

The current study showed an average level of CCP and CV among individuals in the Kingdom of Saudi Arabian. As well as the current study concluded that individuals' perceptions of climate change are an individual response determined by the individual's gender, age, and career field and is affected by his values about climate. Individuals live in the same extreme climatic conditions but differ in their perception of them according to those determinants. The results found statistically significant differences in the emotional subscale of CCP, total score, and CV due to gender and age group variables in the favorite of females and individuals whose ages ranged from 30 to 45-year subgroups. Also, the results found statistically significant differences in the CV due to career field variables in favor of agriculture, engineering, and construction fields. As well as the results revealed that the climate value represents a statistically significant predictor of CCP. These findings shed light on the need for a climate communications system to increase the level of CCP and CV, especially among males and individuals in the age group over 45 years, and individuals working in various professions, whether education, business, and others; to improve the engagement in mitigation and adaptation measures to climate changes that are currently taking place in the Kingdom of Saudi Arabia and other Arab countries from extreme changes in temperature, rain, floods, and others.

### Strengths, limitations, and future directions

This study is a predictive, descriptive study to measure CCP and CV levels in the Kingdom of Saudi Arabia and predict CCP from CV. One of the strengths of this study is that it is considered one of the first Arabic studies that examine CCP and CV. Also, the current study is considered a comparative study of the CCP and CV levels due to gender, career field, and age group variables.

Among the limitations of this study include a predictive, descriptive comparative research design; thus, we need more intervention studies to examine how we can improve CCP and values.

## Data availability statement

The original contributions presented in this study are included in the article/**Supplementary material**, further inquiries can be directed to the corresponding author.

## Ethics statement

The studies involving human participants were reviewed and approved by the KKU (EDU-29/1443/10). The patients/participants provided their written informed consent to participate in this study.

## Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

## Acknowledgments

The author express their gratitude to King Khalid University, Saudi Arabia, for providing administrative and technical support.

## Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.1044697/full#supplementary-material

# References


Ajzen, I. (2005). *Attitudes, personality, and behavior*. Maidenhead: Open University Press.

Ajzen, I. (2012). "Values, attitudes, and behavior," in *Methods, theories, and empirical applications in the social sciences*, eds S. Salzborn, E. Davidov, and J. Reinecke (Wiesbaden: VS Verlag für Sozialwissenschaften). doi: 10.1007/978-3-531-18898-0_5

Altea, L. (2020). Perceptions of climate change and its impacts: A comparison between farmers and institutions in the Amazonas region of Peru. *Clim. Dev.* 12, 134–146. doi: 10.1080/17565529.2019.1605285

Arnout, B. (2022a). An epidemiological study of psychological problems related to climate change: A procedural framework for mental health system workers. *Work* 75, 1–22. doi: 10.3233/WOR-220040

Arnout, B. (2022b). *The scientific encyclopedia of the psychology of climate change*. Riyadh: Takween for Publishing and Distribution.

Basannagari, B., and Kala, C. P. (2013). Climate change and apple farming in Indian Himalayas: A study of local perceptions and responses. *PLoS One* 8:e77976. doi: 10.1371/journal.pone.0077976

Bauman, T., Steg, L., and Kiers, H. A. L. (2018). Measuring values in environmental research: A test of an environmental portrait value questionnaire. *Front. Psychol.* 9:564. doi: 10.3389/fpsyg.2018.00564

Busse, M., and Menzel, S. (2014). The role of perceived socio-spatial distance in adolescents' willingness to engage in pro-environmental behavior. *J. Environ. Psychol.* 40, 412–420. doi: 10.1016/j.jenvp.2014.10.002

Carmi, N., and Kimhi, S. (2015). Further than the eye can see: Psychological distance and perception of environmental threats. *Hum. Ecol. Risk Assess.* 21, 2239–2257. doi: 10.1080/10807039.2015.1046419

Carmichael, J. T., and Brulle, R. J. (2017). Elite cues, media coverage, and public concern: An integrated path analysis of public opinion on climate change, 2001–2013. *Environ. Polit.* 26, 232–252. doi: 10.1080/09644016.2016.1263433

Clarke, C., Shackleton, S., and Powell, M. (2012). Climate change perceptions, drought responses and views on carbon farming amongst commercial livestock and game farmers in the semiarid Great Fish River Valley, Eastern Cape Province, South Africa. *Afr. J. Range Forage Sci.* 29, 13–23. doi: 10.2989/10220119.2012.687041

Clayton, C., and Manning, C. (2018). *Psychology and climate change*. London: Academic Press.

Daniel, H., Ajzen, I., and Daigle, J. (2001). Predicting hunting intentions and behavior: An application of the theory of planned behavior. *Leis. Sci.* 23, 165–178. doi: 10.1080/014904001316896855

de Matos Carlos, S., da Cunha, D. A., Pires, M. V., and Do Couto-Santos, F. R. (2020). Understanding farmers' perceptions and adaptation to climate change: The case of Rio das Contas basin, Brazil. *GeoJournal* 85, 805–821. doi: 10.1007/s10708-019-09993-1

Fourment, M., Ferrer, M., Barbeau, G., and Quénol, H. (2020). Local perceptions, vulnerability and adaptive responses to climate change and variability in a winegrowing region in Uruguay. *Environ. Manage.* 66, 590–599. doi: 10.1007/s00267-020-01330-4

Gifford, R. (2011). The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. *Am. Psychol* 66, 290–302. doi: 10.1037/a0023566

Gurgiser, W., Juen, I., Singer, K., Neuburger, M., Schauwecker, S., Hofer, M., et al. (2016). Comparing peasants' perceptions of precipitation change with precipitation records in the tropical Callejón de Huaylas. *Peru. Earth Syst. Dynam.* 7, 499–515. doi: 10.5194/esd-7-499-2016

Hansen, J., Sato, M., and Ruedy, R. (2012). Perception of Climate Change. *Proc. Natl. Acad. Sci. U.S.A.* 109, E2415–E2423. doi: 10.1073/pnas.1205276109

Hicks, C., Cinner, J., Stoeckl, N., and McClanahan, T. (2015). Linking ecosystem services and human-values theory. *Conserv. Biol.* 29, 1471–1480. doi: 10.1111/cobi.12550

Hussein, A., Hussein, T., and Moussaid, G. (2019). Climate change perception in Lebanon: An exploratory study. *Int. J. Mark. Stud.* 11, 53–59. doi: 10.5539/ijms.v11n4p53

Jones, C., Hine, D. W., and Marks, A. D. G. (2017). The future is now: Reducing psychological distance to increase public engagement with climate change. *Risk Anal.* 37, 331–341. doi: 10.1111/risa.12601

Kahan, D. (2015). Climate-science communication and the measurement problem. *Adv. Polit. Psychol.* 36:S1. doi: 10.1111/pops.12244

Kim, K., and Ahn, S. (2019). The moderating role of cultural background in temporal framing: Focusing on climate change awareness advertising. *Asian J. Commun.* 29, 363–385. doi: 10.1080/01292986.2019.1624793

Kyselá, E., Tvinnereim, E., and Ivarsflaten, E. (2019). Attitudes to public spending on environmental risk reduction: The role of temporal and spatial distance. *Environ. Sociol.* 5, 362–373. doi: 10.1080/23251042.2019.1643528

Lehner, F., and Stocker, T. F. (2015). From Local Perception to Global Perspective. *Nat. Clim Change* 5, 731–734. doi: 10.1038/nclimate2660

Marshall, J. S., Warrington, R., Watson, W., and Kim, H. L. (2018). An introduction to immunology and immunopathology. *Allergy Asthma Clin. Immunol.* 14:49. doi: 10.1186/s13223-018-0278-1

Marshall, N., Thiault, L., Beeden, A., Beeden, R., Benham, C., Curnock, M., et al. (2019). Our environmental value orientations influence how we respond to climate change. *Front. Psychol.* 10:938. doi: 10.3389/fpsyg.2019.00938

Milfont, T. L. (2012). The interplay between knowledge, perceived efficacy, and concern about global warming and climate change: A one-year longitudinal study. *Risk Anal.* 32, 1003–1020. doi: 10.1111/j.1539-6924.2012.01800.x

Sánchez-Cortés, M. S., and Lazos, C. E. (2011). Indigenous perception of changes in climate variability and its relationship with agriculture in a Zoque Community of Chiapas, Mexico. *Climat. Change* 107, 363–389. doi: 10.1007/s10584-010-9972-9

Schwartz, S. H. (1994). Are there universal aspects in the structure and contents of human values? *J. Soc. Issues* 50, 19–45. doi: 10.1111/j.1540-4560.1994.tb01196.x

Singh, A. S., Zwickle, A., Bruskotter, J. T., and Wilson, R. (2017). The perceived psychological distance of climate change impacts and its influence on support for adaptation policy. *Environ. Sci. Policy* 73, 93–99. doi: 10.1016/j.envsci.2017.04.011

Soliman, M., Alisat, S., Bashir, N. Y., and Wilson, A. E. (2018). Wrinkles in time and drops in the bucket: Circumventing temporal and social barriers to pro-environmental behavior. *SAGE Open* 8:1. doi: 10.1177/2158244018774826

Spence, A., Poortinga, W., and Pidgeon, N. (2012). The psychological distance of climate change. *Risk Anal.* 32, 957–972. doi: 10.1111/j.1539-6924.2011.01695.x

Sterman, J. D., and Sweeney, L. B. (2007). Understanding public complacency about climate change: Adults' mental models of climate change violate conservation of matter. *Climat. Change* 80, 213–238. doi: 10.1007/s10584-006-9107-5

Stoknes, P. E. (2015). *What we think about when we try not to think about global warming: Toward a new psychology of climate action*. White River Junction, VT: Chelsea Green Publishing.

Weber, E. (2016). What shapes perceptions of climate change? New research since 2010. *WIREs Clim. Change* 7, 125–134. doi: 10.1002/wcc.377

frontiers | Frontiers in Psychology

TYPE Brief Research Report
PUBLISHED 12 January 2023
DOI 10.3389/fpsyg.2022.1021858



OPEN ACCESS

EDITED BY
Mandy Rossignol,
University of Mons,
Belgium

REVIEWED BY
Mario Reutter,
Julius Maximilian University of Würzburg,
Germany
Daniela Acquadro Maran,
University of Turin,
Italy

*CORRESPONDENCE
Joshua M. Carlson
✉ joshcarl@nmu.edu

SPECIALTY SECTION
This article was submitted to Environmental Psychology, a section of the journal Frontiers in Psychology

RECEIVED 17 August 2022
ACCEPTED 22 December 2022
PUBLISHED 12 January 2023

CITATION
Carlson JM, Fang L, Coughtry-Carpenter C and Foley J (2023) Reliability of attention bias and attention bias variability to climate change images in the dot-probe task.
*Front. Psychol.* 13:1021858.
doi: 10.3389/fpsyg.2022.1021858



# Reliability of attention bias and attention bias variability to climate change images in the dot-probe task

Joshua M. Carlson*, Lin Fang, Caleb Coughtry-Carpenter and John Foley

Department of Psychological Science, Northern Michigan University, Marquette, MI, United States

Climate change is one of the most pressing issues of the 21st century, which is perhaps why information about climate change has been found to capture observers' attention. One of the most common ways of assessing individual differences in attentional processing of climate change information is through the use of reaction time difference scores. However, reaction time-based difference scores have come under scrutiny for their low reliability. Given that a primary goal of the field is to link individual differences in attention processing to participant variables (e.g., environmental attitudes), we assessed the reliability of reaction time-based measures of attention processing of climate change information utilizing an existing dataset with three variations of the dot-probe task. Across all three samples, difference score-based measures of attentional bias were generally uncorrelated across task blocks ($r$ =−0.25 to 0.31). We also assessed the reliability of newer attention bias variability measures that are thought to capture dynamic shifts in attention toward and away from salient information. Although these measures were initially found to be correlated across task blocks ($r$ =0.17–0.67), they also tended to be highly correlated with general reaction time variability ($r$ =0.49–0.83). When controlling for general reaction time variability, the correlations across task blocks for attention bias variability were much weaker and generally nonsignificant ($r$ =−0.25 to 0.33). Furthermore, these measures were unrelated to pro-environmental disposition indicating poor predictive validity. In short, reaction time-based measures of attentional processing (including difference score and variability-based approaches) have unacceptably low levels of reliability and are therefore unsuitable for capturing individual differences in attentional bias to climate change information.

KEYWORDS

**dot-probe, reliability, climate change, attention bias, attention bias variability**

# 1. Introduction

Anthropogenic climate change is one of the most serious problems facing the global community (Pecl et al., 2017; Tollefson, 2019, 2020). Information about climate change should therefore demand individuals' attention (Luo and Zhao, 2021). Yet, only recently has research explored the extent to which climate change related information captures attention. Initial research using climate change relevant images of environmental damage found that these images captured the attention of individuals with pro-environmental attitudes (Beattie and McGuire, 2012). Follow up studies have generally supported the finding that climate change-relevant (or other environmentally harmful) objects capture attention in individuals with pro-environmental dispositions (Sollberger et al., 2017; Carlson et al., 2019b; Meis-Harris et al., 2021). In addition, words related to climate change (Whitman et al., 2018) and graphical information of climate change (Luo and Zhao, 2019) capture attention in politically liberal individuals more concerned with climate change. Thus, there is emerging evidence that climate change relevant information captures observers' attention—what can be referred to as an *attentional bias* for climate change or environmentally relevant information. Such findings may offer insight into how best disseminate information about climate change that is attention grabbing in such a way as to promote large scale societal changes.

Research assessing the attentional capture of environmentally relevant stimuli has primarily used reaction time (RT; Carlson et al., 2019b, 2020; Meis-Harris et al., 2021) and eye tracking (Beattie and McGuire, 2012; Sollberger et al., 2017; Luo and Zhao, 2019) based measures. RT measures of attentional bias are typically calculated using a difference score (e.g., the difference in RTs between conditions where attention is facilitated vs. not facilitated). Broadly speaking, RT-based difference scores have come under scrutiny for low internal and/or test–retest reliability (Hedge et al., 2018; Goodhew and Edwards, 2019). For individual differences (i.e., correlational) research, between subject variability is necessary and needs to consistently/reliably measure the construct of interest. Given that one of the broad goals in the newly developing field of environmental attention bias research is to link variability in attentional processing to individual differences such as pro-environmental disposition (Beattie and McGuire, 2012; Sollberger et al., 2017; Carlson et al., 2019b; Meis-Harris et al., 2021) and political orientation (Whitman et al., 2018; Luo and Zhao, 2019), it is important to assess the reliability of environmental attention bias measures. However, reliability estimates for attention bias measures are rarely reported in the literature.

Given the low reliability of RT difference score-based estimates of attentional bias, the field of experimental psychopathology (where attentional bias is often linked to affective disorders/traits) sought to improve upon traditional (difference score-based) attention bias measures. As a result, innovative attention bias variability (ABV) measures were developed, which are thought to capture dynamic shifts of attention with alternating periods of attentional focus toward and away from affective information (Iacoviello et al., 2014; Zvielli et al., 2015). Early research using ABV measures found that they were more reliable than the traditional approach (Naim et al., 2015; Price et al., 2015; Davis et al., 2016; Rodebaugh et al., 2016; Zvielli et al., 2016; Molloy and Anderson, 2020). However, subsequent work has shown that general RT variability and mean RT speed influence measures of ABV and when controlled for significantly reduce their reliability (Kruijt et al., 2016; Carlson and Fang, 2020; Carlson et al., 2022a). ABV measures have not been used in the field of environmental attention bias. However, if found to be reliable in this context, they could be useful measures of attentional bias to environmental information.

Given that RT measures are commonly used in environmental attention bias research, and a goal of this research is often to link variability in attentional biases to relevant individual differences, we sought to assess the reliability of both traditional attention bias and innovative ABV measures. To meet this end, we utilized three existing datasets from previously published research utilizing the dot-probe task to assess attentional bias to emotionally positive and negative climate change relevant images (Carlson et al., 2020). We computed the correlation of attention bias measures for emotionally positive and negative climate change relevant images across blocks in the dot-probe tasks to assess the reliability of these measures. Based on previous research using non-environmental stimuli (e.g., threat or food related images; Carlson and Fang, 2020; Vervoort et al., 2021), we hypothesized that RT measures of attentional bias to climate change information would not be reliable and therefore unsuitable for individual differences research.

# 2. Materials and methods

## 2.1. Participants

This report included 177 participants from three separate samples. Sample one contained 58 (female = 47) individuals between the ages of 18–34 ($M = 21.00$, $SD = 3.71$). Sample two included 59 (female = 45) individuals 18–38 years old ($M = 20.41$, $SD = 3.69$). Sample three was comprised of 60 individuals (female = 52) 18–36 years old ($M = 20.68$, $SD = 3.83$). With $N \geq 58$, this study was powered to detect correlations of $r \geq 0.35$ (with each sample at $\alpha = 0.05$, and power = 0.80) and therefore able to detect reliabilities considered to be unacceptably low. Across all three samples, participants provided informed written consent and received course credit (in undergraduate psychology courses) for their participation. The study was approved by the Northern Michigan University (NMU) Institutional Review Board (IRB; HS16-768).

## 2.2. Dot-probe task

Each sample utilized a modified dot-probe task (MacLeod et al., 1986; MacLeod and Mathews, 1988) with climate change

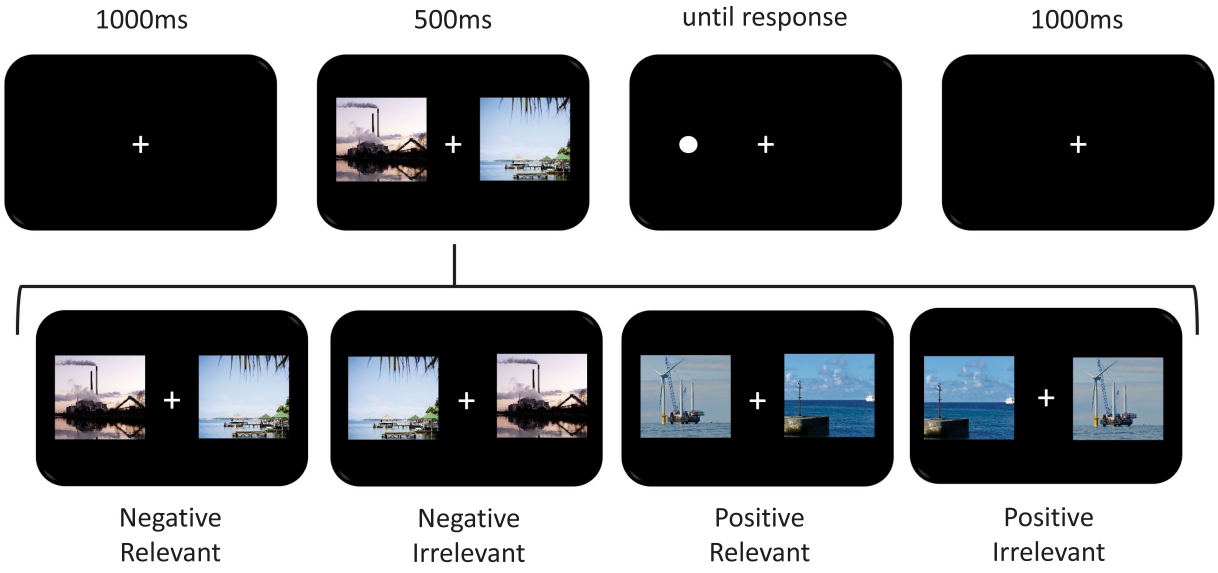



FIGURE 1
Trial structure of the dot-probe task of attentional bias. First, each trial started with a 1,000ms white fixation cue (+) in the center of a black background. Second, two images were simultaneously presented to the left and right side of the fixation cue for 500ms. All trials contained a climate relevant and a climate irrelevant image pair. These images each extended 10°×12° of the visual angle and were separated by 14.5° of the visual angle. Third, a target dot appeared immediately after the images were removed and remained on the screen until a response was recorded. Fourth and finally, a 1,000ms intertrial interval separated trials. Participants were seated 59cm from the screen and instructed to focus on the central fixation cue throughout each trial while using their peripheral vision to locate the target dot as quickly as possible. An E-Prime serial response box was used to indicate left and right sided targets by (respectively) pressing the "1" button with their right index finger and the "2" button with their right middle finger. Faster reaction times to targets occurring at locations preceded by a climate change relevant image indicates attentional bias for the climate change relevant image over the irrelevant image.

relevant images. The details of the specific images and dot-probe tasks used in this report have been previously published (Carlson et al., 2020). Briefly, images used in each experiment were selected from the affective images of climate change database (https://affectiveclimateimages.weebly.com; Lehman et al., 2019).[1] The database contains a total of 320 digital images rated on their emotional valence (1 unpleasant to 9 pleasant), emotional arousal (1 calm to 9 exciting), and relevance (1 least relevant to 9 most relevant) to climate change. All tasks were programmed in E-Prime (Psychology Software Tools, Pittsburg, PA) and displayed on a 60 Hz 16″ LCD computer monitor. All variants of the task used the same general sequence of events, which are depicted and summarized in Figure 1. It should be noted that for relatively simplistic and universal emotional stimuli (such as facial expressions), shorter (<300 ms) interstimulus intervals result in more robust bias effects (Torrence et al., 2017), greater reliability (Chapman et al., 2019), and a stronger association with anxiety (Bantin et al., 2016). However, informal pilot testing in our lab lead to the conclusion that the complex scenes of climate change related information used here would need longer display times for the content to be processed and therefore a stimulus duration of 500 ms was used here. As previously reported, this stimulus duration has been found to elicit attention bias effects for climate change images in the dot-probe task (Carlson et al., 2019b, 2020).

Climate-relevant and climate-irrelevant images were randomly presented to the left visual field or right visual field for each participant. There were an equal number of trials with the target dot occurring on the same side of the screen as the climate change-relevant image and on the same side as the climate change-irrelevant image (see below for more details of each specific sample). Faster reaction times (RTs) to targets occurring at the climate-relevant location (i.e., traditionally referred to as congruent trials in the dot-probe literature) compared to climate-irrelevant location (i.e., incongruent trials) are considered representative of attentional bias (MacLeod et al., 1986; MacLeod and Mathews, 1988). At the conclusion of each block, participants received feedback about their overall accuracy and reaction time to encourage accurate rapid responses. The specific design of each sample is summarized below.

Sample one utilized a 2 × 2 (emotional valence × relevance of the target location) factorial design and consisted of 3 blocks

1 The following images were used in Sample 1: 12, 13, 29, 39, 46, 49 (positive relevant), 8, 18, 23, 20, 37, 62 (negative relevant), 178, 194, 200, 210, 221, 240, 256, 277, 280, 303, 308, and 315 (irrelevant). The following images were used in Sample 2: 12, 13, 29, 39, 46, 49 (solution relevant), 8, 18, 21, 23, 35, 42 (cause relevant), 7, 16, 19, 20, 37, 62 (effect relevant), 178, 194, 200, 210, 221, 222, 240, 243, 256, 277, 280, 281, 289, 295, 303, 308, 312, and 315 (irrelevant). Sample 3 used the same cause and effect images used in sample 2.

of 120 trials with 30 in each cell: positive relevant, positive irrelevant, negative relevant, & negative irrelevant. This yielded 360 total trials, with 90 trials in each cell. Positive images included windmills and solar panels, whereas negative images included industrial air pollution, melting ice, and natural disasters.

Sample two utilized a 2 × 3 factorial design with location relevancy (relevant vs. irrelevant) × image type (cause vs. effect vs. solution) as the independent variables. The dot-probe task used in sample 2 contained 3 blocks of 180 trials with 30 in each cell: yielding 540 total trials, with 90 trials in each cell type. Causes included images of industrial air pollution and deforestation. Effects included images of melting ice and natural disasters. Solutions included images of windmills and solar panels.

Sample three utilized a 2 × 2 factorial design with location relevancy (relevant vs. irrelevant) and image type (cause vs. effect) as the independent variables. The dot-probe task in sample 3 consisted of 3 blocks of 144 trials with 36 trials in each cell: yielding 432 total trials, with 108 trials in each cell type. Cause and effect images included the same types of stimuli used in sample 2.

## 2.3. Data reduction and analysis procedures

Consistent with previous research (Torrence et al., 2017; Carlson et al., 2019a), we only included correct responses between 150 and 750 ms after the presence of the target in the dot-probe task to eliminate premature responses and lapses in attention (98.24% of the data was included for Sample 1, 95.38% for Sample 2, and 95.12% for Sample 3). Traditional attentional bias was defined as the difference between the mean RT of incongruent and congruent conditions (i.e., mean incongruent – congruent RT). The calculation of ABV was based on the trial-level bias score method (Zvielli et al., 2015), which has been shown to be more reliable than other ABV approaches (Molloy and Anderson, 2020). To compute the trial level bias score, each congruent trial was first paired with the closest incongruent trial with a maximum distance of 5 trials backward or forward. Similarly, each incongruent trial was paired with its closest congruent trial. Next, the trial level bias scores were obtained by subtracting the RT of congruent from incongruent trials for each pair (see Figure 2). To calculate ABV, the summed distance between succeeding trial level bias scores was divided by the total number of trial level bias scores. General RT variability (RTV) was obtained by calculating the standard deviation of RTs across all (congruent and incongruent) trials. All measures were computed separately for each block. To examine the reliability of traditional attentional bias and ABV, bivariate Pearson correlations across blocks were performed in SPSS 28. In addition, in order to control for the influence of general RTV, partial correlations across blocks were also conducted for each measurement.

# 3. Results

## 3.1. Traditional attentional bias score reliability

In each of the three independent samples analyzed here, traditional measures of attentional bias were generally uncorrelated across blocks 1–3 for different types of climate change images.[2] These measures were also generally uncorrelated with general RTV and partial correlations controlling for RTV did not drastically alter the association between traditional measures of attentional bias across blocks. For all correlations with traditional measures of attentional bias, see Table 1 (samples 1–3, respectively).

## 3.2. Attention bias variability reliability

In general, across samples 1–3, ABV-based measures of attentional bias were moderately to highly correlated across blocks and moderately to highly correlated with general RTV. In partial correlations controlling for RTV, ABV-based measures only weakly correlated across blocks and in the majority of cases these correlations were no longer significant. See Table 1 for all ABV correlations for samples 1–3, respectively.

## 3.3. Attention bias variability correlations with pro-environmental disposition

The New Ecological Paradigm questionnaire (Dunlap et al., 2000) was administered to samples 2 and 3 as a measure of pro-environmental disposition. Although ABV in these samples appears to be driven by RT variability, we nevertheless assessed the degree to which these scores offer predictive validity for pro-environmental disposition.[3] Across samples 2 and 3, ABV scores were unrelated to pro-environmental disposition (Sample 2: Cause $r = 0.03$, Effect $r = -0.08$, Solution $r = -0.16$ & Sample 3: Cause $r = -0.02$ & Effect $r = 0.02$, $ps \geq 0.22$). Note that in a separate sample, climate change anxiety was also unrelated to these ABV scores.[4]

2 Note that it could be argued that correlations might be weaker across blocks due to meaningful changes in bias across time. As an alterative approach, we performed odd-even split-half Pearson correlations for each condition. Split-half reliability for attentional bias to climate change solutions in Sample 2 revealed a significant negative correlation ($r = -0.30$, $p = 0.023$). All of the remaining split-half correlations were non-significant ($r = -04$ to 0.26, $ps > 0.05$).

3 Note that the associations with pro-environmental disposition and traditional measures of attentional bias from this sample have been reported elsewhere (Carlson et al., 2020).

4 In a separate sample ($N = 120$), we found no association between ABV and climate change anxiety for positive ($r = 0.08$, $p = 0.39$) and negative ($r = -0.001$, $p = 0.99$) images of climate change.

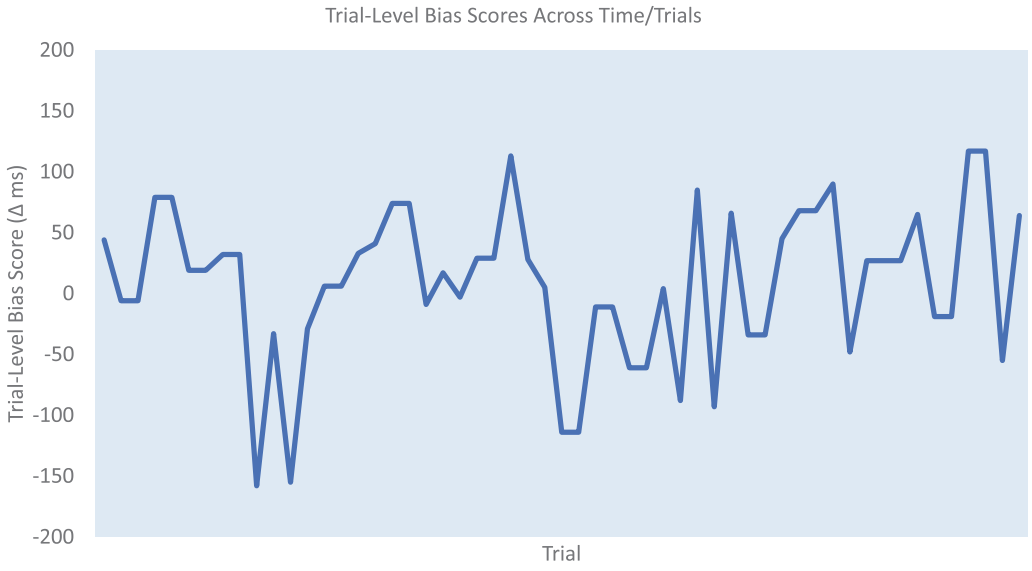



FIGURE 2
An example of trial level bias scores (TLBSs) of one block in the dot-probe task. Attention bias variability (ABV) is computed as the summed distance between succeeding TLBSs divided by the total number TLBSs.

## 4. Discussion

This study aimed to assess the reliability of RT-based measures of attention bias and ABV to climate change images in the dot-probe task. The results obtained here across three dot-probe tasks of attentional bias to climate change relevant images indicate that neither the traditional (RT difference score) approach nor the innovative ABV approach were reliable measures of attentional bias. The traditional approach was not consistently influenced by general RT variability, but was nevertheless unreliable. This finding is consistent with a growing body of literature using the dot-probe task in other fields (Schmukle, 2005; Staugaard, 2009; Price et al., 2015; Aday and Carlson, 2019; Chapman et al., 2019; Van Bockstaele et al., 2020). On the other hand, ABV scores initially correlated across blocks demonstrating some degree of reliability, which is consistent with prior ABV research (Naim et al., 2015; Price et al., 2015; Davis et al., 2016; Rodebaugh et al., 2016; Zvielli et al., 2016; Molloy and Anderson, 2020). Yet, when controlling for general RT variability, ABV measures were no longer correlated across blocks indicating that they likely measure general RT variability rather than attention bias behavior. Again, this finding echoes what has been reported in prior studies assessing attentional bias to threat and food related stimuli (Kruijt et al., 2016; Carlson and Fang, 2020; Vervoort et al., 2021; Carlson et al., 2022a). Finally, ABV measures were found to be unrelated to individual differences in pro-environmental orientation (and climate change anxiety)—suggesting poor predictive validity. Thus, many of the shortcomings of the RT difference score and ABV approaches reported in other fields appear to generalize to the use of environmental stimuli in the dot-probe task.

Based on these findings, we recommend that RT-based measures of attentional bias to environmental information should not be used for individual differences (or correlational) research. As much of the field of environmental attentional bias research is interested in linking variability in attentional bias to individual differences related to environmentalism or climate change concern (Beattie and McGuire, 2012; Sollberger et al., 2017; Whitman et al., 2018; Carlson et al., 2019b; Luo and Zhao, 2019; Meis-Harris et al., 2021), new/different approaches to capturing attentional bias are needed for these research objectives. As previously mentioned, eye tracking is another common approach to measuring attentional bias to climate change relevant information (Beattie and McGuire, 2012; Sollberger et al., 2017; Luo and Zhao, 2019). Some research suggests that eye-tracking measures of attention are (more) reliable (Sears et al., 2019; van Ens et al., 2019; Soleymani et al., 2020), whereas other research suggests that eye tracking may not be more reliable (Skinner et al., 2018). Therefore, future research should aim to assess the reliability of eye tracking-based measures from the paradigms used to measure environmental attentional bias. In addition, electroencephalographic measures of brain activity have been found to more reliably measure covert attention (Kappenman et al., 2014; Reutter et al., 2017) and may be appropriate for measuring environmental attentional biases.

Although the results obtained here indicate that RT-based measures in the dot-probe task are not suitable for capturing individual differences in attentional bias to climate change information, this does not preclude the use of RT-based tasks to assess the effects of experimental manipulations on attentional bias. Reliability is not required for comparisons across experimental groups/conditions, but is for individual differences research. The field needs to identify ways to increase the reliability

TABLE 1 Correlations across blocks in samples 1–3.

| **Sample 1** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Block** | **AB positive climate change images** | | | | **AB negative climate change images** | | | |
| | **1** | **2** | **3** | **RTV** | **1** | **2** | **3** | **RTV** |
| 1 | – | 0.21 | 0.09 | 0.12 | – | −0.06 | −0.05 | 0.02 |
| 2 | *0.19* | – | 0.09 | 0.24 | *−0.06* | – | 0.18 | −0.14 |
| 3 | *0.07* | *0.05* | – | 0.20 | *−0.05* | *0.16* | – | −0.11 |
| | **ABV positive climate change images** | | | | **ABV negative climate change images** | | | |
| 1 | – | 0.31* | 0.38* | 0.65* | – | 0.41* | 0.29* | 0.61* |
| 2 | *−0.01* | – | 0.45* | 0.49* | *−0.03* | – | 0.39* | 0.70* |
| 3 | *−0.05* | *0.20* | – | 0.64* | *−0.16* | *−0.11* | – | 0.64* |

| **Sample 2** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Block** | **AB effects** | | | | **AB causes** | | | | **AB solutions** | | | |
| | **1** | **2** | **3** | **RTV** | **1** | **2** | **3** | **RTV** | **1** | **2** | **3** | **RTV** |
| 1 | – | −0.12 | 0.18 | 0.10 | – | −0.02 | 0.06 | −0.14 | – | 0.11 | −0.09 | 0.22 |
| 2 | *−0.11* | – | 0.16 | −0.02 | *−0.01* | – | 0.08 | 0.08 | *0.11* | – | −0.25 | 0.01 |
| 3 | *0.15* | *0.18* | – | 0.43* | *0.07* | *0.08* | – | 0.09 | *−0.08* | *−0.25* | – | −0.04 |
| | **ABV effects** | | | | **ABV causes** | | | | **ABV solutions** | | | |
| 1 | – | 0.42* | 0.17 | 0.66* | – | 0.38* | 0.23 | 0.52* | – | 0.53* | 0.48* | 0.76* |
| 2 | *−0.13* | – | 0.54* | 0.74* | *0.10* | – | 0.59* | 0.60* | *0.13* | – | 0.42* | 0.58* |
| 3 | *−0.29** | *0.24* | – | 0.55* | *−0.25* | *0.29** | – | 0.72* | *−0.13* | *0.03* | – | 0.68* |

| **Sample 3** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Block** | **AB effects** | | | | **AB causes** | | | |
| | **1** | **2** | **3** | **RTV** | **1** | **2** | **3** | **RTV** |
| 1 | – | 0.27* | 0.31* | −0.10 | – | 0.10 | 0.29* | 0.15 |
| 2 | *0.27** | – | 0.06 | 0.04 | *0.05* | – | 0.22 | 0.30* |
| 3 | *0.31** | *0.06* | – | −0.01 | *0.26** | *0.16* | – | 0.26* |
| | **ABV effects** | | | | **ABV causes** | | | |
| 1 | – | 0.67* | 0.54* | 0.83* | – | 0.59* | 0.59* | 0.81* |
| 2 | *0.09* | – | 0.66* | 0.77* | *−0.16* | – | 0.58* | 0.81* |
| 3 | *0.00* | *0.33** | – | 0.65* | *0.03* | *0.01* | – | 0.71* |

*$p < 0.05$, Shaded/gray region with italicization on the bottom reflects partial correlations controlling for reaction time variability (RTV). AB, attention bias; ABV, attention bias variability.

of attention bias estimates. Reaction times start from a promising point (highly correlated across blocks: Sample 1: $r = 0.77–0.92$, Sample 2: $r = 0.85–0.92$, and Sample 3: $r = 0.82–0.91$), but data quality quickly diminishes when calculating differences scores (Hedge et al., 2018).

Initial research, based on RTs in the dot-probe task, indicates that emotionally positive images of climate change solutions capture attention to a greater extent than emotionally negative images of climate change causes and effects (Carlson et al., 2020). Future experimental research is needed to determine whether the same pattern is observed using other images as well as verbal, auditory, and multimodal information about climate change. Indeed, determining what types of climate change relevant information is best suited to capture individuals' attention would be useful in the effective design of environmental communication related to climate change. Furthermore, identifying interventions, contextual factors, and other manipulations that can modify attention to climate change information has important implications for increasing attentional focus on climate change messaging. For example, research has shown that attention training can increase attention to climate change information (Carlson et al., 2022b). In summary, although much research on environmental attentional biases focuses on individual differences in attentional bias and our data indicate that RT-based (difference score & ABV) measures of attentional bias are unsuitable for correlational research, more experimental research is needed to

better understand the variables that lead to an effective focus of attention on climate change information.

This study is not without limitation. First, the samples utilized here were primarily comprised of college-age females, and although it is unlikely that the reliability of attention bias and ABV measures differ across populations, the homogeneity of our sample(s) limits the generalization of the results. In addition, another limitation of this study is the sole use of climate change relevant images rather than other stimulus types. Although the reliability of attentional bias and ABV to other types of information (e.g., threat-related information) does not appear to be related to stimulus type (Staugaard, 2009; Carlson and Fang, 2020), it is possible that attention to climate change related information differs based on the stimulus type (e.g., images vs. words). Future research is needed to assess this possibility. Finally, although the dot-probe task is among the most common RT-based methods of assessing attentional bias, the extent to which RT-based reliability estimates of attentional bias observed here in the dot-probe task generalize to other RT-based tasks/measures is unclear. Yet, given that reliability is generally an issue for RT-based (difference score) measures (Hedge et al., 2018; Goodhew and Edwards, 2019), we do not expect these findings to be specific to the dot-probe task, but RT-based measures more broadly.

## 5. Conclusion

In summary, the present study aimed to assess the reliability of the dot-probe task using climate change relevant images. Both traditional (reaction time difference score) and innovative ABV measures were used, and both were found to lack reliability in measuring individual differences in attentional bias to climate images. These findings strongly suggest that the dot-probe task, and likely other RT difference score-based measures, are unsuitable for individual differences research assessing the correlation between participant factors, such as climate concern, and attention bias. Due to the growing body of work focusing on these and other individual differences, we argue that other measures of attention bias should be adopted for these purposes. No matter which measure of attentional bias is used, the reliability estimates of the measure should be included. Finally, RT-based cognitive tasks, such as the dot-probe, may still be appropriate for measuring differences in attention bias following various experimental interventions.

## Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://osf.io/E9S8P/.

## Ethics statement

The studies involving human participants were reviewed and approved by Northern Michigan University IRB. The patients/participants provided their written informed consent to participate in this study.

## Author contributions

JC designed the study. JC and LF processed and analyzed the data. JC, LF, CC-C, and JF drafted the manuscript. All authors contributed to the article and approved the submitted version.

## Acknowledgments

The authors would like to thank the students at Northern Michigan University for participating in this research as well as the students in the Cognitive×Affective Behavior & Integrative Neuroscience (CABIN) Lab for assisting in the collection of this data.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



## References

Aday, J. S., and Carlson, J. M. (2019). Extended testing with the dot-probe task increases test–retest reliability and validity. *Cogn. Process.* 20, 65–72. doi: 10.1007/s10339-018-0886-1

Bantin, T., Stevens, S., Gerlach, A. L., and Hermann, C. (2016). What does the facial dot-probe task tell us about attentional processes in social anxiety? A systematic review. *J. Behav. Ther. Exp. Psychiatry* 50, 40–51. doi: 10.1016/j.jbtep.2015.04.009

Beattie, G., and McGuire, L. (2012). See no evil? Only implicit attitudes predict unconscious eye movements towards images of climate change. *Semiotica* 2012, 315–339. doi: 10.1515/sem-2012-0066

Carlson, J. M., Aday, J. S., and Rubin, D. (2019a). Temporal dynamics in attention bias: effects of sex differences, task timing parameters, and stimulus valence. *Cogn. Emot.* 33, 1271–1276. doi: 10.1080/02699931.2018.1536648

Carlson, J. M., and Fang, L. (2020). The stability and reliability of attentional bias measures in the dot-probe task: evidence from both traditional mean bias scores and trial-level bias scores. *Motiv. Emot.* 44, 657–669. doi: 10.1007/s11031-020-09834-6

Carlson, J. M., Fang, L., and Kassel, D. (2022a). The questionable validity of attention bias variability: evidence from two conceptually unrelated cognitive tasks. *J. Affect. Dis. Rep.* 10:100411. doi: 10.1016/j.jadr.2022.100411

Carlson, J. M., Kaull, H., Steinhauer, M., Zigarac, A., and Cammarata, J. (2020). Paying attention to climate change: positive images of climate change solutions capture attention. *J. Environ. Psychol.* 71:101477. doi: 10.1016/j.jenvp.2020.101477

Carlson, J. M., Lehman, B. R., and Thompson, J. L. (2019b). Climate change images produce an attentional bias associated with pro-environmental disposition. *Cogn. Process.* 20, 385–390. doi: 10.1007/s10339-019-00902-5

Carlson, J. M., Voltz, M., Foley, J., Gentry, L., and Fang, L. (2022b). Changing how you look at climate change: Attention bias modification increases attention to climate change. *Clim. Chang.* 175. doi: 10.1007/s10584-022-03471-3

Chapman, A., Devue, C., and Grimshaw, G. M. (2019). Fleeting reliability in the dot-probe task. *Psychol. Res.* 83, 308–320. doi: 10.1007/s00426-017-0947-6

Davis, M. L., Rosenfield, D., Bernstein, A., Zvielli, A., Reinecke, A., Beevers, C. G., et al. (2016). Attention bias dynamics and symptom severity during and following CBT for social anxiety disorder. *J. Consult. Clin. Psychol.* 84, 795–802. doi: 10.1037/ccp0000125

Dunlap, R. E., Van Liere, K. D., Mertig, A. G., and Jones, R. E. (2000). Measuring endorsement of the new ecological paradigm: a revised NEP scale. *J. Soc. Issues* 56, 425–442. doi: 10.1111/0022-4537.00176

Goodhew, S. C., and Edwards, M. (2019). Translating experimental paradigms into individual-differences research: contributions, challenges, and practical recommendations. *Conscious. Cogn.* 69, 14–25. doi: 10.1016/j.concog.2019.01.008

Hedge, C., Powell, G., and Sumner, P. (2018). The reliability paradox: why robust cognitive tasks do not produce reliable individual differences. *Behav. Res. Methods* 50, 1166–1186. doi: 10.3758/s13428-017-0935-1

Iacoviello, B. M., Wu, G., Abend, R., Murrough, J. W., Feder, A., Fruchter, E., et al. (2014). Attention bias variability and symptoms of posttraumatic stress disorder. *J. Trauma. Stress.* 27, 232–239. doi: 10.1002/jts.21899

Kappenman, E. S., Farrens, J. L., Luck, S. J., and Proudfit, G. H. (2014). Behavioral and ERP measures of attentional bias to threat in the dot-probe task: poor reliability and lack of correlation with anxiety. *Front. Psychol.* 5:1368. doi: 10.3389/fpsyg.2014.01368

Kruijt, A.-W., Field, A. P., and Fox, E. (2016). Capturing dynamics of biased attention: new attention bias variability measures the way forward? *PLoS One* 11:e0166600. doi: 10.1371/journal.pone.0166600

Lehman, B., Thompson, J., Davis, S., and Carlson, J. M. (2019). Affective images of climate change. *Front. Psychol.* 10:960. doi: 10.3389/fpsyg.2019.00960

Luo, Y., and Zhao, J. (2019). Motivated attention in climate change perception and action. *Front. Psychol.* 10:1541. doi: 10.3389/fpsyg.2019.01541

Luo, Y., and Zhao, J. (2021). Attentional and perceptual biases of climate change. *Curr. Opin. Behav. Sci.* 42, 22–26. doi: 10.1016/j.cobeha.2021.02.010

MacLeod, C., and Mathews, A. (1988). Anxiety and the allocation of attention to threat. *Q. J. Exp. Psychol. A* 40, 653–670. doi: 10.1080/14640748808402292

MacLeod, C., Mathews, A., and Tata, P. (1986). Attentional bias in emotional disorders. *J. Abnorm. Psychol.* 95, 15–20. doi: 10.1037/0021-843X.95.1.15

Meis-Harris, J., Eyssel, F., and Kashima, Y. (2021). Are you paying attention? How pro-environmental tendencies relate to attentional processes. *J. Environ. Psychol.* 74:101591. doi: 10.1016/j.jenvp.2021.101591

Molloy, A., and Anderson, P. L. (2020). Evaluating the reliability of attention bias and attention bias variability measures in the dot-probe task among people with social anxiety disorder. *Psychol. Assess.* 32, 883–888. doi: 10.1037/pas0000912

Naim, R., Abend, R., Wald, I., Eldar, S., Levi, O., Fruchter, E., et al. (2015). Threat-related attention bias variability and posttraumatic stress. *Am. J. Psychiatry* 172, 1242–1250. doi: 10.1176/appi.ajp.2015.14121579

Pecl, G. T., Araújo, M. B., Bell, J. D., Blanchard, J., Bonebrake, T. C., Chen, I.-C., et al. (2017). Biodiversity redistribution under climate change: impacts on ecosystems and human well-being. *Science* 355:eaai9214. doi: 10.1126/science.aai9214

Price, R. B., Kuckertz, J. M., Siegle, G. J., Ladouceur, C. D., Silk, J. S., Ryan, N. D., et al. (2015). Empirical recommendations for improving the stability of the dot-probe task in clinical research. *Psychol. Assess.* 27, 365–376. doi: 10.1037/pas0000036

Reutter, M., Hewig, J., Wieser, M. J., and Osinsky, R. (2017). The N2pc component reliably captures attentional bias in social anxiety. *Psychophysiology* 54, 519–527. doi: 10.1111/psyp.12809

Rodebaugh, T. L., Scullin, R. B., Langer, J. K., Dixon, D. J., Huppert, J. D., Bernstein, A., et al. (2016). Unreliability as a threat to understanding psychopathology: the cautionary tale of attentional bias. *J. Abnorm. Psychol.* 125, 840–851. doi: 10.1037/abn0000184

Schmukle, S. C. (2005). Unreliability of the dot probe task. *Eur. J. Pers.* 19, 595–605. doi: 10.1002/per.554

Sears, C., Quigley, L., Fernandez, A., Newman, K., and Dobson, K. (2019). The reliability of attentional biases for emotional images measured using a free-viewing eye-tracking paradigm. *Behav. Res. Methods* 51, 2748–2760. doi: 10.3758/s13428-018-1147-z

Skinner, I. W., Hübscher, M., Moseley, G. L., Lee, H., Wand, B. M., Traeger, A. C., et al. (2018). The reliability of eyetracking to assess attentional bias to threatening words in healthy individuals. *Behav. Res. Methods* 50, 1778–1792. doi: 10.3758/s13428-017-0946-y

Soleymani, A., Ivanov, Y., Mathot, S., and de Jong, P. J. (2020). Free-viewing multi-stimulus eye tracking task to index attention bias for alcohol versus soda cues: satisfactory reliability and criterion validity. *Addict. Behav.* 100:106117. doi: 10.1016/j.addbeh.2019.106117

Sollberger, S., Bernauer, T., and Ehlert, U. (2017). Predictors of visual attention to climate change images: an eye-tracking study. *J. Environ. Psychol.* 51, 46–56. doi: 10.1016/j.jenvp.2017.03.001

Staugaard, S. R. (2009). Reliability of two versions of the dot-probe task using photographic faces. *Psychol. Sci. Q.* 51, 339–350.

Tollefson, J. (2019). Humans are driving one million species to extinction. *Nature* 569, 171–172. doi: 10.1038/d41586-019-01448-4

Tollefson, J. (2020). How hot will earth get by 2100? *Nature* 580, 443–445. doi: 10.1038/d41586-020-01125-x

Torrence, R. D., Wylie, E., and Carlson, J. M. (2017). The time-course for the capture and hold of visuospatial attention by fearful and happy faces. *J. Nonverbal Behav.* 41, 139–153. doi: 10.1007/s10919-016-0247-7

Van Bockstaele, B., Lamens, L., Salemink, E., Wiers, R. W., Bögels, S. M., and Nikolaou, K. (2020). Reliability and validity of measures of attentional bias towards threat in unselected student samples: seek, but will you find? *Cognit. Emot.* 34, 217–228. doi: 10.1080/02699931.2019.1609423

van Ens, W., Schmidt, U., Campbell, I. C., Roefs, A., and Werthmann, J. (2019). Test-retest reliability of attention bias for food: robust eye-tracking and reaction time indices. *Appetite* 136, 86–92. doi: 10.1016/j.appet.2019.01.020

Vervoort, L., Braun, M., De Schryver, M., Naets, T., Koster, E. H., and Braet, C. (2021). A pictorial dot probe task to assess food-related attentional bias in youth with and without obesity: overview of indices and evaluation of their reliability. *Front. Psychol.* 12:561. doi: 10.3389/fpsyg.2021.644512

Whitman, J. C., Zhao, J., Roberts, K. H., and Todd, R. M. (2018). Political orientation and climate concern shape visual attention to climate change. *Clim. Chang.* 147, 383–394. doi: 10.1007/s10584-018-2147-9

Zvielli, A., Bernstein, A., and Koster, E. H. (2015). Temporal dynamics of attentional bias. *Clin. Psychol. Sci.* 3, 772–788. doi: 10.1177/2167702614551572

Zvielli, A., Vrijsen, J. N., Koster, E. H., and Bernstein, A. (2016). Attentional bias temporal dynamics in remitted depression. *J. Abnorm. Psychol.* 125, 768–776. doi: 10.1037/abn0000190

frontiers | Frontiers in Psychology

TYPE Original Research
PUBLISHED 09 February 2023
DOI 10.3389/fpsyg.2023.1117452



OPEN ACCESS

EDITED BY
Paola Passafaro,
Sapienza University of Rome, Italy

REVIEWED BY
Moslem Savari,
Khuzestan University of Agricultural Sciences and Natural Resources, Iran
Adriana Zait,
Alexandru Ioan Cuza University, Romania

*CORRESPONDENCE
Sebastian Seebauer
✉ sebastian.seebauer@joanneum.at

SPECIALTY SECTION
This article was submitted to Environmental Psychology, a section of the journal Frontiers in Psychology

RECEIVED 06 December 2022
ACCEPTED 23 January 2023
PUBLISHED 09 February 2023

CITATION
Seebauer S and Ellmer HP (2023) Mental representation of climate-relevant behaviours: Confirmatory testing of similarity patterns obtained in a card sorting task by young adults.
*Front. Psychol.* 14:1117452.
doi: 10.3389/fpsyg.2023.1117452



# Mental representation of climate-relevant behaviours: Confirmatory testing of similarity patterns obtained in a card sorting task by young adults

Sebastian Seebauer* and Hans Peter Ellmer

LIFE Institute for Climate, Energy and Society, Joanneum Research Forschungsgesellschaft mbH, Graz, Austria

Efforts to promote climate-friendly consumption need to address groups of interrelated behaviours; however, experts and laypeople have different perspectives on which climate-relevant behaviours belong together. Understanding laypeople's mental representations, or the perceived similarity of behaviours, may provide orientation on which behaviours should be promoted in concert in order to communicate comprehensibly and to catalyse spillover. The present study uses data on perceived similarity between 22 climate-relevant behaviours collected from 413 young adults in Austria in an open card sorting task. Five posited categorisations by domain, location, impact, difficulty, and frequency are tested in a confirmatory approach for their fit with the observed similarity patterns. By analysing co-occurrence matrices, edit distances and similarity indices, the best fit is found for the null hypothesis of random assignment. Ranking by test statistics shows that the domain categorisation fits next best, followed by impact, frequency, difficulty, and location. The categories of waste and advocacy behaviours emerge consistently in lay mental representations. The categories of behaviours with a high carbon footprint and difficult behaviours that are performed by few other people stand out from other, less extreme behaviours. Categorisation fit is not moderated by personal norms, stated competencies, and environmental knowledge. The analytical approaches for confirmatory testing of expected categorisations against observed similarity patterns may be applied to analyse any card sorting data.

KEYWORDS

**shared concept, pro-environmental behaviour, grouping, spillover mechanism, category system, taxonomy, mental model**

## 1. Introduction

The grand challenge of combating climate change requires decarbonisation across all sectors, including the choices of private consumers (European Commission, 2019). As the achieved reductions in carbon emissions continue to fall below climate targets (Boehm et al., 2022), it becomes clear that focussing on selected consumer behaviours is no longer sufficient, but that changes across all aspects of private consumption are necessary (International Energy Agency, 2022). Thus, efforts at promoting climate-friendly consumption need to address groups of interrelated behaviours that can be tackled in concert.

Experts and laypeople, however, or those who design climate policy and those who are supposed to react to this policy in their daily lives, have a different understanding of which behaviours belong together. From the perspective of experts, all climate-relevant behaviours are conceptually linked in that they all contribute to a person's carbon footprint. By contrast, laypeople hardly hold an overarching mental concept that carbon- and energy-intensive activities belong together (Truelove and Gillis, 2018). Instead, laypeople form their mental representations by grouping behaviours that relate to the same practices and habits, that are performed with the same domestic appliances or that hold the same meaning for themselves or a meaning shared with others (Gabe-Thomas et al., 2016; Doran et al., 2018).

Thus, experts need to promote multiple interrelated climate-friendly behaviours not (only) in a way that makes sense from a science or policy standpoint, but in a way that aligns with how their lay audience considers behaviours to be connected to each other. Adjusting to lay perceptions may render experts' messages more comprehensible and actionable (see Section "1.1. Communicating comprehensibly by means of perceived similarity" below) and may leverage off existing behaviours to catalyse subsequent behaviour change in similar domains (Section "1.2. Catalysing spillover by means of perceived similarity").

Laypeople's mental representations of climate-relevant behaviours manifest, *inter alia*, in how they perceive some behaviours as similar and other behaviours as dissimilar. Consumers form mental representations through a cognitive process of grouping related objects, products or services according to their personal goals; this process results in their personal taxonomy of categories that constitute similarity (Loken, 2006; Gabe-Thomas et al., 2016). Sorting is an established technique for eliciting these taxonomies. Tasking people with ordering or grouping items allows identification of the criteria they use when categorising concepts by their similarities and differences (Gabe-Thomas et al., 2016; Doran et al., 2018). Sorting tasks may even reveal intuitive, implicit or unconscious categorisations. Thus, the present paper employs the sorting method to investigate which categorisations are key to the perceived similarity of various climate-relevant behaviours.

## 1.1. Communicating comprehensibly by means of perceived similarity

A clear understanding of perceived similarity is important for designing green marketing programmes that aim to encourage comprehensive changes spanning several climate-relevant behaviours (Thogersen, 2004). Programmes can be expected to be more successful if they cater to laypeople's nuanced perceptions (Truelove and Gillis, 2018). Perceived similarity indicates how consumers arrange behaviours in their mental space and therefore shows entry points for promoting multiple climate-friendly behaviours together (Bernard et al., 2009; Kneebone et al., 2018).

Persuasive messages for broad lifestyle change are more comprehensible to consumers if they address those behaviours jointly which have the same meaning to the audience (Gabe-Thomas et al., 2016). Communication programmes should focus on themes and comparisons that link several perceptually similar behaviours (Bernard et al., 2009). Understanding where lay and expert taxonomies diverge allows the taking of dedicated steps to correct lay misperceptions (Doran et al., 2018).

## 1.2. Catalysing spillover by means of perceived similarity

Perceived similarity is prominently discussed to facilitate spillover, that is, one behaviour change triggering another behaviour change (Maki et al., 2019). Consumers transfer behavioural practices from one context to another because of their psychological need to maintain a self-image of being consistent and to avoid cognitive dissonance from being inconsistent (Thogersen, 2004). If a consumer does not see two behaviours as similar, performing one behaviour but not the other would not evoke feelings of inconsistency or dissonance. Thus, perceived similarity may be considered a precondition for spillover. Consumers may transfer behaviours between contexts they themselves see as similar, even if experts would regard these behaviours as disjoint and unrelated.

There is (still) considerable disagreement in the spillover literature on what makes behaviours similar: behaviours connected to the same motivational goal (Truelove et al., 2014; Nash et al., 2017), behaviours performed in contexts that are temporally or spatially close to each other (Thogersen and Crompton, 2009), or behaviours requiring similar effort, resources, and skills (Thogersen and Crompton, 2009; Margetts and Kashima, 2017; Höchli et al., 2019). The classification of behaviours as similar, and therefore prone to spillover, is mostly based on expert judgements; however, the perceptions of similarity by those consumers who engage in these behaviours are a better indicator of whether spillover might take place (Truelove et al., 2014; Maki et al., 2019). Thus, effective behavioural change programmes "should select key actions perceived as similar to, and thus able to be catalysed by, householders' existing behaviours" (Kneebone et al., 2018:8).

## 1.3. Categorisations of climate-relevant behaviour

Categorisations assign behaviours to the same category if they are conceptually related. Previous research points to five categorisations that guide why laypeople group some behaviours as similar and distinguish other behaviours as dissimilar (Boudet et al., 2016): Domain, Location, Impact, Difficulty, and Frequency. The present study compares how these five categorisations appear in observed similarity patterns; next, these five categorisations are introduced in detail.

Similarity by consumption domain is arguably the most established categorisation (Kaiser and Wilson, 2004; Barr et al., 2005; DEFRA, 2008; Bernard et al., 2009; Blanken et al., 2015; Truelove and Gillis, 2018). In many studies, the domains of recycling and waste avoidance (e.g., separating waste, using returnable bottles), transport (e.g., using the car or public transport), and advocacy (e.g., environmental activism, participating in the public discourse) appear as distinct domains. However, there is less agreement on how to group domestic energy use for heating, hot water and electricity; nutrition choices; and shopping decisions for electronic devices, clothing and other consumer goods. Doran et al. (2018) report a catch-all category of energy use at home comprising energy-saving and efficient home appliances. Gabe-Thomas et al. (2016) report an everything-else cluster comprising water use, lighting, heating, and smaller electric devices. The present paper operationalises the *Domain* categorisation with the four categories energy use

and consumption, transport, waste, and advocacy: the latter three categories are well established as distinct domains by previous research; energy use and consumption is adopted as an umbrella category for domestic and shopping behaviours.

Similarity by location refers to the places where behaviours are performed. The clustering of electrical appliances in Gabe-Thomas et al. (2016) differentiates between the locations kitchen (e.g., fridge, oven, kettle, dishwasher, washing machine, and tumble dryer) and entertainment (e.g., TV, computer, games console, and stereo system). Kneebone et al. (2018) distinguish indoor (kitchen, bathroom, and laundry) versus outdoor (garden) water use. Stern (2000) draws a general line between private versus public sphere environmentalism. Thus, the present paper operationalises the *Location* categorisation with the four categories indoor, outdoor, online, and political space, thereby differentiating whether behaviours are performed physically inside or outside the home, virtually in online commerce or on social media, or in the environment of the political debate.

Similarity by impact refers to the energy demand and related carbon emissions of behaviours. Truelove and Gillis (2018) propose environmental impact as a dimension of similarity. Energy is, however, an intangible and abstract concept to most laypeople: laypeople do not group items of similar energy demand unless directly asked to do so (Baird and Brier, 1981); laypeople do not understand energy consumption very well (Darby, 2006; Bartiaux, 2008) and "do not hold consistent mental models of energy as a concept" (Gabe-Thomas et al., 2016:11). Laypeople underrate the substantial, albeit indirect environmental impact of political behaviours (Truelove and Gillis, 2018). Still, as a dimension deemed critical by experts, the present paper operationalises the *Impact* categorisation *via* the relative shares of specific behaviours in the average personal carbon footprint with the four categories >10, 5−10, <5% and no direct impact. Carbon impacts are calculated by applying the ECHOES methodology to the study population (Bird et al., 2019). For instance, carbon emissions from using the car amount on average to 6.6% of all personal emissions; therefore, this behaviour is assigned to the 5−10% category. Advocacy behaviours are assigned to the no direct impact category, because they influence climate policy and may indirectly lead to a reduction in carbon emissions but do not directly affect the footprint of the person who engages in advocacy behaviours.

Similarity by difficulty refers to the effort in inconvenience, discomfort, time, and money required to perform a behaviour (Truelove and Gillis, 2018). Financial and behavioural cost, cognitive effort, and efficacy beliefs are repeatedly discussed as a dimension of similarity (Thogersen, 2004; Karlin et al., 2014; Boudet et al., 2016; Kneebone et al., 2018). The present paper operationalises the *Difficulty* categorisation with the four categories of 0−25, 26−50, 51−75, and 76−100% engagement probability. The higher the engagement probability, the less difficult the behaviour, as a higher percentage of the population is likely to engage in that very behaviour. Engagement probabilities are derived from a General Ecological Behaviour attitude distribution, using the selected behaviours reported in Kaiser and Wilson (2004), Kaiser et al. (2007), Kaiser et al. (2008), Kaiser and Schultz (2009), and Kaiser et al. (2010) for Swiss, Dutch, and German samples as signposts and mapping other behaviours by interpolation and analogy.

Finally, similarity by frequency refers to how often and regularly a behaviour is performed. Frequency is considered relevant in expert analyses of similarity (Karlin et al., 2014; Höchli et al., 2019). Behavioural frequency may overlap with behavioural difficulty: Laypeople do not differentiate frequency of action and financial cost (Truelove and Gillis, 2018). However, the Difficulty categorisation is based on how many people perform the behaviour, whereas the Frequency categorisation is based on how often people perform the behaviour. The present paper operationalises the *Frequency* categorisation with four factors as categories that are derived from a principal component analysis of self-reported behavioural frequency (see Section "2.3. Analytical approach").

Most people seem to hold the same mental representations of perceived similarity. Doran et al. (2018) find that categorisations in a Norwegian and a German sample correspond highly. In Gabe-Thomas et al. (2016), the same cluster solution holds for female and male participants. By contrast, Thogersen (2004) finds that the moral importance of behaving environmentally responsibly moderates perceived similarity between behaviours. Thus, in the light of ambiguous previous research, the present paper explores moderator variables that could explain why people with a specific background or beliefs prefer some categorisations to others. Three potential moderator variables are analysed: One is personal norms (in other words, feeling morally obliged to engage in climate protection), because personal norms are broadly confirmed as a central factor in the cognitive processes influencing pro-environmental behaviour (Stern, 2000; Bamberg and Möser, 2007). The other two are environmental knowledge and stated competencies because informed and skilled people might be able to assess behaviours more precisely in the Impact and Difficulty categorisations (Frick et al., 2004; Steg and Vlek, 2009).

## 1.4. Aim of the paper

As argued above, perceived similarity is an important lever for communicating comprehensibly and for catalysing spillover. However, it is still unclear by which categorisations laypeople structure their mental representations of climate-relevant behaviours. The present paper extends previous exploratory research by carrying out confirmatory testing on how well the posited categorisations Domain, Location, Impact, Difficulty, and Frequency fit with observed similarity patterns. Perceived similarity is elicited in an open sorting task of climate-relevant behaviours in a sample of 413 young adults. In total, 22 behaviours (listed in **Table 1**) are analysed in order to cover a broad range of the climate-relevant actions private consumers may take (Truelove and Gillis, 2018). Personal norms, stated competencies, and environmental knowledge are tested for moderator effects on the fit of the posited categorisations.

The scope of the present paper does not include the categorisation of curtailment and efficiency behaviours, which is widely used in environmental psychology. Curtailment refers to actions that cut back consumption, whereas efficiency refers to actions that maintain consumption levels but require fewer carbon emissions or less energy (Gardner and Stern, 2008). Maintenance, that is, actions that require regular management, may constitute a third category but is close to efficiency (Karlin et al., 2014). The curtailment versus efficiency categorisation is not included in the analysis, because the analytical approach of the present paper requires a consistent number of four categories in all tested categorisations. Moreover, curtailment and efficiency overlap in some behaviours: for instance, car use (behaviour 9 in the present study, see **Table 1**) involves choosing the car type as well as everyday driving; or heating (behaviour 1) involves putting on a sweater and programming the thermostat as well as installing a

TABLE 1 Assignment of behaviours to categories.

| | | Domain | Location | Impact | Difficulty | Frequency |
|---|---|---|---|---|---|---|
| 1. | Heating | Energy use and consumption | Indoor | >10% | 51–75% | Factor2 |
| 2. | Showering | Energy use and consumption | Indoor | <5% | 76–100% | Factor4 |
| 3. | Saving hot water | Energy use and consumption | Indoor | <5% | 76–100% | Factor2 |
| 4. | Turning on the light | Energy use and consumption | Indoor | <5% | 76–100% | Factor2 |
| 5. | Using electronic devices | Energy use and consumption | Indoor | <5% | 51–75% | Factor2 |
| 6. | Streaming video | Energy use and consumption | Online | <5% | 51–75% | Factor4 |
| 7. | Separating waste | Waste | Indoor | <5% | 76–100% | Factor4 |
| 8. | Avoiding plastic | Waste | Indoor | <5% | 51–75% | Factor4 |
| 9. | Using the car | Transport | Outdoor | 5–10% | 26–50% | Factor3 |
| 10. | Using public transport | Transport | Outdoor | <5% | 26–50% | Factor3 |
| 11. | Using the bicycle | Transport | Outdoor | <5% | 51–75% | Factor3 |
| 12. | Flying | Transport | Outdoor | >10% | 26–50% | Factor2 |
| 13. | Buying clothes | Energy use and consumption | Online | 5–10% | 26–50% | Factor2 |
| 14. | Buying electronic devices | Energy use and consumption | Online | <5% | 51–75% | Factor2 |
| 15. | Eating meat | Energy use and consumption | Indoor | >10% | 76–100% | Factor1 |
| 16. | Buying organic food | Energy use and consumption | Outdoor | 5–10% | 0–25% | Factor4 |
| 17. | Buying local food | Energy use and consumption | Outdoor | 5–10% | 26–50% | Factor4 |
| 18. | Participating in an NGO for climate protection | Advocacy | Political space | no direct impact | 0–25% | Factor1 |
| 19. | Speaking out for climate protection online | Advocacy | Online | no direct impact | 0–25% | Factor1 |
| 20. | Speaking with other people about climate protection | Advocacy | Outdoor | no direct impact | 0–25% | Factor1 |
| 21. | Donating for climate protection | Advocacy | Online | no direct impact | 0–25% | Factor1 |
| 22. | Demonstrating for climate protection | Advocacy | Political space | no direct impact | 0–25% | Factor3 |

For criteria in assigning behaviours to posited categories, see section "1.3. Categorisations of climate-relevant behaviour". NGO, non-governmental organisation.

non-fossil heating system. Boudet et al. (2016) and Doran et al. (2018) provide support for omitting this categorisation by showing that the notion of a curtailment versus efficiency dichotomy is not held by laypeople.

## 2. Materials and methods

### 2.1. Respondents

Standardised self-completion questionnaires were distributed from February to May 2020 to students in their final high school year (12th or 13th year of formal education), aged 17–21 years. The survey was implemented in 24 vocational and general secondary schools in urban and rural locations in the Austrian provinces of Styria and Tyrol. Students completed an online questionnaire in the classroom during school hours, using the school's computers or their own electronic devices. A researcher was present on-site for oversight and clarification. Because of school closures in the COVID-19 national lockdown starting in mid-March 2020, however, data collection had to shift to an entirely online survey: teachers distributed an email invitation to the online survey and up to two reminders to their respective students who completed the questionnaire as a home-schooling exercise.

Out of $n$ = 502 respondents in total, $n$ = 364 fully and $n$ = 49 partially completed the sorting task. **Supplementary Table 1** gives

TABLE 2 $Chi^2$ test statistics of co-occurrence matrices.

| | Equal1 | Equal2 | Domain | Location | Impact | Difficulty | Frequency |
|---|---|---|---|---|---|---|---|
| All | 57,230 | 24,327 | 78,081 | 127,268 | 88,837 | 117,970 | 113,744 |
| Personal norms high | 2.31 | 1.00 | 3.37 | 5.17 | 3.65 | 4.88 | 4.64 |
| Personal norms low | 2.38 | 1.00 | 3.02 | 5.26 | 3.65 | 4.78 | 4.72 |
| Stated competencies high | 2.33 | 1.00 | 3.32 | 5.23 | 3.70 | 4.93 | 4.76 |
| Stated competencies low | 2.37 | 1.00 | 3.08 | 5.22 | 3.59 | 4.75 | 4.60 |
| Environmental knowledge high | 2.31 | 1.00 | 3.40 | 5.24 | 3.77 | 5.05 | 4.73 |
| Environmental knowledge low | 2.38 | 1.00 | 3.02 | 5.20 | 3.52 | 4.66 | 4.62 |
| df | 441 | 210 | 210 | 210 | 210 | 210 | 210 |

All: $Chi^2$ values in the $n$ = 364 sample. High/low median split subsamples of moderator variables: $Chi^2$ values divided by the Equal2 $Chi^2$ value to facilitate comparison between different subsample sizes.

TABLE 3 Descriptives, confidence intervals and correlations of edit distances.

| | Domain | Location | Impact | Difficulty | Frequency |
|---|---|---|---|---|---|
| Mean | 7.78 | 10.63 | 9.06 | 9.72 | 9.15 |
| Standard deviation | 2.12 | 1.57 | 1.63 | 1.68 | 1.83 |
| Lower bound of 95% confidence interval | 7.56 | 10.47 | 8.89 | 9.54 | 8.97 |
| Upper bound of 95% confidence interval | 8.00 | 10.79 | 9.23 | 9.89 | 9.34 |
| Correlation with personal norms | 0.01 | 0.00 | −0.05 | 0.04 | 0.02 |
| Correlation with stated competencies | 0.05 | 0.00 | 0.04 | 0.04 | 0.10 |
| Correlation with environmental knowledge | −0.01 | 0.01 | 0.02 | 0.05 | 0.03 |

$n$ = 364.

TABLE 4 Descriptives, confidence intervals and correlations of similarity indices in the Domain categorisation.

| | Consumption | Transport | Waste | Advocacy |
|---|---|---|---|---|
| $n$ | 409 | 398 | 391 | 389 |
| Mean | 0.40 | 0.51 | 0.89 | 0.86 |
| Standard deviation | 0.15 | 0.32 | 0.31 | 0.24 |
| Lower bound of 95% confidence interval | 0.38 | 0.48 | 0.86 | 0.84 |
| Upper bound of 95% confidence interval | 0.41 | 0.54 | 0.92 | 0.88 |
| Correlation with personal norms | 0.00 | −0.06 | 0.06 | 0.00 |
| Correlation with stated competencies | 0.03 | −0.02 | 0.06 | −0.05 |
| Correlation with environmental knowledge | 0.05 | −0.07 | 0.08 | −0.01 |

the sample composition by gender, age, education of parents, and completed in the classroom vs. at home.

## 2.2. Procedure and materials

The respondents completed an open card sorting task, assigning 22 climate-relevant behaviours (in card sorting terminology, behaviours refer to cards; the 22 behaviours are listed in Table 1) to four groups (in card sorting terminology, groups refer to piles) in a single sorting routine without repetition. The sorting task was implemented as a drag-and-drop task in the online questionnaire. Respondents were instructed to group those behaviours they regarded as similar and related. Respondents were free to assign as many behaviours to each group as they liked. Respondents were allowed to sort only some of the 22 behaviours and to leave some behaviours unsorted; the following Section "2.3. Analytical approach" describes how missing values from partial completion are addressed in the analysis. The four groups were not named, either by the researchers or by the respondents, and therefore do not carry any meaning apart from indicating that behaviours assigned to the same group are perceived as similar.

The set of 22 behaviours was selected to cover the scope of climate-relevant behaviours that young adults perform in their everyday lives and in which they have agency even while still living in the parental home. Sorting 22 cards is at the upper limit of acceptable respondent burden (Doran et al., 2018). Predefining the number of groups to four avoided the lumper-splitter-problem common in sorting tasks, that is, some respondents lumping cards into very few

TABLE 5 Descriptives, confidence intervals and correlations of similarity indices in the Location categorisation.

| | Indoor | Outdoor | Online | Political space |
|---|---|---|---|---|
| *n* | 406 | 408 | 384 | 377 |
| Mean | 0.40 | 0.32 | 0.28 | 0.92 |
| Standard deviation | 0.17 | 0.13 | 0.12 | 0.28 |
| Lower bound of 95% confidence interval | 0.39 | 0.31 | 0.27 | 0.89 |
| Upper bound of 95% confidence interval | 0.42 | 0.34 | 0.29 | 0.94 |
| Correlation with personal norms | −0.01 | 0.11 | 0.01 | −0.03 |
| Correlation with stated competencies | 0.04 | 0.02 | 0.02 | 0.04 |
| Correlation with environmental knowledge | 0.05 | 0.12 | 0.01 | −0.13 |

TABLE 6 Descriptives, confidence intervals and correlations of similarity indices in the Impact categorisation.

| | >10% | 5–10% | <5% | No direct impact |
|---|---|---|---|---|
| *n* | 383 | 399 | 410 | 389 |
| Mean | 0.46 | 0.31 | 0.36 | 0.86 |
| Standard deviation | 0.38 | 0.18 | 0.13 | 0.24 |
| Lower bound of 95% confidence interval | 0.43 | 0.29 | 0.34 | 0.84 |
| Upper bound of 95% confidence interval | 0.50 | 0.32 | 0.37 | 0.88 |
| Correlation with personal norms | 0.02 | −0.01 | 0.15 | 0.00 |
| Correlation with stated competencies | −0.01 | −0.01 | 0.09 | −0.05 |
| Correlation with environmental knowledge | 0.11 | 0.00 | 0.09 | −0.01 |

TABLE 7 Descriptives, confidence intervals and correlations of similarity indices in the Difficulty categorisation.

| | 0–25% | 26–50% | 51–75% | 76–100% |
|---|---|---|---|---|
| *n* | 392 | 401 | 395 | 399 |
| Mean | 0.62 | 0.30 | 0.33 | 0.38 |
| Standard deviation | 0.19 | 0.15 | 0.15 | 0.20 |
| Lower bound of 95% confidence interval | 0.60 | 0.29 | 0.31 | 0.36 |
| Upper bound of 95% confidence interval | 0.64 | 0.32 | 0.34 | 0.40 |
| Correlation with personal norms | 0.00 | −0.03 | 0.05 | −0.03 |
| Correlation with stated competencies | −0.03 | −0.02 | −0.01 | 0.05 |
| Correlation with environmental knowledge | −0.01 | −0.05 | 0.03 | 0.05 |

TABLE 8 Descriptives, confidence intervals and correlations of similarity indices in the Frequency categorisation.

| | Factor1 | Factor2 | Factor3 | Factor4 |
|---|---|---|---|---|
| *n* | 389 | 395 | 396 | 405 |
| Mean | 0.52 | 0.42 | 0.31 | 0.43 |
| Standard deviation | 0.17 | 0.18 | 0.21 | 0.16 |
| Lower bound of 95% confidence interval | 0.50 | 0.40 | 0.29 | 0.41 |
| Upper bound of 95% confidence interval | 0.54 | 0.43 | 0.33 | 0.44 |
| Correlation with personal norms | −0.03 | 0.09 | −0.05 | 0.05 |
| Correlation with stated competencies | −0.05 | 0.01 | −0.02 | 0.02 |
| Correlation with environmental knowledge | 0.00 | 0.02 | −0.05 | 0.03 |

piles and other respondents splitting cards into very many piles, resulting in high variance in the number of piles (Bernard et al., 2009).

The sorting task was part of a survey study on climate attitudes and behaviours among young adults. Prior to the sorting task, respondents self-reported how frequently they perform the 22 behaviours. It can therefore be assumed that the climate relevance of all behaviours was salient when the respondents started the sorting task. Self-reported behavioural frequency is used to derive the Frequency categorisation (see Section "2.3. Analytical approach" below). Frequency was measured with single items for fifteen behaviours and with multi-item scales for seven behaviours (2—4 items each; aggregated to mean indices; for exact wordings and descriptive statistics see **Supplementary Table 2**).

Personal norms, stated competencies and environmental knowledge were assessed as potential moderator variables of categorisations. Three personal norms items expressed pro-environmental self-identity and feelings of responsibility and obligation toward climate protection (Steinhorst et al., 2015; Seebauer, 2018). Respondents self-assessed their competencies for engaging in climate-friendly actions with six items on information retrieval, technical skills, and understanding production systems (Nilsson et al., 2017; UNESCO, 2017). Items on personal norms and stated competencies were aggregated to mean indices. Respondents were asked eight quiz questions about effective carbon saving, each quiz question featuring three multiple-choice options with one correct answer (Frick et al., 2004). The quiz questions were aggregated formatively to a sum score of correct answers, ranging from 0 to 8, with higher scores indicating better environmental knowledge. For details of item wordings, response scales, and descriptive statistics, see **Supplementary Table 2**.

## 2.3. Analytical approach

The unit of analysis is respondents, allowing analysis of respondent attributes as moderator variables. This is in contrast to the exploratory sorting studies by Gabe-Thomas et al. (2016) and Kneebone et al. (2018) who use the piles produced by respondents as a unit of analysis.

The observed similarity pattern (i.e., how each respondent placed behaviours in groups) is compared to five posited categorisations: Domain, Location, Impact, Difficulty, and Frequency. All posited categorisations consist of four categories in order to conform with the group limit in the sorting task and to ensure equal probability of random assignment. The Domain, Location, Impact, and Difficulty categorisations are derived from previous research (see Section "1.3. Categorisations of climate-relevant behaviour"). The Frequency categorisation uses the four factors with the highest eigenvalue in a principal component analysis of self-reported behavioural frequency (see **Supplementary Table 3**); thus, the Frequency categorisation pools behaviours in the same factor if they are performed with similar frequency.

The analysis adopts a confirmatory rationale and statistically tests how well posited categories fit with the observed responses. *Co-occurrence matrices*, *edit distances,* and *similarity indices* are used to compare categorisations. These three approaches complement each other, as they test either entire categorisations (co-occurrence matrix and edit distance) or specific categories (similarity index), either for the entire sample (co-occurrence matrix) or within each respondent (edit distance and similarity index).

The *co-occurrence matrix* is organised as an item-by-item table with 22 rows and 22 columns. The observed co-occurrence matrix is available for the $n$ = 364 subsample who sorted all 22 behaviours and it lists for all pairs of behaviours how many respondents assigned these two behaviours to the same group (**Supplementary Table 4**). The entries in the matrix cells can range from 0 (no one considers the two behaviours similar) to 364 (all respondents consider the two behaviours similar). The observed distribution in the co-occurrence matrix is compared to several expected distributions: Equal1, the null hypothesis of stochastic independence with the expected frequency in each cell calculated from the row sums and column sums of the observed matrix as in a common $Chi^2$ crosstabs test. Equal2, the null hypothesis of equal distribution from random assignment with a 25% probability per group, that is, an expected frequency of 364*0.25 in each cell, except the matrix diagonal with an expected frequency of 364. The distributions as stated by the Domain, Location, Impact, Difficulty, and Frequency categorisations, with an expected frequency of 364*0.95 = 345.8 in each cell where the categorisation posits a pair of behaviours to belong to the same category, an expected frequency of 364*0.05 = 18.2 in all other cells, and an expected frequency of 364 in the matrix diagonal. The 0.95/0.05 multiplicator allows for a 5% error rate by respondents and fulfils the technical requirement of $Chi^2$ tests of expected frequencies >5 in each cell. As in a common $Chi^2$ crosstabs test, the $Chi^2$ test statistic is calculated within each cell as the squared difference between observed and expected frequency divided by the expected frequency, totalled over all cells. With the exception of Equal1, the total $Chi^2$ test statistic is halved, because the upper and lower triangle of the matrix along the diagonal are symmetrical. In the same logic of correcting for symmetry, degrees of freedom are reduced by 22 for the cells in the matrix diagonal, which must number 364 both in the observed and the expected matrix, and then halved. Because differences between observed and expected frequencies accumulate over many cells, the $Chi^2$ test statistics yield very high numbers that by far exceed critical $Chi^2$ values for statistical significance. Still, the $Chi^2$ test statistics of the respective categorisations may be compared to assess their relative fit.

The *edit distance* is a combinatorial function that shows how far apart a respondent's sort is from the posited categorisation. For each respondent, the edit distance gives the minimal number of behaviours they would have to move between groups in order to convert their sort to perfectly represent the posited categorisation. The edit distance is available for the $n$ = 364 subsample who sorted all 22 behaviours. This approach recognises that the groups the behaviours are sorted into are not independent of each other. The edit distance is averaged over all respondents and then tested for statistical significance *via* confidence intervals: if the lower bound of the confidence interval does not include 0, the observed similarity pattern deviates significantly from the respective categorisation. If the confidence intervals of the mean edit distances of different categorisations do not overlap, it may be concluded that some categorisations fit better with the observed data than others.

For the *similarity index*, the raw data are recoded into binary variables for each pair of behaviours, coded 1 if these two behaviours are assigned to the (any) same group and coded 0 if they are assigned to (any) different groups. The similarity index is calculated by averaging the binary variables of all pairs of behaviours included in the posited category, resulting in a value between 1 and 0 for each respondent. Its mirror, the dissimilarity index, is the average over the pairwise comparisons between all behaviours not included in the posited category, also resulting in a value between 1 and 0

for each respondent. (Dis-)similarity indices are calculated for each category within each posited categorisation. The indices are available for the $n = 413$ sample who at least partially completed the sorting task because averaging within each category allows correction for missing values. Moreover, averaging allows comparison of categories comprising different numbers of behaviours. Testing for statistical significance is implemented *via* confidence intervals: for the observed similarity pattern to conform to the posited category, the upper bound of the confidence interval of the similarity index should include 1, and the lower bound of the confidence interval of the dissimilarity index should include 0. The lower bound of the confidence interval of the similarity index and the upper bound of the confidence interval of the dissimilarity index should not include 0.25 to reject the null hypothesis that behaviours were sorted randomly. Two categories within the same categorisation can be considered separate concepts if the confidence intervals of their (dis-)similarity indices do not overlap.

Potential *moderator effects* of personal norms, stated competencies and environmental knowledge are assessed by comparing the $Chi^2$ test statistics of two co-occurrence matrices obtained by splitting the sample by the median of the respective moderator variable; and by correlating edit distances and similarity indices with the moderator variables.

Confidence intervals use a significance level of $p < 0.05$. Testing *via* confidence intervals is analogue to *t*-tests: for instance, testing whether a confidence interval does not include 0 corresponds to a one-sample *t*-test whether a mean is significantly different from 0; testing whether confidence intervals overlap corresponds to a *t*-test comparing group means. The null hypotheses of an edit distance of 0 or a similarity index of 1 assume perfect congruence with the posited categorisation. These strict tests are likely to be rejected; however, the main interest of the present study does not lie in determining statistical significance, but in comparing which categorisations fit better with the observed similarity patterns than others.

# 3. Results

## 3.1. Co-occurrence matrices

Testing how well entire categorisations fit with the entire sample shows that the respondents do not seem to have a shared mental representation of which climate-relevant behaviours belong together. Equal2 and Equal1, the two null hypotheses assuming random assignment and stochastic independence, have the lowest $Chi^2$ test statistics and therefore fit best with the observed data (Table 2). Presumably, the individual patterns of how respondents sorted behaviours to groups differ widely and level each other out, resulting in an overall random pattern in the co-occurrence matrix.

However, $Chi^2$ test statistics may still be compared to assess which posited categorisations fit better than others. Ranking the $Chi^2$ test statistics (Table 2, top row) suggests that the Domain categorisation fits best, followed by Impact, and then with substantially higher $Chi^2$ values followed by Frequency, Difficulty, and finally Location.

This ranking of categorisations is not moderated by personal norms, stated competencies, and environmental knowledge. For easier comparison, Table 2 presents the $Chi^2$ test statistics as multiples of the Equal2 baseline in the respective subsample. Within each high or low subsample, the ranking of categorisations is the same as in the full sample; for instance, the ranking from Domain to Impact, Frequency, Difficulty, and finally Location applies to high personal norms as well as to low personal norms. Thus, it does not seem to depend on the respondents' personal norms, stated competencies, and environmental knowledge which categorisation they apply in their similarity patterns.

## 3.2. Edit distances

Comparing the edit distances also tests the fit of entire categorisations, but shows how far individual respondents deviate from the posited categorisation. Mean edit distances range from 7 to 10 (Table 3), meaning respondents would, on average, have to move 7−10 behaviours to another group in order to comply with the posited categorisation. All lower bounds of the confidence intervals are higher than 0, thus according to the strict null hypothesis all categorisations must be rejected (Table 3). Still, this does not preclude comparing the fit between categorisations. The mean edit distances replicate the ranking observed in the co-occurrence matrices, with Domain showing the best fit, followed by Impact, Frequency, Difficulty, and finally Location with increasingly higher edit distances. However, the decrease in fit by edit distance from Impact to Frequency is less pronounced than the decrease in fit by co-occurrence matrices, and the Impact and Frequency edit distances do not differ statistically significantly, since their confidence intervals overlap.

Again, there is no indication of moderator effects by personal norms, stated competencies, and environmental knowledge. Correlation coefficients between edit distances and moderator variables in Table 3 are $r < |0.10|$ throughout, suggesting that the individual level of personal norms, stated competencies, and environmental knowledge is unrelated to the degree to which a respondent represents a specific categorisation in their similarity pattern.

## 3.3. Similarity indices

Similarity indices provide a nuanced picture of how well respondents conform to specific categories within a categorisation. As above, the strict null hypothesis must be rejected for all categories in all categorisations, because the upper bounds of the confidence intervals of all similarity indices are lower than 1 (Tables 4−8) and the lower bounds of all confidence intervals of all dissimilarity indices are higher than 0 (Supplementary Tables 5−9). The result in the co-occurrence matrices that the Equal2 baseline fits best reappears here in that the upper bounds of the confidence intervals of the dissimilarity indices include 0.25, indicating that respondents may have assigned behaviours to groups randomly. By contrast, the lower bounds of the confidence intervals of the similarity indices all exceed 0.25, pointing to some shared, non-random mental representations held by the respondents. Yet, as above, despite rejecting the null hypothesis the fit of categories may be compared, with the added benefit that similarity indices allow comparison within as well as between categorisations.

The highest similarity indices emerge in the waste category of the Domain categorisation ($M = 0.89$) on the one hand; and the advocacy category in Domain ($M = 0.86$), political space in Location

($M$ = 0.92) no direct impact in Impact (0.86) and high Difficulty (0−25%: $M$ = 0.62) on the other hand. Advocacy, political space, no direct impact and high difficulty reach similarly high indices because they all include selected behaviours of political and civil engagement (behaviours 18−22, see Table 1). These categories seem to reflect shared representations of related behaviours that most respondents hold.

The following have low similarity indices: the energy use and consumption category in the Domain categorisation ($M$ = 0.40); indoor, outdoor, and online in Location ($M$ = 0.40, $M$ = 0.32, $M$ = 0.28, respectively); the middle categories in Impact (5−10%: $M$ = 0.31; <5%: $M$ = 0.36); the middle categories in Difficulty (26−50%: $M$ = 0.30; 51−75%: $M$ = 0.33); and Factor3 in Frequency ($M$ = 0.31). These all indicate that respondents hardly agree that the behaviours within these categories belong together. The umbrella character of energy use and consumption comprising half of all investigated behaviours might make it likely that respondents assign some of these many behaviours to another group. Distinctions between categories could be more blurry in the middle than at the extremes of the Impact and Difficulty spectrum. Location just does not seem to be a mental concept the respondents use to structure their climate-relevant activities.

However, despite the overall low means in similarity indices, hardly any confidence intervals overlap between categories of the same categorisation. This indicates that some categories represent perceived similarity better than others do. For instance, even in Location, the categorisation least adopted by the respondents, it may still be concluded that the indoor category ($M$ = 0.40) reflects significantly better lay mental representations than do the outdoor or online categories ($M$ = 0.32, $M$ = 0.28).

Interestingly, the high Impact (>10% share of the personal carbon footprint: $M$ = 0.46) and the high Difficulty (0−25% engagement probability: $M$ = 0.62) categories stand out against the other categories of Impact and Difficulty. Behaviours with a high carbon footprint (heating, flying, and eating meat) and behaviours that are performed by few other people (buying organic food, various political, and civil engagement behaviours) seem to be perceived as separate from less carbon-intensive and less difficult behaviours. That high impact and high difficulty behaviours go together is also reflected in the $M$ = 0.52 similarity index of Factor1 in Frequency (eating meat, various political and civil engagement behaviours).

Consistent with the results in co-occurrence matrices and edit distances, the moderator variables personal norms, stated competencies, and environmental knowledge do not have any discernible effect on similarity indices. Correlations of $r < |0.15|$ in all categorisations (Tables 4−8) indicate that even the perceived similarity within specific categories does not depend on the norms, competencies, or knowledge a respondent has.

# 4. Discussion and conclusion

The present paper compares the perceived similarity of climate-relevant behaviours to five posited categorisations: Domain, Location, Impact, Difficulty, and Frequency. Co-occurrence matrices, edit distances and similarity indices assess in a confirmatory approach how well the posited categorisations fit with the similarity patterns observed in an open card sorting task.

The best fit is found for the null hypotheses of stochastic independence and random assignment, suggesting there is no common structure to the respondents' sorting and thus no shared mental representation of similarity held by all respondents. This resonates with Gabe-Thomas et al.'s (2016) finding of substantial disagreement between laypeople in how they categorise behaviours. None of the posited categorisations can be statistically confirmed. Personal norms, stated competencies, and environmental knowledge do not influence perceived similarity. This puts into question the validity of categorisations used by experts and found in exploratory sorting studies. However, this overall result should not be mistaken to discard previous research, as the statistical testing uses strict null hypotheses that are likely to be rejected. Instead, the present study should be taken as a starting point that indicates which categorisations and categories feature higher or lower perceived similarity.

Indeed, some categories of behaviours perceived as more similar than others emerge. Organising behaviours in a Domain taxonomy seems to relatively best represent how young adults mentally structure their everyday actions. The Impact categorisation performs second best. The Difficulty and Frequency categorisations can be differentiated, as indicated by the difference in $Chi^2$ test statistics and edit distance; this contradicts Truelove and Gillis, 2018 finding that laypeople tend to confound these two categorisations. Throughout, categories within the same categorisations are perceived as distinct, as indicated by differences in similarity indices; presumably, these categories do structure, albeit weakly, how young adults think about climate-relevant behaviours.

Within the Domain categorisation, waste behaviours (behaviours 7 and 8, separating waste and avoiding plastic) and advocacy behaviours (behaviours 18−22, participating in an non-governmental organisation (NGO) for climate protection, speaking out for climate protection online, speaking with other people about climate protection, donating for climate protection, demonstrating for climate protection) belong together in laypeople's mental representations. Behaviours of high Impact (behaviours 1, 12, and 15, heating, flying, and eating meat) and high Difficulty (behaviours 16 and 18−22, buying organic food and the above advocacy behaviours) seem to stand out and form a subset of similar meaning within lay mental representations. Future research could follow up on this interesting finding and explore how behaviours at the extreme end of the spectrum relate to and possibly advance each other.

## 4.1. Implications for policy

Perceived similarity may provide orientation on which behaviours should be promoted in concert in order to communicate comprehensibly and to catalyse spillover (see Sections "1.2. Catalysing spillover by means of perceived similarity" and "1.3. Categorisations of climate-relevant behaviour"). Presumably, consumers are more likely to listen to and adopt persuasive arguments that refer to behaviours they perceive as similar.

The results suggest designing policy interventions for broad behavioural change around Domain categories, as this categorisation has the relatively best fit with the observed data. Promoting selected behaviours from the waste or advocacy categories is likely to carry over to other behaviours within the same category. By contrast, campaigns focussing on Location, the worst-fitting categorisation, are likely to fall short; for instance, promoting various outdoor behaviours together could not be expected to catalyse spillover.

If a campaign is bound to a specific categorisation, it should focus on the best-performing category within this categorisation. Take the example of an intervention using descriptive social norms, in other words, the effect that the actions observed in important others serve as a cue for socially accepted behaviours (Staats et al., 2004). This intervention would communicate to its audience how many other people already perform the target behaviours, which equals engagement probability in the Difficulty categorisation. Difficulty has weak overall fit, as shown by the co-occurrence matrix and the edit distance, but its categories clearly differ in the similarity indices. When communicating single behaviours, behaviours from the 76−100% Difficulty category could be highlighted (e.g., turning off the lights, saving hot water), because large parts of the population already perform these behaviours and therefore convey a strong descriptive norm. When communicating bundles of behaviours, it could be recommended to address 0−25% Difficulty behaviours (e.g., buying organic food, demonstrating for climate protection) because of the substantially higher similarity index of this category. However, since only a few people already perform 0−25% Difficulty behaviours, the intervention would have to highlight selected frontrunner groups as the important others who convey a descriptive norm.

## 4.2. Limitations and directions for future research

As in any other empirical study, the results underlie important caveats which at the same time point to avenues for future research. First and foremost, the findings only apply to young adults in Austria and need to be replicated in other population segments and in other geographies. Sampling young adults rather than the general population might have biassed the results. Young adults can be expected to perceive less similarity between climate-relevant behaviours than grown-ups: They perform pro-environmental behaviours less frequently than grown-ups (Krettenauer, 2017; Wang et al., 2021) and might thus be less likely to experience communalities between behaviours. They still undergo socialisation processes (Haustein et al., 2009; Klöckner and Matthies, 2012) whereas grown-ups already hold common norms that indicate which behaviours are related to each other. Presumably, the present study reports a lower level of perceived similarity than could be expected in the general population. However, entering young adulthood coincides with recovering from an "adolescent dip" in pro-environmental behaviours (Olsson and Gericke, 2016; Keith et al., 2021). Thus, young adults might be about to return to general population levels of perceived similarity. Future research could provide more clarity on how perceived similarity shifts over the life course, either in longitudinal studies or by comparing age cohorts. The present study sample is quite homogeneous in terms of age, educational level and living situation; this homogeneity presumably works in favour of shared mental representations. Thus, future studies using more diverse samples might find an even worse fit of the categorisations analysed here.

Similarity indices are biassed to indicate lower similarity in categories with a higher number of posited behaviours because consistency is harder to achieve in categories comprising many behaviours, as the pairwise binaries may level each other out and may converge to a within-respondent average of 0.5. This bias could, for instance, explain why in the Domain categorisation the waste category (two behaviours, $M = 0.89$) scores a higher similarity index than the energy use and consumption category (11 behaviours, $M = 0.40$). Thus, future studies could be advised to compare categories comprising an equal number of behaviours.

Another limitation to be noted is that the assignment of behaviours to categories in each of the Domain, Location, Impact, Difficulty, and Frequency categorisations is not clear-cut. All five categorisations involve some ambiguities in the posited assignment of behaviours to categories. In Domain, energy use and consumption is an umbrella category comprising highly diverse behaviours. In Location, buying clothes and electronic devices (behaviours 13 and 14) are assigned to the online location because these two product segments have the largest share in Austrian online commerce (Handelsverband, 2022), presumably even more so among the young adult population studied here; however, clothes and electronic devices may also be bought outdoors in brick-and-mortar stores. In Location, avoiding plastic (behaviour 8) starts indoor at home when packing refillable containers but is realised outdoor when buying unpackaged food. Location could alternatively use places such as home, job/school, or free time activities as categories. In Impact, the shares of behaviours in the carbon footprint show substantial interpersonal variation, and donating (behaviour 21) may have a direct impact when buying carbon emission certificates. In Difficulty, engagement probabilities vary considerably between the Swiss, Dutch, and German estimates produced by Kaiser and colleagues, and their attitude distributions might be outdated since they were calculated in the 2000s. In Frequency, some behaviours have cross-loadings on other factors (e.g., behaviour 15, eating meat). Error from these ambiguities might reduce the statistical fit of posited categorisations. Future studies could attempt to clarify these ambiguities in an exploratory pre-study; or could systematically vary and compare to which category the respective behaviours are assigned, which however brings the risk of overfitting to the data and shifting from the confirmatory to a more exploratory approach.

Finally, due to constraints in survey administration, the respondents were not asked to name the groups of behaviours they formed in the card sorting task. Naming groups is common practice in exploratory sorting studies (e.g., Gabe-Thomas et al., 2016). Future research should elicit the subjective meanings of the categories formed by respondents and could check to which extent the group names mirror the names of posited categories.

Still, the present paper introduces three analytical approaches for confirmatory testing of posited categorisations against observed similarity patterns: co-occurrence matrix, edit distance, and similarity index. After valuable exploratory studies in recent years (Gabe-Thomas et al., 2016; Doran et al., 2018; Kneebone et al., 2018), these approaches may help in consolidating research–not just on the mental representations of climate-relevant behaviours, but also on cognitive biases and misleading beliefs among climate sceptics (Zhao and Luo, 2021), or potentially for any card sorting data.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

## Author contributions

SS and HE: methodology and writing—review and editing. Both authors contributed to the article and approved the submitted version.

## Funding

This research received financial support from the Austrian Climate and Energy Fund and was carried out within the Austrian Climate Research Programme (funding no. B960259).

## Conflict of interest

SS and HE were employed by Joanneum Research Forschungsgesellschaft mbH.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1117452/full#supplementary-material

## References

Baird, J., and Brier, J. (1981). Perceptual awareness of energy requirements of familiar objects. *J. Appl. Psychol.* 66, 90–96. doi: 10.1037/0021-9010.66.1.90

Bamberg, S., and Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera. A new meta-analysis of psycho-social determinants of pro-environmental behavior. *J. Environ. Psychol.* 27, 14–25. doi: 10.1016/j.jenvp.2006.12.002

Barr, S., Gilg, A., and Ford, N. (2005). The household energy gap: Examining the divide between habitual-and purchase-related conservation behaviours. *Energy Policy* 33, 1425–1444. doi: 10.1016/j.enpol.2003.12.016

Bartiaux, B. (2008). Does environmental information overcome practice compartmentalisation and change consumers' behaviours? *J. Clean. Prod.* 16, 1170–1180. doi: 10.1016/j.jclepro.2007.08.013

Bernard, R., Ryan, G., and Borgatti, S. (2009). "Green cognition and behavior: A cultural domain analysis," in *Networks, resources and economic action*, eds C. Greiner and W. Kokot (Berlin: Dietrich Reimer Verlag).

Bird, N., Schwarzinger, S., Kortschak, D., Strohmaier, M., and Lettmayer, G. (2019). *A detailed methodology for the calculation of cumulative energy demand per survey respondent*. Available online at: https://echoes-project.eu/sites/echoes.drupal.pulsartecnalia.com/files/documents/ECHOES-D5.1_Energy_evaluation_methodology_191015_final.pdf (accessed January 31, 2023).

Blanken, I., van den Ven, N., and Zeetenberg, M. (2015). A meta-analytic review of moral licensing. *Pers. Soc. Psychol. Bull.* 41, 540–558. doi: 10.1177/0146167215572134

Boehm, S., Jeffery, L., Levin, K., Hecke, J., Schumer, C., Fyson, C., et al. (2022). *State of climate action 2022*. Washington, DC: World Resources Institute. doi: 10.46830/wrirpt.22.00028

Boudet, H., Flora, J., and Armel, K. (2016). Clustering household energy-saving behaviours by behavioural attribute. *Energy Policy* 92, 444–454. doi: 10.1016/j.enpol.2016.02.033

Darby, S. (2006). *The effectiveness of feedback on energy consumption. A review for DEFRA of the literature on metering, billing and direct displays*. Oxford: Environmental Change Institute, University of Oxford.

DEFRA (2008). *A framework for pro-environmental behaviours*. London: Department for Environment, Food and Rural Affairs.

Doran, R., Böhm, G., and Hanss, D. (2018). Using card sorting to explore the mental representation of energy transition pathways among laypeople. *Front. Psychol.* 9:2322. doi: 10.3389/fpsyg.2018.02322

European Commission, (2019). *Clean energy for all Europeans*. Brussels: European Commission. doi: 10.2833/9937

Frick, J., Kaiser, F. G., and Wilson, M. (2004). Environmental knowledge and conservation behavior: Exploring prevalence and structure in a representative sample. *Pers. Individ. Dif.* 37, 1597–1613. doi: 10.1016/j.paid.2004.02.015

Gabe-Thomas, E., Walker, I., Verplanken, B., and Shaddick, G. (2016). Householders' mental models of domestic energy consumption: Using a sort-and-cluster method to identify shared concepts of appliance similarity. *PLoS One* 11:e0158949. doi: 10.1371/journal.pone.0158949

Gardner, G., and Stern, P. (2008). The short list: The most effective actions US households can take to curb climate change. *Environ. Sci. Policy Sustain. Dev.* 50, 12–25. doi: 10.3200/ENVT.50.5.12-25

Handelsverband (2022). *eCommerce studie österreich–konsumentenverhalten im Distanzhandel*. Available online at: https://www.handelsverband.at/publikationen/studien/ecommerce-studie-oesterreich/ (accessed January 31, 2023).

Haustein, S., Klöckner, C., and Blöbaum, A. (2009). Car use of young adults: The role of travel socialization. *Transp. Res. Part F* 12, 168-178. doi: 10.1016/j.trf.2008.10.003

Höchli, B., Brügger, A., Abegglen, R., and Messner, C. (2019). Using a goal theoretical perspective to reduce negative and promote positive spillover after a bike-to-work campaign. *Front. Psychol.* 10:433. doi: 10.3389/fpsyg.2019.00433

International Energy Agency (2022). *Energy efficiency 2022*. Available online at: https://www.iea.org/reports/energy-efficiency-2022 (accessed January 31, 2023).

Kaiser, F., and Schultz, W. (2009). The attitude–behavior relationship: A test of three models of the moderating role of behavioral difficulty. *J. Appl. Soc. Psychol.* 39, 186–207. doi: 10.1111/j.1559-1816.2008.00435.x

Kaiser, F., and Wilson, M. (2004). Goal-directed conservation behavior: The specific composition of a general performance. *Pers. Individ. Dif.* 36, 1531–1544. doi: 10.1016/j.paid.2003.06.003

Kaiser, F., Byrka, K., and Hartig, T. (2010). Reviving Campbell's paradigm for attitude research. *Pers. Soc. Psychol. Rev.* 14, 351–367. doi: 10.1177/1088868310366452

Kaiser, F., Midden, C., and Cervinka, R. (2008). Evidence for a data-based environmental policy: Induction of a behavior-based decision support System. *Appl. Psychol. Int. Rev.* 57, 151–172. doi: 10.1111/j.1464-0597.2007.00291.x

Kaiser, F., Oerke, B., and Bogner, F. (2007). Behavior-based environmental attitude: Development of an instrument for adolescents. *J. Environ. Psychol.* 27, 242–251. doi: 10.1016/j.jenvp.2007.06.004

Karlin, B., Davis, N., Sanguinetti, A., Gamble, K., Kirkby, D., and Tokols, D. (2014). Dimensions of conservation: Exploring differences among energy behaviors. *Environ. Behav.* 46, 423–452. doi: 10.1177/0013916512467532

Keith, R., Given, L., Martin, J., and Hochuli, D. (2021). Urban children's connections to nature and environmental behaviors differ with age and gender. *PLoS One* 16:e0255421. doi: 10.1371/journal.pone.0255421

Klöckner, C., and Matthies, E. (2012). Two pieces of the same puzzle? Script-based car choice habits between the influence of socialization and past behavior. *J. Appl. Soc. Psychol.* 42, 793-821. doi: 10.1111/j.1559-1816.2011.00817.x

Kneebone, S., Fielding, K., and Smith, L. (2018). It's what you do and where you do it: Perceived similarity in household water saving behaviours. *J. Environ. Psychol.* 55, 1–10. doi: 10.1016/j.jenvp.2017.10.007

Krettenauer, T. (2017). Pro-environmental behavior and adolescent moral development. *J. Res. Adolesc.* 27, 581–593. doi: 10.1111/jora.12300

Loken, B. (2006). Consumer psychology: Categorization, inferences, affect, and persuasion. *Annu. Rev. Psychol.* 57, 453–485. doi: 10.1146/annurev.psych.57.102904.190136

Maki, A., Carrico, A., Raimi, K., Truelove, H., Araujo, B., and Yeung, K. (2019). Meta-analysis of pro-environmental behavior spillover. *Nat. Sustain.* 2, 307–315. doi: 10.1038/s41893-019-0263-9

Margetts, E., and Kashima, Y. (2017). Spillover between pro-environmental behaviours: The role of resources and perceived similarity. *J. Environ. Psychol.* 49, 30–42. doi: 10.1016/j.jenvp.2016.07.005

Nash, N., Whitmarsh, L., Capstick, S., Hargreaves, T., Poortinga, W., Thomas, G., et al. (2017). Climate-relevant behavioral spillover and the potential contribution of social practice theory. *Wiley Interdiscip. Rev. Clim. Change* 8:e481. doi: 10.1002/wcc.481

Nilsson, A., Bergquist, M., and Schultz, W. (2017). Spillover effects in environmental behaviors, across time and context: A review and research agenda. *Environ. Educ. Res.* 23, 573–589. doi: 10.1080/13504622.2016.1250148

Olsson, D., and Gericke, N. (2016). The adolescent dip in students' sustainability consciousness—Implications for education for sustainable development. *J. Environ. Educ.* 47, 35-51. doi: 10.1080/00958964.2015.1075464

Seebauer, S. (2018). The psychology of rebound effects: Explaining energy efficiency rebound behaviors with electric vehicles and building insulation in Austria. *Energy Res. Soc. Sci.* 46, 311–320. doi: 10.1016/j.erss.2018.08.006

Staats, H., Harland, P., and Wilke, H. (2004). Effecting durable change: A team approach to improve environmental behaviour in the household. *Environ. Behav.* 36, 341–367. doi: 10.1177/0013916503260

Steg, L., and Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *J. Environ. Psychol.* 29, 309–317. doi: 10.1016/j.jenvp.2008.10.004

Steinhorst, J., Klöckner, C., and Matthies, E. (2015). Saving electricity–For the money or the environment? Risks of limiting pro-environmental spillover when using monetary framing. *J. Environ. Psychol.* 43, 125–135. doi: 10.1016/j.jenvp.2015.05.012

Stern, P. (2000). Psychology and the science of human-environment interactions. *Am. Psychol.* 55, 523–530.

Thogersen, J. (2004). A cognitive dissonance interpretation of consistencies and inconsistencies in environmentally responsible behaviour. *J. Environ. Psychol.* 24, 93–103. doi: 10.1016/S0272-4944(03)00039-2

Thogersen, J., and Crompton, T. (2009). Simple and painless? The limitations of spillover in environmental campaigning. *J. Consum. Policy* 32, 141–163.

Truelove, H., and Gillis, A. (2018). Perception of pro-environmental behavior. *Glob. Environ. Change* 49, 175–185. doi: 10.1016/j.gloenvcha.2018.02.009

Truelove, H., Carrico, A., Weber, E., Raimi, K., and Vandenbergh, M. (2014). Positive and negative spillover of pro-environmental behavior: An integrative review and theoretical framework. *Glob. Environ. Change* 29, 127–138. doi: 10.1016/j.gloenvcha.2014.09.004

UNESCO, (2017). *Education for sustainable development goals: Learning objectives*. Available online at: https://www.unesco.de/sites/default/files/2018-08/unesco_education_for_sustainable_development_goals.pdf (accessed January 31, 2023).

Wang, Y., Hao, F., and Liu, Y. (2021). Pro-environmental behavior in an aging world: Evidence from 31 countries. *Int. J. Environ. Res. Public Health* 18:1748. doi: 10.3390/ijerph18041748

Zhao, J., and Luo, Y. (2021). A framework to address cognitive biases of climate change. *Neuron* 109, 3548-3551. doi: 10.1016/j.neuron.2021.08.029

# Frontiers in Psychology

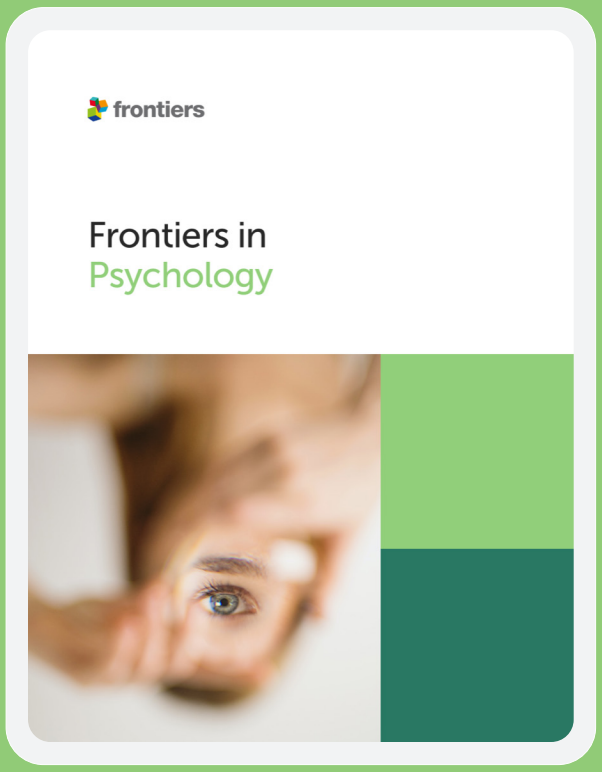
**Paving the way for a greater understanding of human behavior**

The most cited journal in its field, exploring psychological sciences - from clinical research to cognitive science, from imaging studies to human factors, and from animal cognition to social psychology.

---

## Discover the latest Research Topics

See more →




**Frontiers**

Avenue du Tribunal-Fédéral 34
1005 Lausanne, Switzerland
frontiersin.org

**Contact us**

+41 (0)21 510 17 00
frontiersin.org/about/contact