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Executive Summary

Behavioral economics combines psychological insights with economic decision-making to understand why people behave as they do and how to steer human behavior in desired directions. Specifically, the use of laboratory or field experiments allows behavioral economists to identify causal relationships between an experimental manipulation by a researcher and certain human behavior. Explaining human behavior can be one of the most exciting tasks for a behavioral scientist, and at the same time, it can be like squeezing water from a stone. For example, there are people who collect yogurt cup lids all year or recycle their tea bags in three different ways to protect the planet but still fly to Bali once a year. Among other things, it is mainly the lack of understanding of the consequences of human behavior on the environment, which has severe and detrimental effects on the world's climate, causing ecological, economic, and social crises. A new field of research — behavioral environmental economics — applies theories of behavioral economics to environmental issues to explain puzzles of individual behavior regarding the environment. This thesis is a collection of four essays that contribute to the nascent field of behavioral environmental economics. Essays 1 and 2 address the need for simple measurements to capture people's belief in climate change and pro-environmental behavior. Essays 3 and 4 are about how to understand and promote pro-environmental behavior.

In essay 1, we address the need to assess people's belief in climate change with one item. Thus, our developed single item aims to provide researchers with a brief but psychometrically valid instrument for assessing belief in climate change. This is helpful when researchers conduct more extensive surveys and including multiple-item assessments is too costly or unfeasible. We consider three critical aspects of climate change in the single item, namely, the occurrence of climate change, that climate change is detrimental, and that climate change is caused by humans. In highly powered samples, we find that our single item is correlated with established constructs measuring belief in climate change. Moreover, the convergent, predictive, and discriminant validity of our single item supports the validity and usage of our single item.

In essay 2, we validate the Tree Task, an incentivized task that measures pro-environmental behavior in laboratory or field experiments. Short, vivid, and easy to explain, the Tree Task enriches existing tasks that measure pro-environmental behavior. In the Tree Task,

participants have to weigh immediate financial rewards for themselves and long-term benefits for the environment. In other words, participants receive money that they can keep for themselves, or they can plant trees to mitigate climate change. As expected, we find in the experiment that higher costs per tree lead to fewer trees planted and that trees with a higher carbon dioxide offset are planted more frequently. In addition, we demonstrate that the number of trees planted correlates with established self-reports capturing environmental attitudes and intentions, belief in climate change, and values in line with pro-environmental behavior. Therefore, we recommend the use of the Tree Task as a valid measure for assessing pro-environmental behavior.

In essay 3, we experimentally investigate how priming on future events unrelated to an environmental context influences individual pro-environmental behavior. We use the Tree Task as the primary outcome variable to measure pro-environmental behavior. In the Tree Task, people choose between keeping money for themselves or investing money in planting trees and thus mitigating climate change. As a secondary outcome variable, we assess self-reported pro-environmental intentions. The results show that people who are primed on positive and negative future events statistically significantly plant more trees and show higher pro-environmental intentions than people primed on leisure activities in the control group. The difference in the trees planted between positive and negative future event priming is statistically insignificant. Exploring different potential mechanisms behind our results, we find that both future primes activated greater concern for the future and the environment, whereas the leisure prime triggered present concerns. While these results align with our research question, we cannot rule out that the leisure priming may have activated other concerns, unrelated to the present or future, potentially leading to fewer trees planted.

In essay 4, we explore how gain and loss framing can promote voluntary pro-environmental behavior. Building on loss aversion, a core concept in behavioral economics, we assume that people work more under a loss frame than under a gain frame. In the experiment, people can choose to work on a real effort task and generate donations for a reforestation organization to mitigate climate change or refuse to work and advance to the next task. In the gain frame, with every completed task, the researchers sequentially increase the donation amount. In the loss frame, with every incomplete task, the total donation amount is reduced. Both gain and loss framing are economically equivalent. The results reveal that people in the loss treatment solve more tasks. However, the treatment effect is weak and marginally statistically significant. Interestingly, the effect of the loss frame increases and is statistically significant when controlling for people with low intrinsic motivation to protect the environment. This finding opens a novel avenue for future researchers to tailor gain and loss framing according to people's environmental values.

Essay 1: Measuring belief in climate change with a single-item

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Abstract

Brief, but psychometrically valid assessments of psychological constructs are increasingly needed to be included in larger psychological and other social scientific studies, such as Many Labs projects or representative surveys. Here, we provide a novel one-item measure of individual differences in belief in climate change. Based on two studies (N = 913, N = 288) recruited from various global regions, we establish convergent, predictive, and discriminant validity. More specifically, we find that the single-item measure correlates with other constructs measuring belief in climate change and with relevant downstream constructs, among them intentions to engage in pro-environmental behavior, actual consequential behavior, and self-reported everyday behaviors. We therefore conclude that the single item is a suitable instrument to measure belief in climate change when multiple-item assessments are either too costly or otherwise unfeasible.

Keywords: single-item, climate change, measurement, pro-environmental intention, pro-environmental behavior

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1.1 Introduction

One of society's most pressing social, cultural, and political challenges is the mitigation of anthropogenic climate change (Creutzig et al., 2022). Although governmental policies play an important role at the systemic level, research is clear about the importance of understanding individual attitudes and behavior in combatting climate change (De Keersmaecker et al., 2022, Nielsen et al., 2021). Individual behavior contributes strongly to climate change (Dietz et al., 2009), including consumption choices, investment choices, civic behavior, or organizational citizenship. This manifests in daily transport decisions, how people heat their homes, global food consumption, as well as decisions about whom and what policies to vote for.

As the most recent report from the *American Psychological Association* highlights, this makes individual pro-environmental behavior a crucial research interest for psychologists (American Psychological Association, 2022). A meta-analysis has revealed that an important variable associated with pro-environmental attitudes, intentions, and behavior is belief in climate change (Hornsey et al., 2016). People vary in the degree to which they believe that climate change is real, detrimental, and human-caused. In consequence, this belief manifests in downstream variables such as pro-environmental behavior and policy support (Berger and Wyss, 2021a, Leiserowitz et al., 2021, Poortinga et al., 2019, van der Linden et al., 2019).

In the present research, we examine whether belief in climate change as a source of individual differences can be measured with a novel single item. Psychometrically, multiple indicators are typically more reliable as they provide greater coverage of the conceptual domain and increased measurement precision (Gardner et al., 1998, van der Linden and Rosenthal, 2016). Furthermore, the "signal" to "noise" ratio typically increases with more indicators of a latent construct (Nunnally, 1978). Nevertheless, the traditional view that the reliability of single-item measures is often inferior to that of multi-item measures has been repeatedly challenged (Bergkvist, 2015, Bowling, 2005, Wanous and Reichers, 1996). Single-item measures have successfully been implemented across a variety of contexts, among them self-esteem (Robins et al., 2001), happiness (Abdel-Khalek, 2006), narcissism (van der Linden and Rosenthal, 2016), risk attitudes (Dohmen et al., 2011), social identification (Postmes et al., 2013), and subjective well-being (Diener et al., 1985).

Despite the putative downsides, there are also significant benefits to a single-item measure of belief in climate change. Generally speaking, single-item measures are less costly, less time-consuming, and they reduce item redundancy and cognitive fatigue among participants (Allen et al., 2022, Bowling, 2005, Bergkvist, 2015, Postmes et al., 2013). In the domain of social scientific research about climate change — a highly interdisciplinary

research field often relying on global assessments of public opinion and attitudes — these benefits are arguably of even greater relevance. There are many different research fields investigating a large variety of pro-environmental behaviors, including food choices (Camilleri et al., 2019), travel choices (Whitmarsh et al., 2020), or the abstract willingness to trade-off personal benefits against environmental consequences (Berger and Wyss, 2021b, Lange and Dewitte, 2021). This research frequently tries to capture whether or not a research participant accepts anthropogenic climate change to be real. As this research routinely requires validated and brief measurement instruments — for example when belief in climate change is not the primary research interest — we sought to develop an additional single-item measurement for use both within and outside psychological research. Our research thereby complements existing single-item measures (van Valkengoed et al., 2021), such as the single-item measure of the Six Americas measure (Swim and Geiger, 2017), or shorter measures such as the Six America Short SurveY (SASSY) scale (Chryst et al., 2018). As a critical complement, the present research provides either a shorter measurement (i.e., in comparison to the SASSY scale), or a non-nominal scale (i.e., in comparison to the single-item Six Americas measure, where participants self-categorize in one of six categories). We test our single item in two separate studies.

1.2 Study 1

Study 1 examined to what extent a single-item measure can be used to capture people's individual differences in belief in climate change. We designed a highly powered and pre-registered study, recruiting a geographically diverse sample of adults. The single item addresses three dimensions of climate change that are typically examined with separate items (e.g., Poortinga et al. 2019). First, people are asked if they believe that climate change occurs. This dimension taps into the physical science basis. Second, people are asked about the consequences of climate change being largely negative for human societies. This dimension taps into the impact assessment of climate change. Third, people are asked about climate change being anthropogenic, meaning caused by human activities rather than other natural processes. We provide a test into the degree to which these three dimensions can be reduced to a single-item measure of belief in anthropogenic climate change (abbreviated SIBCC hereafter).

To do so, we assess its correlation with an established measure of belief in climate change (Poortinga et al., 2019) and with related constructs tapping into pro-environmental concern, intentions, and behaviors. More specifically, we measure the revised New-Environmental Paradigm (NEP-R) (Dunlap et al., 2000), environmental values via the Environmental Schwartz Value Survey (E-SVS) (Bouman et al., 2018), and pro-environmental intentions (Fujii, 2006, Mancha and Yoder, 2015), the Carbon Emission

Task Berger and Wyss (2021b), and a version of the General Ecological Behavior (GEB) scale (Kaiser and Wilson, 2004). As indicators of convergent, predictive, and discriminant validity, we expect that our single-item measure positively correlates with a multiple-item measure of belief in climate changes, and with the measures of attitude, intentions, and behavior. The study was pre-registered on the Open Science Framework[1] and received approval from the local ethics committee at the University of Bern (approval number: 142021).

1.2.1 Participants and sample size

As per our pre-registration, we attempted to recruit a total of 1,000 participants, equally divided between Amazon Mechanical Turk (mTurk) and Prolific. The large sample was decided based on budgetary constraints while exceeding the sample size at which correlations typically stabilize (i.e., $n = 250$; Schönbrodt and Perugini 2013). They strongly exceeded the required sample sizes used in similar studies that were based on a-priori power analyses (e.g., Lange and Dewitte 2021). Participants were invited to complete a decision-making study and were paid a flat compensation (mTurk: USD 1.15; Prolific: GBP 1.15), plus a potential behavior-dependent bonus of USD 1 (GPD 1) resulting from the behavioral task. As some participants responded to the questionnaire without logging their final completion code, more than 1,000 participants completed the study. Overall, we collected 1,169 responses. Following the pre-registered data inclusion protocol, we removed participants who did not finish the study within 60 minutes of starting it or failed crucial attention or comprehension checks. In addition and in line with the pre-registration, we excluded all participants who completed less than 70% of the decisions in the Carbon Emission Task. The final sample consisted of 913 valid responses (mTurk: $n = 444$; Prolific: $n = 469$). Table 1.1 displays demographic statistics of both sub-samples (see Table 1.7 in the Appendix A for detailed sample characteristics).

[1] See pre-registration on OSF.

TABLE 1.1: Sample characteristics of Prolific and Amazon Mechanical Turk (mTurk) sample

Samples	Prolific (n = 469)	mTurk (n = 444)	p-value*	Full sample (N = 913)
Gender (% female)	39	38	.711	38
Age	27.10 (SD = 8.95)	35.51 (SD = 10.13)	.000	31.21 (SD = 10.43)
Political ideology (% liberal)	58	51	.026	55
Education (% university degree)	53	88	.000	70
Low income (% less than $50,000)	78	45	.000	61
Racial identification (% White or Caucasian)	81	60	.000	70

Notes: In terms of political ideology, all participants who indicated to be "very liberal" to "somewhat liberal" are merged and labeled "liberal". *p-values are calculated based on a Wilcoxon-Mann-Whitney test.

1.2.2 Procedure and measures

All study materials were administered in English, and participants were recruited conditional on being fluent in English.[2] Participation was enabled on either a tablet or personal computer. After providing informed consent, participants first completed the Carbon Emission Task as a behavioral measure of pro-environmental behavior, followed by various self-assessments. These variables were assessed to allow for tests of convergent, predictive, and discriminant validity. All tests for convergent and predictive validity were pre-registered. Tests for discriminant validity (i.e., correlation with demographic variables) are exploratory.

1.2.2.1 Single-item measure of belief in climate change (SIBCC)

To measure belief in climate change with a single item, we combined the typical three dimensions of belief in climate change (i.e., its existence, detrimental nature, and anthropogenic origin) into one single item. It is formulated as follows: "*To what extent do you agree with this statement: The occurrence of climate change is caused by human activities and will bring largely negative consequences.*" Participants indicated their answer on a 11-point Likert-scale ranging from -5 (*strongly disagree*) to +5 (*strongly agree*). We opted for an 11-point scale for various reasons. First, research suggests that there is no major difference in internal structure in terms of means, standard deviations, item–item correlations, item–total correlations, Cronbach's alpha, or factor loadings

[2]See in the Appendix B for the experimental material.

depending on the number scale points (Leung et al., 2011). Second, findings indicate that having more scale points seems to reduce skewness (Leung et al., 2011). Third, large household surveys include many items that rely on 11-point scales, among them the Swiss Household Panel, the German Socio-Economic Panel, or the World Value Survey (Scherpenzeel, 2002). Finally, a well-known existing climate attitudes scale also relies on 11 points, measuring belief in climate change ranging from -5 to 5 (Poortinga et al., 2019). The average agreement that climate change is caused by humans is skewed towards positive values (M = 3.45, SD = 1.85, see Figure 1.1 in the Appendix A for the entire distribution).

1.2.2.2 Belief in climate change

To provide a multi-item assessment of climate change belief, we adopted the measure from Poortinga et al. (2019). First, we measured *Trend skepticism* by asking participants the following question: "*You may have heard the idea that the world's climate is changing due to increases in temperature over the past 100 years. What is your personal opinion on this? Do you think the world's climate is changing?*" Answer options ranged on a 4-point Likert-scale ranging from 1 (*definitely not changing*) to 4 (*definitely changing*). Following Poortinga et al. (2019), we dichotomized data to climate change believers (n = 839, 91.89%) coded as 1 (*probably/definitely changing*) and climate change deniers (n = 74, 8.11%) as 0 (*probably/definitely not changing*). Second, we assessed *Attribution skepticism* with the following item: "*Do you think that climate change is caused by natural processes, human activity, or both?*" Likewise, we dichotomized answer options to 0 (*entirely by natural processes, mainly by natural processes*, n = 139, 15.22%) or 1 (*entirely by human activity, mainly by human activity, about equally by natural processes and human activity*, n = 771, 84.45%). We followed Poortinga et al. (2019) and coded participants (n = 3, 0.33%) who did not think that climate change is happening as missing values to avoid overlapping with *Trend skepticism*. Third, participants were asked to assess the impact of climate change on people across the world, using a scale ranging from -5 (*extremely bad*) to +5 (*extremely good*) (M = -1.72, SD = 3.20).

1.2.2.3 Environmental concern

To measure participants' views about the relationship between humans and nature, we assessed the NEP-R scale by Dunlap et al. (2000). The NEP-R scale consists of 15 items and is an established construct in the environmental social sciences and frequently used in studies about pro-environmental behavior (e.g., Berger and Wyss 2021a, Hawcroft and Milfont 2010, Lange and Dewitte 2021, van Valkengoed et al. 2021). Agreement with the

items is measured from 1 (*strongly disagree*) to 5 (*strongly agree*) ($\alpha = .80$, $M = 3.54$, $SD = 0.60$). For our analysis, we followed Cruz and Manata (2020) and calculated a three-factor solution with the factors limits to growth ($\alpha = .59$, $M = 3.69$, $SD = 0.93$), anti-anthropocentrism ($\alpha = .83$, $M = 3.21$, $SD = 0.99$), and concern about ecological damage ($\alpha = .69$, $M = 4.13$, $SD = 0.66$).

1.2.2.4 Biospheric values (E-SVS)

For the assessment of participants' value orientation, we included the Social Value Scale (Steg et al., 2014), an established self-report measure frequently used in pro-environmental behavior research (e.g., Lange and Dewitte 2021). Participants responded on a 9-point Likert-scale between ranging from -1 (*opposed to my guiding principles*) to 7 (*supreme importance*) regarding biospheric (four items, $\alpha = .90$, $M = 5.30$, $SD = 1.34$), altruistic (four items, $\alpha = .78$, $M = 5.43$, $SD = 1.22$), and egoistic values (five items, $\alpha = .79$, $M = 3.72$, $SD = 1.56$).

1.2.2.5 Pro-environmental behavioral intention

Participants' intention to behave pro-environmentally was elicited with three items adopted from Mancha and Yoder (2015) ($\alpha = .87$). Participants responded on a 7-point Likert-scale from 1 (*extremely unlikely*) to 7 (*to extremely likely*). The items tap into participants' behavioral intention with respect to the reduction of one's carbon footprint ($M = 5.03$, $SD = 1.47$), general environmentally friendly behavior ($M = 5.22$, $SD = 1.46$) and the wasting of natural resources ($M = 5.21$, $SD = 1.46$). Moving beyond the pre-registered measures, we also assessed behavioral intentions using four items adopted from Fujii (2006) to increase the number of intention measures. These data are available on the Open Science Framework project page for interested researchers. The items ($\alpha = .79$) tap into behavioral intentions concerning electricity use reduction ($M = 5.77$, $SD = 1.37$), gas use reduction ($M = 5.02$, $SD = 1.67$), garbage reduction ($M = 5.10$, $SD = 1.56$), and car use reduction ($M = 4.95$, $SD = 1.76$).

1.2.2.6 Behavioral assessment of pro-environmental behavior

To measure actual pro-environmental behavior, we relied on a validated experimental protocol coined the Carbon Emission Task (Berger and Wyss, 2021b). Participants face repeated dichotomous trade-offs between two options. *Option A* is financially rewarding, but paired with a real carbon emission. *Option B* is financially non-rewarding, but carbon-neutral. Trade-offs vary in both the financial consequence (i.e., 0.2, 0.4, 0.6, 0.8,

or 1 GBP/USD) and the associated carbon emissions (i.e., 0, 0.23, 1.02, 4.46, 19.85 lbs. CO_2) and are fully crossed. Carbon emissions are generated through the behavior-dependent purchasing and retirement of emission right certificates from the *EU-Emission Trading Scheme*. Attaching actual consequences to behavioral tasks is an increasingly used experimental protocol to study consequential pro-environmental behavior under laboratory-like conditions (see Lange 2022 for a review). In the Carbon Emission Task, all decisions made by participants have real consequences for the environment, as certificates are truly bought, and the environmental consequence is realized depending on participants' decisions. For the purpose of the present study, the pre-registered variable of interest is the proportion of pro-environmental choices made across the 25 trials ($M = 0.50$, $SD = 0.29$).

1.2.2.6 Self-assessment of pro-environmental behavior

To assess people's self-reported pro-environmental behavior, we administered a 31-item version of the General Ecological Behavior scale (Arnold et al., 2018). Participants indicated on a 5-point Likert-scale from 1 to 5 (*never* to *always*) how frequently they engage in pro-environmental behaviors (e.g., "I bring empty bottles to a recycling bin."). In case participants were unable to answer, they were asked to tick not applicable. Following established GEB practices, we dichotomized the 31-items to 0 (*never, sometimes, occasionally*) and 1 (*very often, often*). Similar to (Lange and Dewitte, 2021), we calculate a Rasch Model (eRm package by Mair et al. 2020) in R 4.0.2 (R Core Team, 2020) and estimated person parameters ($M = 0.44$, $SD = 0.16$) with reasonable separation reliability (rel. = .71).[3] This person parameter can be viewed as a person's overall environmental attitude (Kaiser et al., 1999).

1.2.3 Results

In order to present the results of the newly established one-item measure, we tested convergent, predictive, and discriminant validity.[4] First, *convergent validity* was assessed by correlating the one-item measure with the related constructs. These were trend skepticism ($r = .28$, 95% CI [0.22, 0.34], $p < .001$), attribution skepticism ($r = .28$, 95% CI [0.24, 0.36], $p < .001$), perceived impact of climate change ($r = -.23$, 95% CI [-0.29, -0.17], $p < .001$), the three factors of the New-Environmental Paradigm, limits to growth ($r = .33$, 95% CI [0.27, 0.39], $p < .001$), anti-anthropocentrism ($r = .32$, 95% CI [0.27,

[3]The Rasch separation reliability can be interpreted in a similar manner as Cronbach's alpha in traditional self-report scales.

[4]All materials, data, and code to replicate the statistical analyses are available on the Open Science Framework.

0.38], $p < .001$), and concern about ecological damage ($r = .50$, 95% CI [0.45, 0.55], $p < .001$), as well as egoistic ($r = -.03$, 95% CI [-0.09, 0.03], $p < .441$), altruistic ($r = .38$, 95% CI [0.32, 0.43], $p < .001$) and biospheric ($r = .38$, 95% CI [0.32, 0.43], $p < .001$) values. Table 1.2 displays all correlational results.[5] The correlations were all significant and in the expected direction. To conclude, the more people evaluated climate change as real, human caused, and having negative consequence, as well as the more they endorsed the three factors of the NEP-R, the higher they report agreement with the single item measure. We therefore conclude that the convergent validity of the scale was good.

Second, *predictive validity* was assessed through the assessment of correlations with downstream variables — intentions to behave pro-environmentally (Mancha and Yoder, 2015), actual behavior in consequential experimental paradigms (Berger and Wyss, 2021b), as well as self-reported pro-environmental behaviors (Arnold et al., 2018). These correlations all showed significant results in the predicted direction. Endorsement of the one-item measure correlated with intentions to behavior pro-environmentally ($r = .31$, 95% CI [0.25, 0.37], $p < .001$), with average pro-environmental behavior in the 25 trials of the Carbon Emission Task ($r = .21$, 95% CI [0.15, 0.27], $p < .001$), as well as with self-reported pro-environmental behaviors ($r = .29$, 95% CI [0.23, 0.35], $p < .001$).[6]

In addition, we tested if the SIBCC measure continues to predict the outcome variables (i.e., intentions and behaviors) after controlling for demographic variables (see Table 1.3). With respect to all three variables (i.e., abstract behavior, intentions, self-reported behaviors), SIBCC correlates with the dependent variables with or without controls.[7] To conclude, endorsement of the one-item measure correlated with all assessed downstream variables, resulting in good predictive validity of the novel measure.

[5] See Table 1.8 in the Appendix A for Spearman correlations.
[6] See Table 1.9 in the Appendix A for linear regression of SIBCC and other measures of belief in climate change on actual pro-environmental behavior (Carbon Emission Task).
[7] See Table 1.10 in the Appendix A for additional analyses of predictive validity including environmental concern and values.

Table 1.2: Descriptive statistics and Pearson correlations for study variables (N = 913)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	Mean	SD
1. SIBCC	—													3.45	1.85
Convergent validity															
2. Trend skepticism	.28***	—												0.92	0.27
3. Attribution skepticism	.28***	.33***	—											0.85	0.36
4. Perceived impact of CC	-.23***	-.32***	-.50***	—										-1.72	3.20
5. Limits to growth	.33***	.10**	.03	.00	—									3.69	0.93
6. Anti-anthropocentrism	.32***	.26***	.41***	-.66***	.12***	—								3.21	0.99
7. Ecological damage	.50***	.24***	.21***	-.32***	.45***	.37***	—							4.13	0.66
8. Egoistic values	-.03	-.09***	-.24***	.46***	.11***	-.58***	-.05	—						3.72	1.56
9. Altruistic values	.38***	.23***	.18***	-.27***	.24***	.24***	.51***	.12***	—					5.43	1.22
10. Biospheric values	.38***	.22***	.12***	-.21***	.29***	.21***	.55***	.19***	.72***	—				5.30	1.34
Predictive validity															
11. Green behavioral intentions	.31***	.09**	.01	.01	.28***	.01	.35***	.26***	.41***	.53***	—			5.04	1.47
12. Carbon Emission Task	.21***	.14***	.22***	-.36***	.00	.41***	.17***	-.23***	.25***	.25***	.21***	—		0.50	0.29
13. General Ecological Behavior	.29***	.05	.01	-.03	.22***	.09***	.31***	.10***	.32***	.41***	.48***	.25***	—	0.44	0.16

Notes: SIBCC = Single-Item Belief in Climate Change, CC = Climate Change. Limits to growth, Anti-anthropocentrism, Ecological damage are the three factors of the New Environmental Paradigm Scale-Revised. *$p < 0.05$. **$p < .01$. ***$p < .001$.

TABLE 1.3: Linear regression of SIBCC on CET behavior (Models 1 and 2), behavioral intentions (Models 3 and 4), and General Ecological Behavior (Models 5 and 6)

	(1)	(2)	(3)	(4)	(5)	(6)
SIBCC	0.06***	0.05***	0.46***	0.46***	0.05***	0.04***
	(0.01)	(0.01)	(0.05)	(0.05)	(0.01)	(0.01)
Gender		0.08***		0.42***		0.06***
		(0.02)		(0.09)		(0.01)
Age		0.04***		-0.02		0.01*
		(0.01)		(0.05)		(0.02)
Political ideology			-0.01		-0.02	0.00
			(0.01)		(0.05)	(0.01)
Education			-0.01		0.10**	0.01
			(0.01)		(0.05)	(0.01)
Low income			-0.05***		0.09*	0.00
			(0.01)		(0.05)	(0.01)
Intercept	0.50***	0.46***	5.04***	4.87***	0.44***	0.42***
	(0.01)	(0.01)	(0.05)	(0.06)	(0.01)	(0.01)
Observations	913	913	913	913	913	913
R-squared	0.05	0.12	0.10	0.13	0.08	0.12

Notes: The table presents estimates from ordinary least squares (OLS) regressions. All continuous predictors are mean centered and scaled by 1 standard deviation. Robust standard errors are shown in parentheses. Gender is dummy-coded (1 if female) as well as education (1 if at least university degree) and low income (1 if below GBP 50,000 annual income). *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

Third, to examine *discriminate validity*, we test whether our single-item measure differs across groups for which differences are theoretically expected (Hattie and Cooksey, 1984). Precisely, we follow van Valkengoed et al. (2021), who also show that women believe more in the occurrence and anthropogenic causes of climate change than men (McCright, 2010) and that conservative voters perceive the occurrence and detrimental impact of climate change as less strongly than liberal voters McCright and Dunlap (2011).

For the overall sample, we detect a significant difference ($U = 87810$, $p < .005$, Wilcoxon-Mann-Whitney test) of belief in climate change perceptions between women ($M = 3.61$, $SD = 1.86$, $n = 349$) and men ($M = 3.36$, $SD = 1.84$, $n = 564$).[8] However, post-hoc analyses showed that this effect may be driven through differences on the Prolific sample ($U = 22996$, $p < .022$, Wilcoxon-Mann-Whitney test) and to a lesser extent through differences on the mTurk sample ($U = 21047$, $p < .103$). Similar to previous literature (McCright and Dunlap, 2011, van Valkengoed et al., 2021), we found that climate change

[8] Five participants defined their gender non-binary, other, or did not disclose their gender. These individuals are excluded from this analysis.

perceptions significantly differ between liberals and conservatives ($U = 80997$, $p < .001$, Wilcoxon-Mann-Whitney test), such that liberals more strongly endorse the item that they belief in climate change.[9] This result emerges less robust in the Prolific sample ($U = 23746$, $p < .031$, Wilcoxon-Mann-Whitney test) compared to the mTurk sample ($U = 17291$, $p < .001$, Wilcoxon-Mann-Whitney test), suggesting a greater political divide in terms of endorsement of the item in the United States. To conclude, the single-item measure is weakly (Prolific) or moderately (mTurk) related to differences in gender and political ideology.

1.2.4 Discussion

Based on Study 1, the single item demonstrated initial validity. The single item is significantly correlated with established measures tapping into belief in climate change (*trend skepticism, attribution skepticism, impact assessment*), environmental concern, and biospheric as well as altruistic values. Similar to the meta-analysis study provided by Hornsey et al. (2016), correlations are larger for concern about climate change and smaller for intentions and behavior. The three-factor analysis of the NEP-R scale shows that the correlation between our single item and NEP-R is mainly driven by the items assessing ecological damage. Results revealed good predictive validity through correlations with downstream variables and pro-environmental behavior.

1.3 Study 2

Study 2 replicated and extended the results of Study 1. First, we replicated the effect between behavior in the Carbon Emission Task and the SIBCC item. In addition, Study 2 includes two additional constructs to assess belief in climate change, the Six America Short Survey (SASSY) scale (Chryst et al., 2018) and a single item of the Six Americas scale (Swim and Geiger, 2017). Thus, beyond validation work of the SIBCC, Study 2 is also a novel test into the degree to which the SASSY scale and the single-item Six Americas scale predict actual, consequential behavior in an experimental paradigm. The Carbon Emission Task was administered with a novel set of parameters (behavioral costs, carbon emissions). Lastly, we include a broader set of outcome measures, and also assessed political support and political activism. The study was pre-registered on the Open Science Framework[10] and received approval from the local ethics committee of the University of Bern (approval number: 182023).

[9] We excluded participants who reported that none of the given political views on a 7-point Likert scale describes them.

[10] See pre-registration on OSF.

1.3.1 Participants and sample size

We based our power analyses on a one-sided Pearson correlation analysis. To detect a correlation coefficient of at least $r = .20$ between SIBCC and pro-environmental behavior (5% alpha level, 95% power), we require a sample size of 266 participants (G*Power 3.1.9.4, Faul et al. 2009). Considering an attrition rate of 15%, we targeted to recruit 306 participants, which we rounded up to 320 participants. A UK sample of 320 respondents were invited via Prolific and 328 completed the survey. Exclusion of participants according to our pre-registered protocol (similar to Study 1) led to a final sample size of N = 288. Table 1.4 provides a description of the sample of Study 2 (see a detailed description of the sample Table 1.11 in the Appendix A).

TABLE 1.4: Sample characteristics of Prolific and Amazon Mechanical Turk (mTurk) sample

Samples	Prolific (N = 288)
Gender (% female)	50%
Age	39.36 ($SD = 11.64$)
Political ideology (% liberal)	54%
Education (% university degree)	69%
Low income (% less than $50,000)	61%

Notes: In terms of political ideology, all participants who indicated to be "very liberal" to "somewhat liberal" were merged and labeled "liberal".

1.3.2 Procedure and measures

Data was collected online via Prolific. After giving written consent, participants first completed the Carbon Emission Task before completing the SIBCC and the other self-report measures.[11] Participants received a flat fee of GBP 1.1, plus any decision-dependent bonus that followed from behavioral responses. It took participants a median of five minutes to complete the survey. We report here on additional scales and changes to the parameters in the Carbon Emission Task compared to Study 1.

1.3.2.1 SASSY scale

The Six America Short Survey (SASSY) scale is an established four-item measure by (Chryst et al., 2018) derived from the original Six Americas model with 36 questions.

[11] See in the Appendix B for the experimental material.

The four questions consider questions about the importance, personal worry and harm, and harm to future generations by global warming. Participants responded on a 5-point Likert-scale about the importance of global warming which we coded from 1 (*not at all important*) to 5 (*extremely important*) ($M = 3.52$, $SD = 0.92$). Individual worry about global warming was captured on a 4-point Likert-scale from 1 (*not at all worried*) to 4 (*very worried*) ($M = 3.05$, $SD = 0.78$). The question about personal harm from global warming ($M = 3.60$, $SD = 0.78$) and harm of future generation ($M = 4.54$, $SD = 0.73$) was measured on a 5-point Likert scale from 1 (*a great deal*) to 4 (*not at all*) including the opt-out answer of 5 (*don't know*) coded as NA ($n = 2$). In addition to the single items, we built a composite scale ($\alpha = .88$, $M = 3.67$, $SD = 0.70$).

1.3.2.2 Single-item of the Six Americas Scale

We included a self-categorizing single item (Swim and Geiger, 2017) that is also derived from the Six Americas model assessing concern on climate change to correlate our item with the different categories of the item. Hence, participants had to self-categorize themselves into one of six statements about climate change. The statements captured categories of being alarmed (38.89%), concerned (38.19%), cautious (13.89%), disengaged (5.21%), doubtful (2.08%) or dismissive (1.74%) about climate change.

1.3.2.3 Policy support and political activism

To measure participants' policy support and political activism, we relied on two questionnaires by Swim and Geiger (2017). First, participants responded to six different policies to what extend they support the policy on a 4-point Likert scale from 1 (*strongly oppose*) to 4 (*strongly support*) ($M = 3.42$, $SD = 0.57$). Second, on a 4-point Likert scale ranging from 1 (*never*) to 4 (*often*), participants reported how many times they have engaged in four different political actions in last 12 months ($M = 1.20$, $SD = 0.40$).

1.3.2.4 Carbon Emission Task

We included a variant of the Carbon Emission Task as described in Study 1, but altered the parameters. In Study 2, financial consequences ranged from GBP 0.2, 0.4, 0.6, 0.8 and GBP 1 and the associated retirement of carbon emissions varied from 0.5, 1, 2, 3 and 4.5 kg CO_2 in a fully-crossed design. The proportion of participants choosing the pro-environmental option was similar to Study 1 ($M = 0.52$, $SD = 0.34$).

1.3.3 Results

To re-assess validity, we correlated the single-item with the four questions of the SASSY scale, a continuous interpretation of the single item of the Six America Scale, policy support and political activism, as well as the Carbon Emission Task. In terms of convergent validity, results in Table 1.5 reveal statistically significant correlations coefficients in the expected direction. SIBCC correlates with the overall mean of the SASSY scale (r = .70, 95% CI [0.64, 0.75], $p < .001$), with importance of global warming (r = .60, 95% CI [0.52, 0.67], $p < .001$), with worry about global warming (r = .64, 95% CI [0.57, 0.70], $p < .001$), with individual harm by global warming (r = .49, 95% CI [0.40, 0.57], $p <$ .001), with the harm of global warming to future generations (r = .70, 95% CI [0.64, 0.75], $p < .001$), and with the mean of the single item of the Six America Scale (r = .70, 95% CI [0.64, 0.75], $p < .001$).

Similar to the results presented in Study 1, predictive validity was assessed through correlations between the SIBCC and outcome measures, among them policy support, political activism (Swim and Geiger, 2017), and behavior in the Carbon Emission Task (Berger and Wyss, 2021b). Results show that the single-item measure correlates positively and statistically significant with policy support (r = .59, 95% CI [0.51, 0.66], $p < .001$), political activism (r = .16, 95% CI [0.04, 0.27], $p < .001$), and with pro-environmental behavior (r = .33, 95% CI [0.22, 0.43], $p < .001$).

Furthermore, we test the degree to which SIBCC predicts outcome measures (CET behavior, policy support, and political activism), both with and without controlling for other demographic factors (see Table 1.6). Throughout all models, SIBCC relates to the outcome measures, as expected.

Table 1.5: Descriptive statistics and Pearson correlations for study variables (N = 288)

Variable	1	2	3	4	5	6	7	8	9	10	Mean	SD
1. SIBCC	—										3.34	2.04
2. SASSY scale	.70***	—									3.67	0.70
3. Importance of GW	.60***	.89***	—								3.52	0.92
4. Worry by GW	.64***	.88***	.76***	—							3.05	0.78
5. Individual harm by GW	.49***	.82***	.60***	.62***	—						3.60	0.78
6. Harm future generations	.70***	.84***	.66***	.67***	.60***	—					4.54	0.73
7. Single item 6 America	.70***	.81***	.73***	.75***	.57***	.75***	—				5.01	1.10
8. Political support	.59***	.64***	.59***	.58***	.44***	.59***	.65***	—			3.42	0.57
9. Political activism	.16**	.25***	.27***	.23***	.24***	.13*	.24***	.16**	—		1.20	0.40
10. CET	.33***	.54***	.51***	.50***	.42***	.44***	.48***	.34***	.17**	—	0.52	0.34

Notes: SIBCC = Single-Item Belief in Climate Change, GW = global warming, CET = Carbon Emission Task. The categories of the single item 6 America were merged to a continuous variable ranging from (1) dismissive to (6) alarmed. *$p < 0.05$. **$p < .01$. ***$p < .001$.

TABLE 1.6: Linear Regression of SIBCC on CET behavior (Models 1 and 2), policy support (Models 3 and 4), and political activism (Models 5 and 6)

	(1)	(2)	(3)	(4)	(5)	(6)
SIBCC	0.11***	0.12***	0.34***	0.32***	0.06***	0.06**
	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)
Gender		0.08**		-0.08		0.00
		(0.04)		(0.05)		(0.05)
Age		0.03		0.04		-0.02
		(0.02)		(0.03)		(0.03)
Political ideology		-0.00		-0.10***		-0.01
		(0.02)		(0.03)		(0.03)
Education		-0.00		-0.10		0.10*
		(0.04)		(0.06)		(0.06)
Low income		0.01		-0.14**		-0.00
		(0.04)		(0.06)		(0.05)
Intercept	0.52***	0.47***	3.42***	3.62***	1.20***	1.13***
	(0.02)	(0.05)	(0.03)	(0.07)	(0.02)	(0.07)
Observations	288	268	288	268	288	268
R-squared	0.11	0.14	0.35	0.43	0.02	0.04

Notes: The table presents estimates from ordinary least squares (OLS) regressions. All continuous predictors are mean centered and scaled by 1 standard deviation. Robust standard errors are shown in parentheses. Gender is dummy-coded (1 if female) as well as education (1 if at least university degree) and low income (1 if below GBP 50,000 annual income). *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

Finally, we examine *discriminant validity*, as in Study 1. Contrary to the Prolific sample in Study 1, we do not detect a significant difference ($U = 9678$, $p = .312$, Wilcoxon-Mann-Whitney test) of belief in climate change perceptions between women ($M = 3.47$, $SD = 1.96$, $n = 144$) and men ($M = 3.22$, $SD = 2.11$, $n = 144$) from the Prolific sample in Study 2. Similar to findings in Study 1, we found statistically significant ($U = 6152$, $p < .001$ Wilcoxon-Mann-Whitney test) greater climate change perceptions of liberals ($M = 3.99$, $SD = 1.42$, $n = 155$) compared to conservatives ($M = 2.59$, $SD = 2.59$, $n = 133$).

1.3.4 Discussion

Study 2 confirms the findings about convergent and predictive validity obtained in Study 1, supporting the usage of the single item. In addition, we extend findings from Study 1 by showing that SIBCC correlates with an alternative set of measures designed to test belief in climate change, and with novel outcome variables tapping into policy support and activism. In addition to the validation work mainly intended here, we also show

that the related measures assessing belief in climate change (SASSY, Six Americas) are correlated with a consequential, but abstract behavioral measure (i.e., the CET).

1.4 General discussion

In the present research, we investigated the validity of a novel and brief measure to assess belief in climate change with a single item. Across two studies, we show that the item is a suitable alternative to longer instruments. Results in Study 1 support the validity of the single item through establishing convergent, predictive, and discriminant validity. Consistent with the results in Study 1, we replicate and extend our findings in Study 2.

One particular strength of our studies is the inclusion of a consequential behavioral measure with actual environmental consequences. In many cases, ostensible validity support may be artificially increased through common-method variance (Podsakoff et al., 2003). Here, we circumvent this issue and thus follow calls that researchers should apply rigorous measurement models and demonstrate that the proposed measure operates as theoretically predicted beyond the world of self-reports (Kaiser and Lange, 2021).

The single-item SIBCC measure complements the single item of the Six America Survey (Swim and Geiger, 2017) and the SASSY scale (Chryst et al., 2018), which are both also correlated with the Carbon Emission Task. SIBCC therefore presents a viable alternative to other measures, enabling researchers to choose among various established measures using a single item (e.g., Swim and Geiger 2017) or a few items (Chryst et al., 2018, Poortinga et al., 2019). Possible use-cases include screening people out for dismissing anthropogenic climate change or to quickly assess belief in climate change when it is not the primary interest of a study.

Despite the disadvantages that one-item measures may bring, recent research calls for more single-item constructs (Allen et al., 2022). Although these often come with a negative reputation, most research published on single-item measures shows that they are often as valid and reliable as their multi-item counterparts (Ahmad et al., 2014, Ang and Eisend, 2018). Climate change beliefs are particularly important to assess in large-scale surveys (e.g., household surveys, panels, international *Many Labs* projects etc.) and the need for brief, validated measures is increasing. That said, a single-item measure of belief in climate change does not come without limitations. For example, it cannot capture complex multi-dimensional attitudinal structures. However, the measure is not designed to replace existing longer instruments, but rather to be included as an additional instrument to our toolbox of assessing public belief in climate change when survey space is limited. Our hope is that an additional validated ultra-short assessment instrument

will increase the evidence-base, as the one-item measure can easily be incorporated in larger studies.

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Appendix A: Additional analysis

TABLE 1.7: Detailed analysis of sample characteristics of Study 1

	Prolific (n = 469)	mTurk (n = 444)
Gender		
Female	182 (39%)	167 (38%)
Male	281	276
Diverse	5	0
Prefer not to say	0	1
Age	27.10 (SD = 8.95)	35.55 (SD = 10.13)
Political		
Very liberal	39	64
Liberal	134	117
Somewhat liberal	101	46
Moderate	96	64
Somewhat conservative	26	37
Conservative	18	66
Very conservative	4	47
None of the above	51	4
Education		
Less than high School diploma	12	0
High School or equivalent	205	50
Bachelor degree (e.g. BA, BSc)	161	288
Master degree (e.g. MA, MS)	79	97
Doctorate (e.g. PhD, EdD, DBA)	7	5
Other	5	4
Income		
Less than $10,000	105	30
$10,000 - $29,999	167	74
$30,000 - $49,999	91	94
$50,000 - $79,999	67	153
$80,000 - $99,999	21	62
$100,000 - $149,999	13	24
$150,000 or more	5	7
Race		
Asian or Pacific Islander	13	98
Black or African American	17	29
Hispanic or Latino	49	36
Native American or Alaskan Native	1	10
White or Caucasian	377	267
Multiracial or Biracial	6	4
A race/ethnicity not listed here	6	0

FIGURE 1.1: Distribution of SIBCC answers (Histogram)

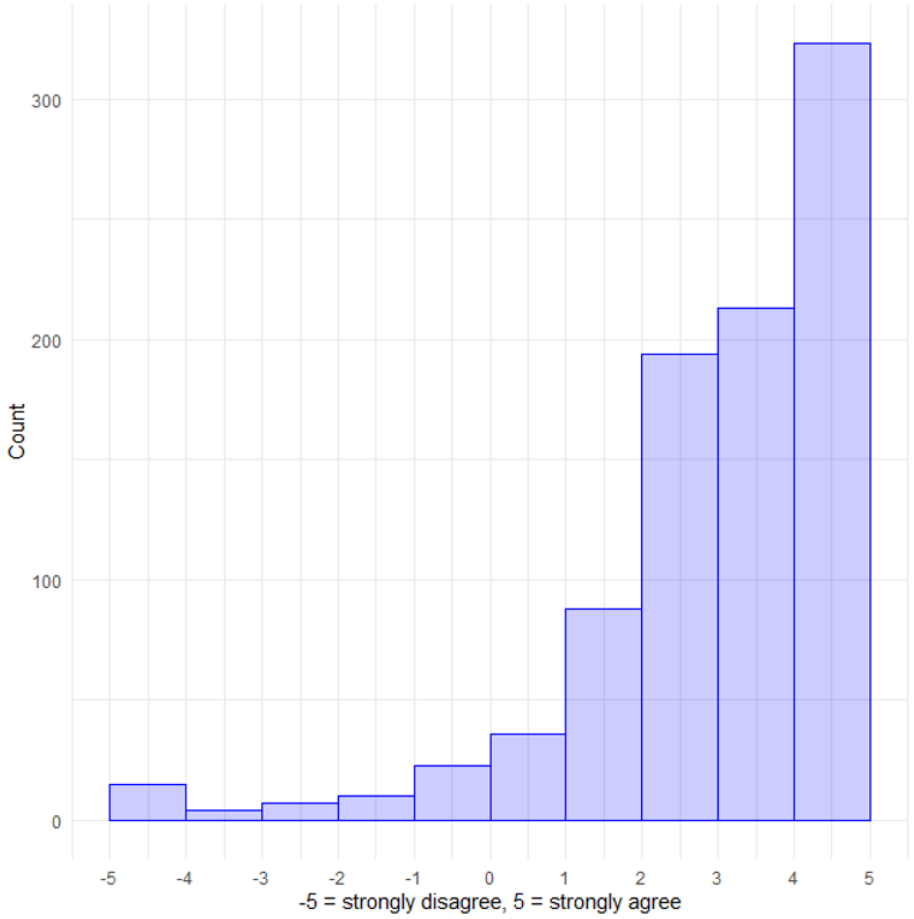


Table 1.8: Descriptive statistics and Spearman correlations for study variables (N = 913)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	Mean	SD
1. SIBCC	—													3.45	1.85
Convergent validity															
2. Trend skepticism	.25***	—												0.92	0.27
3. Attribution skepticism	.22***	.33***	—											0.85	0.36
4. Perceived impact of CC	-.46***	-.31***	-.46***	—										-1.72	3.20
5. Limits to growth	.32***	.09**	.02	-.08	—									3.69	0.93
6. Anti-anthropocentrism	.40***	.26***	.41***	-.64***	.14***	—								3.21	0.99
7. Ecological damage	.56***	.21***	.21***	-.42***	.43***	.43***	—							4.13	0.66
8. Egoistic values	-.10	-.09***	-.24***	.42***	.09***	-.57***	-.11	—						3.72	1.56
9. Altruistic values	.47***	.18***	.16***	-.35***	.24***	.30***	.51***	.05***	—					5.43	1.22
10. Biospheric values	.45***	.17***	.11***	-.32***	.29***	.25***	.52***	.15***	.71***	—				5.30	1.34
Predictive validity															
11. Green behavioral intentions	.34***	.09**	.00	-.10	.27***	.03	.33***	.25***	.42***	.52***	—			5.04	1.47
12. Carbon Emission Task	.24***	.13***	.22***	-.34***	-.02	.41***	.18***	-.23***	.26***	.24***	.19***	—		0.50	0.29
13. General Ecological Behavior	.31***	.05	.00	-.08	.24***	.08***	.30***	.12***	.33***	.41***	.52***	.22***	—	0.44	0.16

Notes: SIBCC = Single-Item Belief in Climate Change, CC = Climate Change. Limits to growth, Anti-anthropocentrism, Ecological damage are the three factors of the New Environmental Paradigm Scale-Revised. *$p < 0.05$. **$p < .01$. ***$p < .001$.

TABLE 1.9: Linear regression of SIBCC and other measures of belief in climate change and actual pro-environmental behavior (Carbon Emission Task)

	(1)	(2)	(3)
SIBCC	0.06***		0.04***
	(0.01)		(0.01)
Trend skepticism		-0.00	-0.02
		(0.04)	(0.04)
Attribution skepticism		0.05*	0.03
		(0.03)	(0.03)
Perceived impact of CC		-0.09***	-0.09***
		(0.01)	(0.01)
Intercept	0.50 ***	0.46 ***	0.49 ***
	(0.01)	(0.04)	(0.04)
Observations	913	910	910
R-squared	0.05	0.13	0.14

Notes: The table presents estimates from ordinary least squares (OLS) regressions. All continuous predictors are mean centered and scaled by 1 standard deviation. Robust standard errors are shown in parentheses. The dependent variable is the number of choices for Option B in the Carbon Emission Task. Three participants ($n = 3$) were dropped in Models 2 and 3 because they were coded as missing values (see 1.2.2 Belief in Climate Change). *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 1.10: Additional analyses of predictive validity: Linear regression with actual pro-environmental behavior (Carbon Emission Task) (Study 1)

	(1)	(2)	(3)	(4)	(5)	(6)
SIBCC	0.03***		0.03**		0.02**	
	(0.01)		(0.01)		(0.01)	
Limits to growth	-0.02**	-0.03***			-0.02***	-0.03***
	(0.01)	(0.01)			(0.01)	(0.01)
Anti-anthropocentrism	0.11**	0.11***			0.10***	0.09***
	(0.01)	(0.01)			(0.01)	(0.01)
Ecological damage	0.02*	0.01			-0.02**	-0.03**
	(0.01)	(0.01)			(0.01)	(0.01)
Biospheric values			0.06***	0.05***	0.05***	0.05***
			(0.01)	(0.01)	(0.01)	(0.01)
Altruistic values			0.04***	0.04***	0.03***	0.03**
			(0.01)	(0.01)	(0.01)	(0.01)
Egoistic values			-0.08***	-0.08***	-0.02**	-0.02**
			(0.01)	(0.01)	(0.01)	(0.01)
Intercept	0.50 ***	0.50 ***	0.50 ***	0.50 ***	0.50 ***	0.50 ***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Observations	913	913	913	913	913	913
R-squared	0.17	0.18	0.15	0.16	0.21	0.22

Notes: The table presents estimates from ordinary least squares (OLS) regressions. All continuous predictors are mean centered and scaled by 1 standard deviation. Robust standard errors are shown in parentheses. The dependent variable is the number of choices for Option B in the Carbon Emission Task. *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 1.11: Detailed analysis of sample characteristics of Study 2

	Prolific (N = 288)
Gender	
Female	144
Male	140
Prefer not to say	2
Non-binary or other	2
Age	39.4 (SD = 11.63)
Political	
very liberal	30
liberal	67
somewhat liberal	58
moderate	62
somewhat conservative	31
conservative	19
very conservative	1
none of the above	20
Education	
Less than high School diploma	0
High School or equivalent	86
Bachelor degree (e.g. BA, BSc)	134
Master degree (e.g. MA, MS)	57
Doctorate (e.g. PhD, EdD, DBA)	8
other	3
Income	
Less than £10,000	10
£10,000 - £29,999	75
£30,000 - £49,999	92
£50,000 - £79,999	70
£80,000 - £99,999	20
£100,000 - £149,999	14
£150,000 or more	7
Employment	
employed full time	180
employed part time	38
I have occasional gigs	11
unemployed looking for work	14
unemployed not looking for work	14
retired	14
student	14
disabled	3

Table 1.12: Descriptive statistics and Spearman correlations for the study variables (N = 288)

Variable	1	2	3	4	5	6	7	8	9	10	Mean	SD
1. SIBCC	—										3.34	2.04
2. SASSY scale	.63***	—									3.67	0.70
3. Importance of GW	.56***	.88***	—								3.52	0.92
4. Worry by GW	.58***	.86***	.73***	—							3.05	0.78
5. Individual harm by GW	.44***	.80***	.56***	.59***	—						3.60	0.78
6. Harm future generations	.58***	.77***	.58***	.59***	.56***	—					4.54	0.73
7. Single item 6 America	.61***	.74***	.68***	.70***	.52***	.60***	—				5.01	1.10
8. Political support	.53***	.58***	.54***	.53***	.42***	.47***	.59***	—			3.42	0.57
9. Political activism	.23**	.33***	.33***	.27***	.26***	.21*	.32***	.22**	—		1.20	0.40
10. CET	.30***	.54***	.52***	.50***	.40***	.42***	.48***	.31***	.20**	—	0.52	0.34

Notes: SIBCC = Single-Item Belief in Climate Change, GW = global warming, CET = Carbon Emission Task. The categories of the single item 6 America were merged to a continuous variable ranging from (1) dismissive to (6) alarmed. *$p < 0.05$. **$p < .01$. ***$p < .001$.

Appendix B: Experimental material

Instructions and questionnaires as displayed to participants in Study 1

Informed consent for study for participation
Experimental Model: The Carbon Emission Task

In this task, you will be asked to make 25 decisions (1 per trial) that may affect your bonus payment. In each of the 25 trials, you will be asked to decide between two general options.
Option A will always involve the opportunity to receive a monetary bonus for you, but it has a real consequence for the environment. Choosing Option A gives you a financial reward (with varying amounts between 20 pence and 1 pound), but will typically lead to emission of carbon dioxide (CO_2, between 0 lbs. and 19.85 lbs.). Carbon dioxide is regarded as a key contributor to climate change and scientists around the globe agree that climate change can only be mitigated if carbon emissions are dramatically reduced. To help you understand the consequence, each decision will "translate" the amount of carbon dioxide emitted by your choice into the emissions caused by driving an average passenger car.
Choosing Option B, on the other hand, will lead to a bonus payment of zero, but will also not cause any emissions of carbon dioxide.
In each of the 25 trials, you will have 15 seconds to make your decisions. If you do not make a decision within the 15 seconds, the screen will automatically proceed to the next trial and you will not receive a bonus opportunity for the trial in which you did not make a decision.

In general, each trial will look similar to the following:

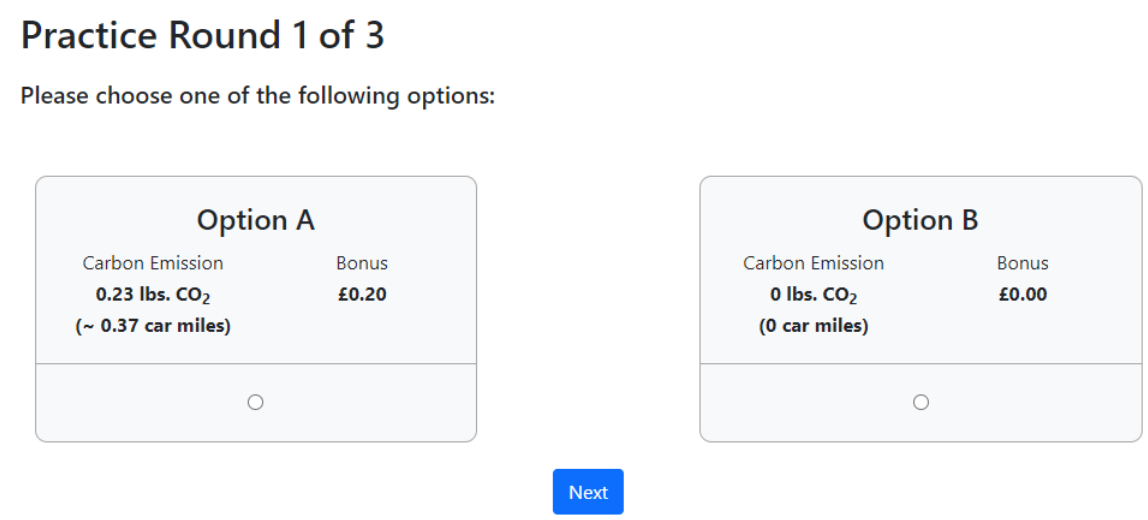
Option A: You will receive a bonus of 40 pence and produce a carbon emission of 4.46 lbs. (which is equivalent of driving 4.97 miles).
Option B: You will not receive a bonus, and there will not be a carbon emission.

Importantly, all of the emissions are real and will actually be affecting the planet. This is realized by the following instrument. The researchers are in possession of CO_2 certificates which allow emissions of carbon dioxide. If you choose the option to forego the bonus (Option B in each trial), the certificate in the equivalent of the emissions associated with Option A are taken out of the market and destroyed. This is made possible by professional service providers from which the researchers buy these certificates. Thus, your decision will have an actual and true consequence for the environment. It is NOT a hypothetical decision.

Your actual bonus payment as well as the actual emission will be based on one of your decisions, which will be randomly drawn from the set of your 25 trials. Your actual bonus will therefore vary between 0 pence and 1 pound.

Before you will make your first decision, you will be able to complete a practice trial and to answer a comprehension question so that you can familiarize yourself with the decision screen. Unlike in the 25 trials, the practice trial will have no bonus and emission consequences but will have a time limit of 20 seconds to make your decision.

—Page Break—



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Control Question

Control question: Does the decision that will determine your bonus have a real consequence for the environment?

(Answering options: *yes* versus *no*)

Summary of the Task

- There are 25 decision rounds containing 2 options.
- Option A: emission of a certain amount of CO_2 and the chance of a bonus payment (chosen at random out of all rounds).
- Option B: no emissions and no chance of a bonus payment.
- The chosen amount will lead to the emission of real CO_2.
- These are NOT hypothetical decisions.

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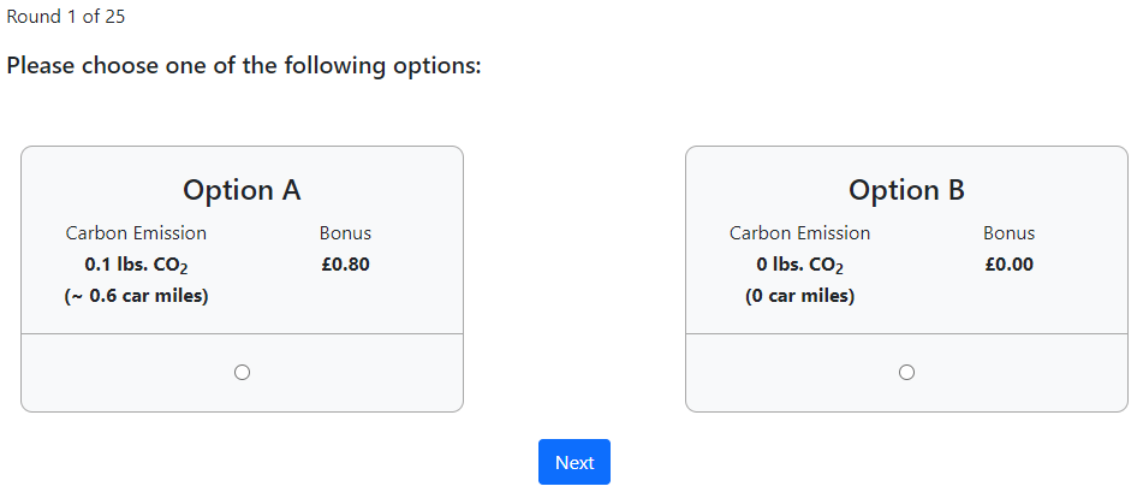
Example of a task trial of the CET



Results

The random payoff round was: XX
In this round you chose Option A and took the bonus.
The random payoff is therefore: £XXX

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The single-item measure of belief in climate change (SIBCC)

Please indicate the extent to which you agree or disagree with the following statement using the scale below. (Answering options: -5 = *strongly disagree* to 5 = *strongly agree*)

The occurrence of climate change is caused by human activities and will bring largely negative consequences.

—*Page Break*—

Belief in climate change

Trend skepticism
You may have heard the idea that the world's climate is changing due to increases in temperature over the past 100 years. What is your personal opinion on this? Do you think the world's climate is changing? (Answering options: *definitely not changing, probably not changing, probably changing, definitely changing*)

Attribution skepticism
Do you think that climate change is caused by natural processes, human activity, or both? (Answering options: *entirely by natural processes, mainly by natural processes, entirely by human activity, mainly by human activity, about equally by natural processes and human activity, I don't think climate change is happening*)

Perceived impacts of climate change
Please indicate how good or bad the impact of climate change is on people across the world? In the following scale: -5 means *extremely bad*, 5 means *extremely good*. You can use the values in-between to indicate where you fall on the scale. (Answering options ranged on a 11-point Likert-Scale from -5 *extremely bad* to 5 *extremely good*)

—Page Break—

New Ecological Paradigm (NEP-R)

Listed below are statements about the relationship between humans and the environment. For each one, please indicate how much you agree with it. (Answering options on a 5-point Likert-scale: *strongly disagree, somewhat disagree, unsure, somewhat agree, totally agree*)

1. We are approaching the limit of the number of people the earth can support.
2. Humans have the right to modify the natural environment to suit their needs.
3. When humans interfere with nature, it often produces disastrous consequences.
4. Human ingenuity will ensure that we do NOT make the earth unlivable.
5. Humans are severely abusing the environment.
6. The earth has plenty of natural resources if we just learn how to develop them.
7. Plants and animals have as much right as humans to exist.
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.
9. Despite our special abilities, humans are still subject to the laws of nature.
10. The so-called "ecological crisis" facing humankind has been greatly exaggerated.
11. The earth is like a spaceship with very limited room and resources.
12. Humans were meant to rule over the rest of nature.
13. The balance of nature is very delicate and easily upset.
14. Humans will eventually learn enough about how nature works to be able to control it.
15. If things continue on their present course, we will soon experience a major ecological catastrophe.

—Page Break—

Biospheric values (E-SVS)

Below you will find 16 values. Behind each value there is a short explanation concerning the meaning of the value. Please rate how important each value is for you AS A GUIDING PRINCIPLE IN YOUR LIFE? (Answering options ranged on a 9-point Likert-scale from -1 *opposed to my values* to 7 *of supreme importance*)

1. EQUALITY: equal opportunity for all
2. RESPECTING THE EARTH: harmony with other species
3. SOCIAL POWER: control over others, dominance
4. PLEASURE: joy, gratification of desires
5. UNITY WITH NATURE: fitting into nature
6. A WORLD AT PEACE: free of war and conflict
7. WEALTH: material possessions, money
8. AUTHORITY: the right to lead or command
9. SOCIAL JUSTICE: correcting injustice, care for the weak
10. ENJOYING LIFE: enjoying food, sex, leisure, etc.
11. PROTECTING THE ENVIRONMENT: preserving nature
12. INFLUENTIAL: having an impact on people and events
13. HELPFUL: working for the welfare of others
14. PREVENTING POLLUTION: protecting natural resources
15. SELF-INDULGENT: doing pleasant things
16. AMBITIOUS: hard working, aspiring

—*Page Break*—

Green behavioral intention

(Answering options on a 7-point Likert-scale: (1) *extremely unlikely* to (7) *extremely likely*)

1. I will try to reduce my carbon footprint in the forthcoming month.
2. I intend to engage in environmentally friendly behavior in the forthcoming month.
3. I plan to stop wasting natural resources in the forthcoming month.
4. (Electricity) I intend to turn off lights as much as possible in the forthcoming month.

5. (Gas) I intend to spend less time in the shower in the forthcoming month.
6. (Package) I intend to buy goods with less packaging in the forthcoming month.
7. (Transportation) I intend to use more environmentally friendly means of transport in the forthcoming month.

General Ecological Behavior Scale (GEB)

Please indicate how often you perform the behaviors below. Choose NA (not applicable) if you are unable to give an answer (for example when asked about your driving habits although you do not hold a license). (Answering options on a 5-point Likert-scale: *never, seldom, occasionally, often, always, NA*)

1. I ride a bicycle or take public transportation to work or school.
2. I buy meat and produce with eco-labels.
3. I buy beverages in cans.
4. I use an oven cleaning spray to clean my oven.
5. I drive my car in or into the city.
6. In the winter, I air rooms while keeping on the heat and leaving the windows open, simultaneously.
7. I drive on freeways at speeds under 100 kph (= 62 mph).
8. If I am offered a plastic bag in a store, I take it.
9. In nearby areas (around 30 kilometers; around 20 miles), I use public transportation or ride a bike.
10. I collect and recycle used paper.
11. I bring empty bottles to a recycling bin.
12. I have pointed out unecological behavior to someone.
13. I contribute financially to environmental organizations.
14. I buy beverages and other liquids in returnable bottles.
15. I buy bleached or colored toilet paper.
16. I buy convenience foods.
17. I buy products in refillable packages.
18. I buy domestically grown wooden furniture.
19. I boycott companies with an unecological background.
20. I buy seasonal produce.
21. I talk with friends about saving electricity.

22. I read about environmental issues.
23. I talk with friends about environmental pollution, climate change, and/or energy consumption.
24. For longer journeys (more than 6 hours of travel time by car), I take an airplane.
25. Please select *always*.
26. I keep the engine running while waiting in front of a railroad crossing.
27. At red traffic lights, I keep the engine running.
28. I kill insects with a chemical insecticide.
29. In winter, I turn down the heat when I leave my apartment for more than 4 hours.
30. I drive to where I want to start my hikes.
31. I drive in such a way as to keep my fuel consumption as low as possible.
32. I drive on freeways at speeds under 120 kph (= 75 mph).

Demographics

What is your year of birth? (exactly 4 numbers, e.g. 1985)

Please select the gender you identify most with. (Answering options: *female, male, diverse, prefer not to specify*)

Which of the following best describes your political views? (Answering options: *very liberal, liberal, somewhat liberal, moderate, somewhat conservative, conservative, very conservative, none of the above*)

What is the highest degree or level of education you have completed? (Answering options: *Less than High School diploma, High School or equivalent, Bachelor degree (e.g. BA, BSc), Master degree (e.g. MA, MS, MEd), Doctorate (e.g. PhD, EdD, DBA), other*)

What is your household income per year? (Answering options: *Less than $10,000, $10,000 - $19,999; $20,000 - $29,999; $30,000 - $39,999; $40,000 - $49,999; $50,000 - $59,999; $60,000 - $69,999; $70,000 - $79,999; $80,000 - $89,999; $90,000 - $99,999; $100,000 - $149,999; $150,000 or more*)

Please select the racial category with which you most closely identify. (Answering options: *Asian or Pacific Islander, Black or African American, Hispanic or Latino, Native American or Alaskan Native, White or Caucasian, Multiracial or Biracial, A race/ethnicity not listed here*)

End of the survey

Thank you for participating in our study. We will transfer the payment for the task to you within the next week. Please note that this additional payment might arrive later than the flat payment and might be listed as a separate transaction.

Your completion code is XX.
Please return to Prolific and enter your code.

Instructions and questionnaires as displayed to participants in Study 2

Informed consent for study for participation
Experimental Model: The Carbon Emission Task

In this task, you will be asked to make 25 decisions (1 per trial) that may affect your bonus payment. In each of the 25 trials, you will be asked to decide between two general options.

Option A will always involve the opportunity to receive a higher bonus payment, but it has a real consequence for the environment. Choosing Option A gives you a financial reward from 20 to 100 pence, but will typically lead to a higher emission of carbon dioxide (between 0.5 and 4.5 kg of CO_2). Carbon dioxide is regarded as a key contributor to climate change and scientists around the globe agree that climate change can only be mitigated if carbon emissions are dramatically reduced. To help you understand the consequences, each decision will translate the amount of carbon dioxide emitted by your choice into the emissions caused by driving an average UK vehicle.

Choosing Option B, on the other hand, will lead to a bonus payment of zero, but will also not cause any emissions of carbon dioxide.

In each of the 25 trials, you will have 15 seconds to make your decisions. If you do not make a decision within the 15 seconds, the screen will automatically proceed to the next trial.

Example: *Option A*: You will receive a bonus of 60 pence and produce a carbon emission of 4.5 kg (the equivalent of driving 18 km).
Option B: You will receive no bonus and produce no carbon emission.

Importantly, all of the emissions are real and will actually be affecting the planet. This is realized by the following method. The researchers have purchased CO_2 certificates that allow emissions of carbon dioxide. Depending on your decisions, these certificates will be ultimately taken out of the market and retired. This is made possible by professional service providers from which the researchers buy these certificates. Thus, your decisions will have actual and true consequences for the environment. They are NOT hypothetical decisions. Your actual bonus payment as well as the actual emissions will be based on one of your decisions, which will be randomly drawn from the trials. Your final bonus will therefore vary between 0 and 100 pence.

Before you will make your first decision, you will be able to complete a practice trial and to answer a comprehension question so that you can familiarize yourself with the decision screen. Unlike in the 25 trials, the practice trial will have no bonus, no emission consequences, and is not timed.

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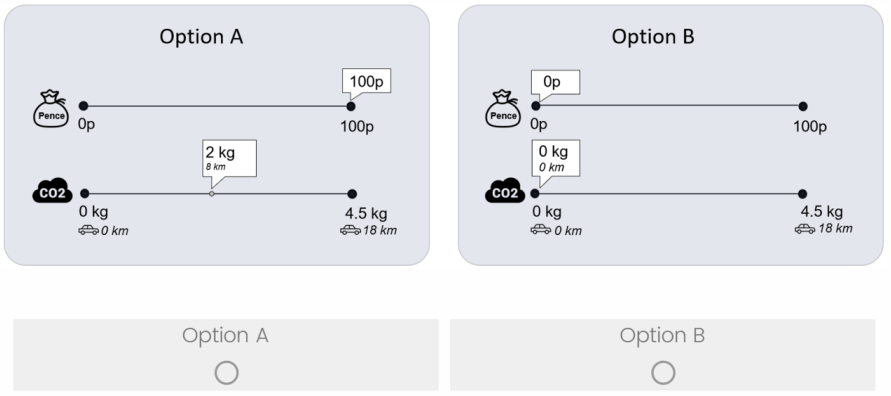
Practice trial: Please choose between Option A and Option B.



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Control question

Control question: Does the decision that will determine your bonus have a real consequence for the environment?

(Answering options: *yes* versus *no*)

Summary of the Task

- There are 25 decision rounds containing 2 options.
- Option A: emission of a certain amount of CO_2 (e.g., 0.5, 1, 2, 3, 4.5) and the chance of a bonus payment (e.g., GBP 0.2, GBP 0.4, GBP 0.6, GBP 0.8, GBP 1) (chosen at random out of all rounds).
- Option B: no emissions and no chance of a bonus payment.

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The single-item measure of belief in climate change (SIBCC)

Please indicate the extent to which you agree or disagree with the following statement using the scale below. (Answering options: -5 = *strongly disagree* to 5 = *strongly agree*)

The occurrence of climate change is caused by human activities and will bring largely negative consequences.

—Page Break—

Six America Short SurveY (SASSY)

How important is the issue of global warming to you personally? (Answering options: 1 = *extremely important* to 5 = *not at all important*)

How worried are you about global warming? (Answering options: 1 = *very worried* to 4 = *not at all worried*)

How much do you think global warming will harm you personally? (Answering options: 1 = *a great deal* to 4 = *not at all* and 5 = *don't know*)

How much do you think global warming will harm future generations of people? (Answering options: 1 = *a great deal* to 4 = *not at all* and 5 = *don't know*)

—*Page Break*—

Single item of the America Six Survey

Please select below the statement regarding climate change that appeals the best to you.

- *Alarmed*: I am very concerned about climate change and think the government and individuals need to act now.
- *Concerned*: I am concerned and think we need to take action but we have time to decide what the appropriate responses should be.
- *Cautious*: I suspect that climate change is happening but I am not certain. We have time to make careful decisions about when and whether to respond.
- *Disengaged*: I have not really thought much about climate change.
- *Doubtful*: I suspect that climate change is NOT happening but I am not certain. I am concerned more about overreacting to climate change.
- *Dismissive*: I do not believe climate change is occurring and certainly do not think humans have caused it. So, I'm not motivated to take or support action to address it.

—*Page Break*—

Policy support

Taking into account the costs involved and possible disruption, to what extent, if at all, would you support or oppose the government bringing in each of the following policies to tackle climate change? (Answering options: 1 = *strongly oppose* to 4 = *strongly support*)

- Regulate carbon dioxide as a pollutant.
- Require utilities to produce at least 20% of electricity from renewables.
- Provide tax rebates for individual purchase of energy-efficient vehicles.

- Provide tax rebates for individual purchase of solar panels.
- Fund research into renewable energy sources.
- Funding to make infrastructure resistant to extreme weather.

—*Page Break*—

Political activism

In the last 12 months, how many times have you engaged in the following actions? (Answering options: 1 = *never* to 4 = *often*)

- Donated to a political candidate that shared their views on the topic.
- Attended a meeting or rally about global warming.
- Met with an elected official or their staff about global warming.
- Elected a political candidate that shared their views on global warming.

—*Page Break*—

Demographics

What is your year of birth? (exactly 4 numbers, e.g. 1985)

Please select the gender you identify most with. (Answering options: *female, male, diverse, prefer not to specify*)

Which of the following best describes your political views? (Answering options: *very liberal, liberal, somewhat liberal, moderate, somewhat conservative, conservative, very conservative, none of the above*)

What is the highest degree or level of education you have completed? (Answering options: *Less than High School diploma, High School or equivalent, Bachelor degree (e.g. BA, BSc), Master degree (e.g. MA, MS, MEd), Doctorate (e.g. PhD, EdD, DBA), other*)

What is your household income per year? (Answering options: *Less than $10,000, $10,000 - $19,999; $20,000 - $29,999; $30,000 - $39,999; $40,000 - $49,999; $50,000 - $59,999; $60,000 - $69,999; $70,000 - $79,999; $80,000 - $89,999; $90,000 - $99,999; $100,000 - $149,999; $150,000 or more*)

Are you employed? (Answering options: *employed full time, employed part time, I have occasional gigs, unemployed looking for work, unemployed not looking for work, retired, student, disabled*)

—*Page Break*—

End of the survey (similar to Study 1)

Essay 2: The Tree Task – An incentivized, one-shot decision task to measure pro-environmental behavior

Andrea Essl, David Hauser, Manuel Suter, Frauke von Bieberstein*

Abstract

To help mitigate climate change and its associated costs, behavioral economists need to better understand the determinants of pro-environmental behavior. How can this behavior be measured in the lab or online? This study presents the Tree Task, an incentivized, one-shot task used to measure pro-environmental behavior in the form of tree planting. In the Tree Task, individuals face a trade-off between individual immediate financial rewards and long-term environmental gains. In particular, participants have to decide between spending money to plant trees or keeping the money for themselves. We find that participants' decisions depend on the costs and environmental impact of a tree. As expected, higher costs lead to fewer planted trees, whereas higher carbon dioxide offsets foster tree planting. The number of trees planted correlates with established self-reports assessing environmental attitudes and intentions, belief in climate change, and values in line with pro-environmental behavior. The Tree Task extends the set of validated tasks measuring incentivized pro-environmental behavior in the lab as a short, vivid, and easy-to-explain task.

Keywords: pro-environmental behavior, behavioral economics, incentivized behavioral task, carbon dioxide offset, climate change mitigation

JEL Codes: C91, D91, Q54, Q56

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2.1 Introduction

Current climate conditions have imposed significant economic costs and social burdens on humanity, and the ongoing climate changes are substantially increasing these costs (Carleton and Hsiang, 2016). One way to mitigate climate change is through demand-side strategies, including behavioral changes. Demand-side strategies have considerable potential, as they may reduce global emissions between 40% and 70% by 2050 (IPCC, 2022). To examine strategies that target individual behavior, scientists need a toolbox of various measures to assess pro-environmental behavior and its determinants. However, there is a lack of validated tasks that measure incentivized pro-environmental behavior (Ropret Homar and Knežević Cvelbar, 2021). Therefore, we present an incentivized, one-shot task to measure pro-environmental behavior in laboratory and online experiments: the Tree Task.

In the Tree Task, individuals decide whether to spend money on planting trees or to keep it for themselves. Participants face a trade-off between individual immediate financial rewards and long-term environmental gains. The degree of pro-environmental behavior is captured with a single outcome variable: the number of trees planted. To validate the Tree Task, we manipulated two independent variables in a within-subject design: high or low costs per tree and high or low carbon dioxide offset per tree. These manipulations are possible because the planting costs and the carbon dioxide absorption capacity of the trees differ. As hypothesized, we find that the number of trees planted increases with a higher carbon dioxide offset per tree and decreases with higher costs per tree. Correlational analyses show that the overall number of trees planted is correlated with environmental attitudes and intentions, belief in climate change, and values in line with pro-environmental behavior. Therefore, we confirm the validity of the Tree Task as a suitable measurement for capturing pro-environmental behavior in laboratory and online experiments.

The Tree Task makes several contributions to the measurement of pro-environmental behavior in laboratory and online experiments. First, the task has high external validity, because the trees are actually planted by a forest restoration organization. Second, the task is short, which allows it to be implemented at a relatively low cost and to be combined with other outcome measures. Third, due to its vividness and simplicity, the Tree Task can be compared cross-culturally and used with children. Finally, the Tree Task complements recent research that has provided validated measures for behavioral economists (see e.g., Buso et al. 2021, Fallucchi et al. 2020, Giamattei et al. 2020, Henry and Sonntag 2019, Kent 2020, Ronayne et al. 2021).

Thus far, behavioral economists have mainly relied on donation tasks and self-reported intentions to measure pro-environmental behavior in laboratory experiments. In such donation tasks, participants can choose to donate a portion of their experimental earnings, an additional endowment, or their show-up fee to an environmental organization (see, e.g., Goff et al. 2017, Vesely et al. 2022). Some donation tasks give a choice of organizations to donate to, whereas others specify a single organization (see, e.g., Ibanez et al. 2017, Lasarov et al. 2022). In addition, most donation tasks provide a fixed amount of which all or part can be donated. Others vary the amount, for instance, depending on the real effort exerted to donate (e.g., the Work for Environmental Protection Task by Lange and Dewitte 2022). The concern with most donation tasks is that participants do not know the concrete impact of their donations on the environment, and thus, they are unable to estimate the impact of different donation amounts. This lack of information may lead to different interpretations, complicate the choice of donation levels, and trigger skepticism; therefore, it may only partly reflect actual pro-environmental behavior.

To measure self-reported pro-environmental intentions, researchers use proxies, such as the intention to purchase green products (Yadav and Pathak, 2017) or the intention to purchase bio-based products (Wensing et al., 2021). An additional approach to measuring pro-environmental intentions assesses a hypothetical willingness to pay for environmental protection, for example, willingness to pay for water resource protection (Halkos and Matsiori, 2014) or for ecotourism (Meleddu and Pulina, 2016). Such self-reports offer important insights but entail the risk of different interpretations by individuals (Gifford, 2014). Furthermore, self-reports tend to overestimate actual behavior, for example, due to social desirability bias (Clements et al., 2015, Geller, 1981). Because of the limitations of current donation tasks and self-reports, there is a need to supplement these measures with other incentivized behavioral tasks that have potentially higher external validity (Ropret Homar and Knežević Cvelbar, 2021, Lades et al., 2021).

Apart from donations, several other behavioral paradigms for the laboratory measure pro-environmental behavior with actual environmental consequences (see also the review by Lange 2023). Many have been introduced in the environmental psychology literature and consider different ad hoc paradigms, such as choosing between a cheaper conventional and a more expensive but more ecological product (Barber et al., 2014), signing up for a sustainability event like beach cleaning (Ho et al., 2020), or signing a petition, for instance, against plastic waste (Rees et al., 2015). Most of these paradigms have in common that they depend on the particular products and events chosen and may be difficult to compare and transfer to other settings.

Only a few behavioral paradigms are more generally applicable and measure incentivized pro-environmental behavior. An example is the Pro-Environmental Behavior Task (Lange

et al., 2018), in which participants are given the choice between an environmentally friendly option, which prolongs the time participants have to wait in the laboratory, and an environmentally harmful option that wastes energy by turning on lights but ends the experiment earlier. However, this task cannot be administered online. Further, there are a few tasks that include choices between receiving a financial reward and offsetting carbon emissions through the cancellation of EU emissions allowance (EUA) under the EU Emissions Trading Scheme (e.g., Diederich and Goeschl 2018, Löschel et al. 2013). An example for such a task is the validated Carbon Emission Task by Berger and Wyss (2021). In the Carbon Emission Task, participants have to make 25 decisions, always choosing between two options. One option pays a monetary bonus of varying amounts and results in varying amounts of carbon dioxide emissions. The other option pays no bonus and is carbon neutral.[1] The task has real environmental consequences, as the researchers retire carbon dioxide certificates from the European Emission Trading System, lowering the total amount of emissions that can be produced in the future. Compared to the Tree Task, 25 decisions can take up a substantial amount of time, there is a risk of inconsistent decisions, and some participants might find it hard to envision the concept of carbon dioxide emission certificates. Therefore, we believe it is important to use a broader set of experimental tasks to meet the different needs of experimental set-ups. The Tree Task complements existing tasks by being a monetary incentivized, vivid, and one-shot task for assessing pro-environmental behavior.

The remainder of this paper is organized as follows: In Section 2.2, we explain the Tree Task and its validation. In Section 2.3, we describe the results, and in Section 2.4, we discuss and conclude.

2.2 Methodology

2.2.1 The Tree Task

The Tree Task consists of four parts: the task explanation, comprehension questions, the actual decision, and a question about the perceived effectiveness of planting trees to mitigate climate change.[2] Participants receive an endowment and have to decide whether they want to keep the money for themselves or spend part or all of it as a contribution to mitigate climate change. Trees are planted with the help of an international forest

[1] The following is an example of such a choice (see Berger and Wyss 2021). Option A: You will receive a bonus of 40 cents and produce a carbon emission of 4.46 lbs. (which is equivalent to driving 4.97 miles). Option B: You will not receive a bonus, and there will not be any carbon emissions.

[2] See in the Appendix B for experimental instructions. We provide ready-to-use templates for the Tree Task for otree and Qualtrics on the Open Science Framework OSF.

restoration organization—in this case, the non-profit organization tree-nation.[3] The name of the organization was not communicated to the participants to avoid any associations based on the organization's name and its reliability. Tree-nation plants the trees within a few weeks after the experiment (participants are aware of this information). Thus, a participant's decision has real-world environmental consequences.

Participants have to choose one of 11 options to be implemented, that is, plant 0 to 10 trees. All decision options are summarized in a table (see Figure 2.1 for an example), and participants see the consequences for each tree planted in terms of the money invested, the money kept for themselves, the amount of carbon dioxide offset in kilograms, and the carbon dioxide compensation translated into car kilometers driven by an average passenger vehicle. To ensure that participants understand the impact of their decisions, they are asked to answer comprehension questions. Afterward, participants make their actual decision about how many trees they want to plant. Participants can also submit their email address to receive a confirmation certificate once the trees are planted. As a control variable, participants are asked to rate how effective they consider tree planting as a climate change mitigation strategy measured on a 4-point Likert scale ranging from *very effective* to *not effective at all*. Participants who consider tree planting not effective at all to mitigate climate change are excluded from the main analysis but are added for a robustness check.

FIGURE 2.1: Exemplary presentation of the Tree Task options and their consequences

Choice	Your investment to mitigate climate change	Your remaining balance	Number of planted trees	Lifetime CO_2 offset	Lifetime CO_2 offset in car kilometers
Choice 0 trees	£ 0	£ 2.00	0	0 kg	0 km
Choice 1 tree	£ 0.20	£ 1.80	1	30 kg	120 km
Choice 2 trees	£ 0.40	£ 1.60	2	60 kg	240 km
Choice 3 trees	£ 0.60	£ 1.40	3	90 kg	360 km
Choice 4 trees	£ 0.80	£ 1.20	4	120 kg	480 km
Choice 5 trees	£ 1.00	£ 1.00	5	150 kg	600 km
Choice 6 trees	£ 1.20	£ 0.80	6	180 kg	720 km
Choice 7 trees	£ 1.40	£ 0.60	7	210 kg	840 km
Choice 8 trees	£ 1.60	£ 0.40	8	240 kg	960 km
Choice 9 trees	£ 1.80	£ 0.20	9	270 kg	1080 km
Choice 10 trees	£ 2.00	£ 0.00	10	300 kg	1200 km

[3]We bought the trees on tree-nation. This organization provides various information about the trees they offer for planting, such as carbon dioxide compensation in a lifetime, the annual carbon dioxide compensation, or the average natural lifetime of the trees.

2.2.2 Hypotheses

The Tree Task aims to be a trade-off between individual immediate financial rewards and long-term environmental gains. Therefore, decision-makers should respond to the different financial costs and carbon dioxide offset levels of a tree. In general, the price of a tree depends on factors such as the type of project, location, maintenance costs, and planting method.[4] The carbon dioxide offset of a tree depends on factors such as mass and wood density (Taverna et al., 2007). The pre-registered hypotheses address the influence of different prices and carbon dioxide offset levels per tree on the number trees planted.[5] In terms of financial costs, we expect that ceteris paribus, the higher the cost of planting a tree, the lower the number of trees planted.

Hypothesis 1: Participants plant more trees if the costs per tree are lower.

Furthermore, individuals should react to environmental benefits. Thus, we expect that the number of trees planted will increase with a higher positive environmental impact of the tree, that is, a higher carbon dioxide offset per tree.

Hypothesis 2: Participants plant more trees if the carbon dioxide offset per tree is higher.

In addition, the Tree Task should be associated with self-reported measures that are used to examine pro-environmental behavior. Therefore, we test whether the number of trees planted positively correlates with self-reports that have been associated with pro-environmental motivation and behavior.

Hypothesis 3: The number of trees planted correlates positively with pro-environmental intentions (Mancha and Yoder, 2015), environmental attitudes (Dunlap et al., 2000), belief in climate change (Berger et al., 2023), and biospheric values (De Groot and Steg, 2010).

Finally, we assess whether the number of trees planted positively correlates with individual characteristics that have been identified in previous research as positively associated with higher pro-environmental intentions or behavior.

Hypothesis 4: The number of trees planted correlates positively with higher education (Mobley et al., 2010), a liberal political ideology (Hine and Gifford, 1991), and being female (Tikka et al., 2000).

[4] See tree-nation's price rational.
[5] See pre-registration on OSF.

2.2.3 Treatments

To validate the Tree Task, we examined whether people's choices in the Tree Task are sensitive to variations in financial costs and environmental benefits. We varied the trees with respect to the price per tree (high vs. low price) and the environmental impact per tree (high vs. low amount of carbon dioxide offset per tree). These variations in the cost and carbon dioxide offset level per tree led us to three different treatments. First, a baseline (BASE) treatment presents a tree with a relatively high cost per tree and a relatively low carbon dioxide offset per tree. Second, the Low Price (LP) treatment has the same carbon dioxide offset but a lower price per tree compared to the baseline treatment. Third, the High Offset (HO) treatment has the same price as the BASE treatment, but a higher carbon dioxide offset per tree. Table 2.1 presents an overview of the treatment variations, which were based on real tree planting projects offered by tree-nation.

TABLE 2.1: Overview of the treatment variations

	BASE	**LP (Low Price)**	**HO (High Offset)**
Costs per tree [GBP]	0.25	0.13	0.25
CO_2 offset per tree [kg CO_2]	20	20	40

2.2.4 Procedure

We conducted a within-subject experiment and designed the Tree Task validation study as follows. After giving informed consent, the participants received information about the Tree Task. They were informed that they had to make three different decisions and that one of their three decisions would be randomly drawn and paid out. The participants received the same amount for each of the three treatments, independent of the cost and carbon emissions offset of a tree. Then, participants received a short text about the benefits of planting trees to mitigate climate change and answered comprehension questions. A table displayed a preview of the costs and the carbon dioxide offset per tree for each of the three decisions. This was followed by the three treatments in randomized order, in which the BASE treatment was always the second decision.

Furthermore, we administered established self-reports in the same fixed order to measure participants' pro-environmental intentions (Mancha and Yoder, 2015), environmental attitudes (Dunlap et al., 2000), biospheric values (De Groot and Steg, 2010), belief in climate change (Berger et al., 2023), and demographics. In detail, pro-environmental intentions were measured with three different items previously used by Mancha and Yoder (2015) (e.g., "I will try to reduce my carbon footprint in the forthcoming month").

The participants were asked to rate the items on a 7-point Likert scale ranging from 1 (*extremely unlikely*) to 7 (*extremely likely*, Cronbach's alpha = 0.91). Environmental attitudes were assessed using the New Ecological Paradigm (Dunlap et al. 2000, Cronbach's alpha = 0.87). Participants indicated for 15 statements about the relationship between humans and the environment how much they agreed with the statement (e.g., "We are approaching the limit of the number of people the Earth can support"). The answers were given on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*totally agree*). Biospheric (Cronbach's alpha = 0.91), altruistic (Cronbach's alpha = 0.79), egoistic (Cronbach's alpha = 0.78), and hedonistic (Cronbach's alpha = 0.84) values were measured with 16 items from De Groot and Steg (2010). Participants rated how important each value was to them as a guiding principle in their life (–1 = *opposed to my principles*, 0 = *not important*, 7 = *extremely important*). Belief in climate change was measured with a single item from Berger et al. (2023). On an 11-point Likert scale ranging from –5 (*strongly disagree*) to 5 (*strongly agree*), participants were asked to what extent they agreed with the statement that the occurrence of climate change is caused by human activities and will bring largely negative consequences. In a control question, participants indicated how effective they considered tree planting as a climate change mitigation measure (4-point Likert scale ranging from *very effective* to *not effective at all*). Finally, we assessed the demographic variables gender, age, education, political ideology, and household income.

2.2.5 Sample

The study was pre-registered on the Open Science Framework (OSF) and received ethical approval from the Faculty of Business Administration, Economics and Social Sciences of the University of Bern (serial number: 202022). We based our power analysis (G*Power 3.1.9.2, Faul et al. 2009) on Hypothesis 3, as this hypothesis was likely to be the least powerful. In a similar validation study (Lange and Dewitte, 2022), the mean correlation between the task measuring pro-environmental behavior (WEPT) and self-report scales assessing pro-environmental behavior was $r = .24$. To account for the testing of multiple hypotheses, we adjusted the alpha level to 1.25%. This adjustment resulted in a sample size of 289 participants that allowed for detecting Pearson correlations of $r = .24$ with high statistical power (corrected alpha level of 1.25%, power of 95%, two-tailed test). However, to be more robust against potential outliers, we used a non-parametric Spearman correlation analysis instead of calculating parametric Pearson correlation coefficients. The non-parametric Spearman correlation analysis is less efficient (relative efficiency = 0.91) in detecting significant relationships compared to the parametric Pearson correlation analysis (Hotelling and Pabst, 1936). Therefore, we increased the sample size with (1.00

– 0.91) / 0.91 × 100 = 10% to a total sample size of 318 participants. Given this sample size, we could detect a minimum effect size of $d = 0.2$ for hypotheses 1 and 2, given the Wilcoxon signed-rank test (matched pairs). Using an attrition rate of 20%, we aimed to recruit 382 participants.

Participants were recruited on the crowdsourcing platform Prolific on September 29, 2022. Prolific is an established crowd-working online platform (Palan and Schitter, 2018). We collected 379 completed surveys. The participants were from the United Kingdom. The experimental sessions lasted, on average, 12 minutes. Participants received a flat payment of GBP 1.50. The mean of the additional payment from the Tree Task was GBP 1.54 (range: GBP 0 to 2.5, $SD = 0.79$). In accordance with the pre-registered protocol, we excluded participants who did not complete the study within 45 minutes of starting ($n = 2$), were faster than two standard deviations from the average completion time ($n = 0$), were not approved for any other reason (e.g., did not have a valid Prolific ID, $n = 0$), failed crucial attention checks ($n = 7$), and did not consider tree planting to be an effective climate protection measure ($n = 7$).[6] The sample for the main analysis consisted of 365 participants (48% female, mean age: 39.3 years, $SD = 12.40$).

2.3 Results

The descriptive statistics are reported in Table 2.2. We found that decision-makers reacted to the financial costs of a tree, as well as to the environmental impact; thus, hypotheses 1 and 2 were supported. Participants planted significantly fewer trees in the BASE treatment compared to the LP and HO treatments ($p < .001$ for both LP and HO compared to BASE, Wilcoxon rank-sum test).[7] Furthermore, the highest number of trees was planted in the LP treatment.

[6] There were overlaps regarding participants who failed a crucial attention check and did not believe in the positive impact of planting trees ($n = 4$) and who failed both attention checks ($n = 2$).
[7] All tests are two-sided.

TABLE 2.2: Descriptive statistics: Number of trees planted per treatment

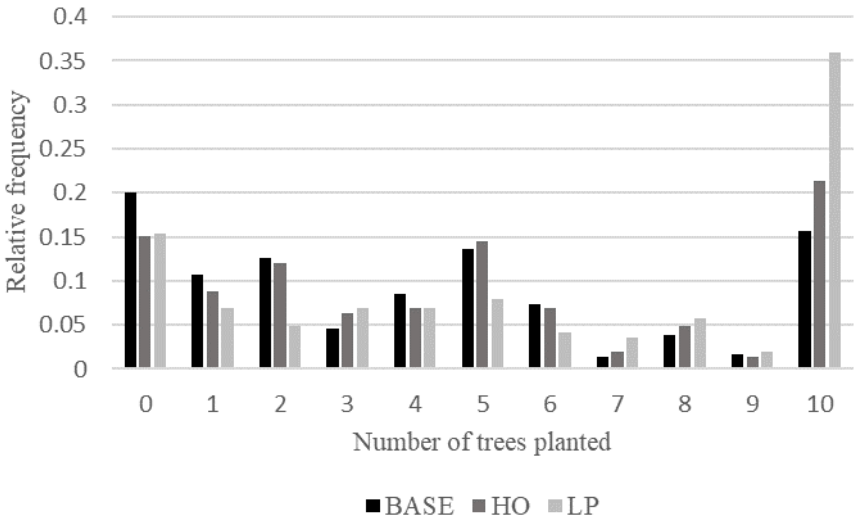
	BASE	**LP**	**HO**
Mean	4.08	5.76	4.72
SD	3.46	3.89	3.56

	BASE vs. LP	**BASE vs. HO**	**LP vs. HO**
z-score	-12.61	5.81	10.20
p-value	$p < .001$	$p < .001$	$p < .001$

Notes: BASE = High Price/Low Offset treatment, LP = Low Price treatment, HO = High Offset treatment. p-values were obtained from Wilcoxon rank-sum tests.

Figure 2.2 shows the distribution of the trees planted by treatment. The mode in the HO and LP treatments is to plant 10 trees, while the mode in the BASE treatment is to plant 0 trees. The choices in the different treatments are highly correlated (BASE vs. LP: $r = .0.79$, 95% CI [0.76, 0.83], $p < .001$; BASE vs. HO: $r = .83$, 95% CI [0.80, 0.86], $p < .001$; LP vs. HO: $r = .85$, 95% CI [0.82, 0.88], $p < .001$). This suggests that participants who chose many trees in one treatment tended to choose many trees in the other treatments as well.

FIGURE 2.2: Relative frequency of trees planted



We used the following random-effects model to check the robustness of the descriptive results:

$$y_{i,k} = \beta_0 + \beta_1' \mathbf{T_{i,k}} + \beta_2 O_i + \beta_3' \mathbf{E_i} + \beta_4' \mathbf{X_i} + \varepsilon_{i,k},$$

where $y_{i,k}$ denotes the number of trees planted by individual i in treatment k, and $\mathbf{T_{i,k}}$ is the vector of the treatments. In addition, O_i is a dummy variable to control for the order of treatments, which takes a value of 1 if the HO treatment is presented first and 0 if the LP treatment is presented first. The BASE treatment was always presented in the middle. The vector of the control variables, $\mathbf{E_i}$, encompasses pro-environmental intentions, environmental attitudes, and beliefs about climate change, while $\mathbf{X_i}$ captures the sociodemographic variables. β_0 is the intercept, and $\varepsilon_{i,k}$ is the idiosyncratic random error term.

The estimated coefficients of the random-effects regressions are displayed in Table 2.3. Specification 1 shows that the differences in the number of trees planted in the LP and HO treatments are highly statistically significant and of remarkable magnitude compared to the BASE treatment. This effect remains stable when we control for the order in which the treatments were presented (Specification 2) and environmental-related variables, including pro-environmental intentions, attitudes, belief in climate change, and individual values (Specification 3). The magnitude and statistical significance level of the treatment effects also remain robust when we control for demographic variables (Specification 4). In summary, Hypothesis 1 (the number of trees planted increases when the cost of planting a tree decreases) and Hypothesis 2 (the number of trees planted increases when there are higher environmental benefits, i.e., a higher carbon emissions offset per tree) are supported.[8] The robustness checks show (see Table 2.5 in the Appendix), that the inclusion of participants (n = 7) who do not believe in the effectiveness of tree planting does not alter the treatment effects. Further, the results also hold when we exclude opportunistic participants (n = 22) that planted no trees in the BASE treatment but at least one tree in the LP or HO treatment.

Regarding extensive margin effects, we find that lower costs (LP) and higher carbon emissions offsets (HO) have a positive effect on the likelihood of planting at least one tree compared to the BASE treatment (see Specification 1 and 2 of Table 2.7 in the Appendix A). On the intensive margin, Specification 4 and 5 of Table 2.7 indicate a statistically significant increase in the number of trees planted, conditional on planting at least one tree, for the LP treatment and the HO treatment compared to the BASE treatment. These findings suggest that the significant positive impact of low financial costs and high environmental benefits on the number of trees planted can be explained by a combination of extensive and intensive margin effects.

[8]The results remain robust when a panel Poisson model with random effects, a pooled OLS regression model or a Tobit regression model is used (see Table 2.6 in the Appendix A).

TABLE 2.3: Effects of cost and carbon emissions offset on the number of trees planted: Random-effects regression model

	No. of trees planted (1)	No. of trees planted (2)	No. of trees planted (3)	No. of trees planted (4)
LP	1.682***	1.682***	1.694***	1.703***
	(0.126)	(0.126)	(0.128)	(0.129)
HO	0.638***	0.638***	0.643***	0.647***
	(0.106)	(0.106)	(0.108)	(0.109)
Order		0.257	0.151	0.206
		(0.359)	(0.346)	(0.337)
Pro-environmental intentions			0.606***	0.605***
			(0.151)	(0.151)
Pro-environmental attitudes			0.393	0.274
			(0.413)	(0.403)
Belief in climate change			0.077	0.083
			(0.107)	(0.110)
Biospheric values			0.026	–0.000
			(0.172)	(0.172)
Altruistic values			0.130	–0.030
			(0.169)	(0.173)
Egoistic values			–0.165	–0.078
			(0.145)	(0.157)
Hedonistic values			0.006	0.037
			(0.135)	(0.135)
Female				0.897**
				(0.349)
Age in years				0.033**
				(0.015)
Education				0.576
				(0.366)
Conservative ideology				–0.129
				(0.095)
Income (> GBP 50,000)				0.226
				(0.372)
Intercept	4.079***	3.946***	–1.362	–1.95
	(0.181)	(0.267)	(1.561)	(1.774)
Sigma u	3.301	3.304	3.099	3.043
Rho	0.822	0.822	0.801	0.794
Wald chi-square	183.09	183.37	270.04	326.17
R-squared overall	0.035	0.036	0.141	0.175
No. of observations	1,095	1,095	1,077	1,071
No. of participants	365	365	359	357

Notes: The table presents estimates from random-effects regressions. Robust standard errors are clustered at the individual level and are shown in parentheses. The dependent variable is the number of trees planted. LP and HO are the treatment dummies, and BASE is the reference category. Order is a binary variable indicating the order in which the treatments were presented, either HO, BASE, and LP (= 1) or LP, BASE, and HO (= 0). Pro-environmental intentions are measured on a 7-point Likert scale. Pro-environmental attitudes are measured on a 5-point Likert scale. Belief in climate change is measured on a scale ranging from –5 (*extremely bad*) to +5 (*extremely good*). Biospheric, altruistic, egoistic, and hedonistic values range from –1 (*opposed my principles*) to 7 (*extremely important*). Age and conservative ideology are continuous variables. The remaining demographic variables are included as dummy variables: Female indicates being female (= 1) or not (= 0), Education indicates whether participants had a bachelor's, master's, or doctorate degree (= 1) or not (= 0), and Income indicates whether participants have a higher annual income than GBP 50,000 (= 1) or not (= 0). *, **, and *** document significance statistical at the 10%, 5%, and 1% levels, respectively.

Next, we tested whether the number of trees planted correlates with self-reports assessing environmental attitudes and intentions, belief in climate change, values in line with pro-environmental behavior, and demographic variables. To test hypotheses 3 and 4, we ran Spearman correlation analyses, and the results are displayed in Table 2.4. For Hypothesis 3, the total number of trees planted was correlated with pro-environmental intentions ($r = .30$, 95% CI [0.21, 0.41], $p < .001$), pro-environmental attitudes ($r = .23$, 95% CI [0.13, 0.33], $p < .001$), belief in climate change ($r = .21$, 95% CI [0.12, 0.31], $p < .001$), biospheric values ($r = .24$, 95% CI [0.15, 0.34], $p < .001$), altruistic values ($r = .21$, 95% CI [0.11, 0.31], $p < .001$), egoistic values ($r = –.08$, 95% CI [–0.18, 0.02], $p = .105$), and hedonistic values ($r = .02$, 95% CI [–0.08, 0.13], $p = .653$). All correlations, apart from the egoistic and hedonistic values, had medium-sized effects and were highly statistically significant in the expected direction. In line with other research (Lange and Dewitte, 2022), egoistic and hedonistic values were negatively correlated or do not correlate with the number of trees planted. Thus, Hypothesis 3 is supported. Regarding Hypothesis 4, we find highly significant correlations between being female ($r = .19$, 95% CI [0.08, 0.28], $p < .001$), a liberal political ideology ($r = –.17$, 95% CI [–0.29, –0.09], $p < .001$), and the number of trees planted. Furthermore, age ($r = .12$, 95% CI [0.01, 0.22], $p = .033$) and education ($r = 0.11$, 95% CI [0.01, 0.22], $p = .037$) are weakly correlated with the number of trees planted. Altogether, Hypothesis 4 is supported.

Table 2.4: Descriptive statistics and Spearman correlations for study variables (N = 365)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	Mean	SD
(1) Trees	—													4.85	3.42
(2) PE intentions	.30***	—												5.14	1.38
(3) PE attitudes	.23***	.36***	—											3.80	0.60
(4) Belief in CC	.21***	.37***	.63***	—										3.20	2.15
(5) Biospheric	.24***	.54***	.54***	.49***	—									5.23	1.43
(6) Altruistic	.21***	.39***	.34***	.43***	.62***	—								5.38	1.28
(7) Egoistic	–.08	.03	–.32***	–.12**	–.06	.02	—							2.43	1.44
(8) Hedonistic	.02	.07	–.00	.13**	.12**	.27***	.33***	—						4.72	1.45
(9) Female	.19***	.12**	.14***	.09	.06	.16***	–.04	.10	—					0.49	0.50
(10) Age in years	.12**	-.12	.12**	.03	.15***	.08***	–.28***	–.23***	.04	—				39.33	12.40
(11) Education	.12**	.08	.15***	.14***	.11**	.07	.02	–.06	–.00	–.01	—			0.66	0.48
(12) Con. ideology	–.17***	–.16***	–.22***	–.36***	–.19***	–.35***	.21***	–.11**	–.12**	.06	.07	—		4.49	0.48
(13) Income	.03	.05	–.05	–.01	.00	–.01	.20***	.08***	–.01	–.09	–.07	.00	—	0.35	0.48

Notes: Trees reflects the mean of the number of trees planted from the three treatments BASE, LP, and HO. PE = Pro-environmental, CC = Climate change, Con = Conservative. Pro-environmental intentions are measured on a 7-point Likert scale, and pro-environmental attitudes are measured on a 5-point Likert scale. Belief in climate change is measured on a scale ranging from –5 (*extremely bad*) to +5 (*extremely good*). Biospheric, altruistic, egoistic, and hedonistic values range from –1 (*opposed my principles*) to 7 (*extremely important*). In addition to age, which is a continuous variable, we included the remaining demographic variables as dummy variables. Female indicates gender, being female (= 1) or not being female (= 0), Education indicates whether participants had a bachelor's, master's, or doctorate degree (= 1) or not (= 0), Conservative ideology is measured on a scale ranging from 1 (*completely left/progressive*) to 10 (*completely right/conservative*). Income shows whether the participant's annual income is higher than GBP 50,000 (= 1) or not (= 0). *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

2.4 Discussion and conclusion

This study presents the Tree Task, an incentivized, one-shot task measuring pro-environmental behavior. The Tree Task can be used for laboratory and online studies and may also complement field studies to investigate psychological mechanisms (e.g., Binder and Blankenberg 2017, Ho et al. 2022). The Tree Task builds on a trade-off between real environmental benefits and individual costs: Participants decide whether they want to plant trees or keep the provided money for themselves. We validated the Tree Task by conducting a pre-registered, highly powered online study. The results show that the Tree Task is a valid measure for assessing pro-environmental behavior. We showed that decision-makers react to a tree's financial costs and to its environmental impact. Furthermore, the number of trees planted correlated positively with self-reports that have been associated with pro-environmental motivation and behavior. The Tree Task has already been applied twice as a dependent variable in between-subject designs. The first study showed that participants primed on future events planted significantly more trees than participants primed unrelated to the future (Essl et al., 2023a). In the second study examining the linguistic savings hypothesis (see Chen 2013) in the environmental domain, participants who read a text about the impact of climate change in the future tense planted significantly more trees than participants who read the same text in the present tense (Essl et al., 2023b).

Measuring pro-environmental behavior with the Tree Task has three main strengths. First, the decisions in the task have a real impact, because the trees are actually planted by an international forest restoration organization. The participants are informed transparently about the concrete environmental impact of the selected number of trees and are invited to receive confirmation after the trees have been planted. Altogether, this leads to a high external validity of the task. Importantly, the costs and carbon dioxide offsets of the trees offered in the Tree Task can vary. This provides researchers with flexibility in designing their studies according to their research budget. Second, the Tree Task is vivid and easy to understand. Trees are an entity that is easily understood across cultural and age boundaries, which allows the task to be tested on a wide target audience, and the results can be compared across different audiences. For example, the task could be used with children and compared cross-culturally. Third, due to the brevity of the Tree Task, it can be easily combined with measurements of other relevant types of pro-environmental behavior, such as the acceptance of environmental policies (see Heinz and Koessler 2021).

The Tree Task can be used to conduct externally and internally valid experiments on a specific type of pro-environmental behavior, that is, investing in planting trees in order to mitigate climate change. However, the task's results may not be generalizable

to all kinds of pro-environmental behaviors. The situation of interest, the conditions that govern behavior in this situation, and the experimental manipulation determine the suitability of a behavioral paradigm (Lange, 2023). The Tree Task consists of a trade-off between immediate individual monetary gains and long-term environmental benefits with regard to climate change mitigation. In certain real-life situations, other dilemmas may exist. For example, there might be a trade-off between time savings and pro-environmental behavior, as in the case when deciding between driving a car or riding a bicycle (Lange et al., 2018). In another trade-off situation people may decide against the environmentally harmful consumption of a product. Thus, they refrain from doing something bad for the environment but do not actively do something good for the environment, such as planting trees. To investigate these types of trade-offs, the Tree Task might be less applicable. Furthermore, there might not be a trade-off at all when choosing a pro-environmental action, as there can be various benefits for the individual resulting from pro-environmental behavior (Chancellor and Lyubomirsky, 2011, Prinzing, 2023). For example, a voluntary reduction in consumption may help individuals perceive a stronger sense of authenticity (Zavestoski, 2002), may reduce the risk of falling into debt (Nepomuceno and Laroche, 2015), and may lead to higher life satisfaction (Hüttel et al., 2020).

The Tree Task complements existing approaches to measuring pro-environmental behavior. Researchers are encouraged to use the Tree Task to measure consequential pro-environmental behavior in the lab or online. Detailed instructions, as well as oTree and Qualtrics templates for the task, are available on OSF.

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Appendix A: Additional analysis

TABLE 2.5: Robustness checks for different samples: Random-effects regression model

Sample		No. of trees planted	No. of trees planted
Main sample			
	LP	1.682***	1.703***
		(0.126)	(0.129)
	HO	0.683***	0.647***
		(0.106)	(0.109)
	No. of observations	1095	1071
	No. of participants	365	357
Incl. tree planting skeptics			
	LP	1.661***	1.686***
		(0.124)	(0.127)
	HO	0.626***	0.636***
		(0.105)	(0.108)
	No. of observations	1116	1089
	No. of participants	372	363
Excl. opportunistic participants			
	LP	1.472***	1.490***
		(0.113)	(0.116)
	HO	0.397***	0.400***
		(0.082)	(0.085)
	No. of observations	1029	1005
	No. of participants	343	335
Total sample			
	LP	1.642***	1.676***
		(0.121)	(0.124)
	HO	0.600***	0.627***
		(0.102)	(0.105)
	No. of observations	1155	1119
	No. of participants	385	373
	Additional controls		
	Order of treatments	NO	YES
	Environmental variables	NO	YES
	Demographic variables	NO	YES

Notes: The table presents the coefficients of the treatment dummy variables (LP and HO) of specifications 1 and 4 of Model 1 for the main sample, the sample including tree skeptics, and the total sample. The dependent variable is the number of trees planted. LP and HO are the treatment dummies, with BASE as the reference category. Robust standard errors are clustered at the individual level and are shown in parentheses. The estimates for the main sample are equal to those of specifications 1 and 4 in Table 3. Order of treatments is a binary variable indicating the order in which the treatments were presented, either HO, BASE, and LP (= 1) or LP, BASE, and HO (= 0). Environmental variables include pro-environmental intentions, environmental attitudes, belief in climate change, and biospheric, hedonistic, egoistic, and altruistic values. Demographic variables include gender, age, education, political ideology, and income. The step-by-step inclusion of control variables shows that these results are robust. Regression results are available upon request. *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

TABLE 2.6: Robustness checks using different regression models: Panel Poisson regression, pooled OLS regression model, and Tobit regression model

	Panel Poisson regression model		Pooled OLS regression model		Tobit regression model	
	# trees	# trees	# trees	# trees	# trees	# trees
LP	0.345***	0.353***	1.682***	1.703***	2.753***	2.769***
	(0.027)	(0.028)	(0.126)	(0.129)	(0.230)	(0.232)
HO	0.145***	0.149***	0.638***	0.647***	1.063***	1.050***
	(0.025)	(0.025)	(0.106)	(0.109)	(0.182)	(0.183)
Order of treatments		0.028		0.206		0.258
		(0.079)		(0.337)		(0.551)
Pro-environmental intentions		0.152***		0.605***		0.912***
		(0.047)		(0.151)		(0.248)
Pro-environmental attitudes		0.111		0.274		0.369
		(0.102)		(0.403)		(0.644)
Belief in climate change		0.024		0.083		0.207
		(0.033)		(0.110)		(0.189)
Biospheric values		–0.018		–0.000		0.084
		(0.048)		(0.172)		(0.272)
Altruistic values		–0.001		–0.030		-0.129
		(0.046)		(0.173)		(0.288)
Egoistic values		–0.008		–0.078		-0.089
		(0.036)		(0.157)		(0.253)
Hedonistic values		–.001		0.037		0.082
		(0.030)		(0.135)		(0.230)
Female		0.204**		0.897**		1.550***
		(0.083)		(0.349)		(0.576)
Age in years		0.007*		0.033**		0.057**
		(0.003)		(0.015)		(0.025)
Education		0.108		0.576		0.935
		(0.090)		(0.366)		(0.594)
Conservative ideology		–0.014		–0.129		-0.179
		(0.023)		(0.095)		(0.152)
Income (>GBP 50,000)		0.058		0.226		0.270
		(0.088)		(0.372)		(0.622)
Constant	1.406***	–0.233	4.079***	–1.950	3.850***	-6.010**
	(0.0443)	(0.504)	(0.181)	(1.774)	(0.293)	(2.888)
Ln alpha	–0.121	–0.239				
	(0.348)	(0.364)				
Wald chi-square (2)	4803.28	4915.57				
R-squared			0.035	0.175		
Var(e.tree)					33.446	27.717
					3.437	2.887
No. of observations	1095	1071	1095	1071	1095	1071
No. of participants	365	357	365	357	365	357

Notes: TThe table presents estimates from the panel Poisson regression model with random effects, a pooled OLS regression model, and a Tobit regression model. Robust standard errors clustered at the individual level are shown in parentheses. The dependent variable is the number of trees planted. LP and HO are the treatment dummies, with BASE as the reference category. All other variables are explained in Table 2.3. The step-by-step inclusion of control variables shows that these results are robust. Regression results are available upon request. *, **, and *** document significance at the 10%, 5%, and 1% levels, respectively.

TABLE 2.7: Extensive and intensive margin analysis

	Pooled logit regression model		Pooled OLS regression model	
	Prob. of planting trees	Prob. of planting trees	No. of trees planted cond.	No. of trees planted cond.
LP	0.322***	0.343***	1.707***	1.720***
	(0.081)	(0.084)	(0.133)	(0.137)
HO	0.362***	0.386***	0.456***	0.423***
	(0.091)	(0.092)	(0.110)	(0.115)
Order of treatments		0.142		0.121
		(0.284)		(0.334)
Pro-environmental intentions		0.203		0.575***
		(0.126)		(0.163)
Pro-environmental attitudes		0.456		0.016
		(0.324)		(0.420)
Belief in climate change		0.105		-0.022
		(0.086)		(0.114)
Biospheric values		0.002		0.009
		(0.132)		(0.181)
Altruistic values		-0.059		-0.032
		(0.145)		(0.175)
Egoistic values		0.094		-0.170
		(0.129)		(0.153)
Hedonistic values		0.064		-0.002
		(0.112)		(0.128)
Female		0.867***		0.371
		(0.309)		(0.338)
Age in years		0.016		0.027*
		(0.012)		(0.015)
Education		0.186		0.548
		(0.300)		(0.366)
Conservative ideology		0.009		-0.146
		(0.080)		(0.094)
Income (> GBP 50,000)		-0.139		0.365
		(0.313)		(0.365)
Intercept	1.386***	-3.048**	5.099***	1.417
	(0.131)	(1.447)	(0.183)	(1.952)
Wald chi-square (2)	18.38	66.55		
Pseudo-R-squared/R-squared	0.004	0.107	0.048	0.151
No. of observations	1,095	1,071	911	887
No. of participants	365	357	314	306

Notes: 1 and 2 present estimates from a pooled logit regression model on the probability of planting at least one tree. Specification 3 and 4 present estimates from a pooled OLS regression model with the number of trees planted conditional on planting at least one tree as the dependent variable. Robust standard errors clustered at the individual level are shown in parentheses. LP and HO are the treatment dummies, and BASE is the reference category. All other variables are explained in Table 2.3. The step-by-step inclusion of control variables shows that these results are robust. Regression results are available upon request. *, **, and *** document significance at the 10%, 5%, and 1% levels, respectively.

Appendix B: Experimental instructions

Welcome and thank you for your participation!

In this study, we will ask you to work on three decision tasks and several survey questions.

All tasks and questions are for research purposes only. Your decisions and answers will be anonymised and will not influence the terms of any future studies offered to you on Prolific.

Click "Continue" to begin the study.

—Page Break—

Description of the decision task

In this part, you will be asked to make three decisions that may affect your additional payment. In each of the three decision tasks, you will be asked to decide between 11 options.

- For each decision task, you will receive GBP 2.50. You will decide whether you want to keep all of the money for yourself, or whether you want to invest parts or all of it as a contribution to fight climate change.
- The money that you decide **NOT** to keep will be invested to plant trees and thus, offset carbon dioxide (CO_2).
- The higher the amount of CO_2 offsets, the better for the environment.
- The CO_2 emissions that can be offset by one tree vary between the decision tasks. Each tree offsets a certain amount of CO_2 emissions and has a different price, depending on which kind of tree is planted.
- An international forest restoration organization will plant the trees within the next two months. Thus, each decision will have an actual and true consequence for the environment. They are **NOT** hypothetical decisions.

Your actual payment for the decision tasks and the planting of the trees will be based on **one of your three** decisions. One of your three decisions will be randomly drawn and **paid out.** Note that each decision is equally likely to be selected, and because you do not know which decision will be selected, you should pay close attention to the decisions you make.

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Why plant trees to fight climate change?

The climate crisis will have an increasingly negative impact in the coming decades. Carbon dioxide (CO_2) is regarded as a key contributor to climate change, and scientists around the globe agree that climate change can be mitigated only if carbon emissions are dramatically reduced and captured. Trees absorb CO_2, making reforestation one of the most effective carbon capture solutions (Intergovernmental Panel on Climate Change, 2022). Therefore, planting more trees will lead to a greater offset of CO_2 emissions and to a greater contribution to the fight against climate change.

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Example for a decision task

- The table below shows different choices and their consequences:
- The first column is the number of the choice.
- The second column shows the different investments that you can make to fight climate change.
- The third column shows the amount of money that you will keep for yourself (your remaining balance).
- For each investment, the corresponding number of trees that will be planted is shown in column 4.
- Column 5 shows the total amount of CO_2 that will be offset by the planted trees during their lifetime.
- To help you better understand the positive environmental effect of your investment, in column 6 the lifetime CO_2 offset is translated into how many car kilometres travelled by an average passenger car can be offset by your choice.
- You are asked to select **ONE** of the choices.

Choice	Your investment to fight climate change	Your remaining balance	Number of planted trees	Lifetime CO_2 offset	Lifetime CO_2 offset in car kilometers
Choice 0 trees	£ 0	£ 2.50	0	0 kg	0 km
Choice 1 tree	£ 0.20	£ 2.30	1	30 kg	120 km
Choice 2 trees	£ 0.40	£ 2.10	2	60 kg	240 km
Choice 3 trees	£ 0.60	£ 1.90	3	90 kg	360 km
Choice 4 trees	£ 0.80	£ 1.70	4	120 kg	480 km
Choice 5 trees	£ 1.00	£ 1.50	5	150 kg	600 km
Choice 6 trees	£ 1.20	£ 1.30	6	180 kg	720 km
Choice 7 trees	£ 1.40	£ 1.10	7	210 kg	840 km
Choice 8 trees	£ 1.60	£ 0.90	8	240 kg	960 km
Choice 9 trees	£ 1.80	£ 0.70	9	270 kg	1080 km
Choice 10 trees	£ 2.00	£ 0.50	10	300 kg	1200 km

Now, suppose you receive GBP 2.50 and you select "Choice 8 trees":

- You invest GBP 1.60 (column 2) of your GBP 2.50 to fight climate change.
- Thus, you keep GBP 0.90 for yourself (column 3).
- The money that you invest to fight climate change will be used to plant 8 trees (column 4) that lead to the trees' lifetime CO_2 offset of 240 kg (column 5).
- This means that the lifetime CO_2 absorption of the 8 trees planted will offset about 960 car kilometers (column 6) travelled by an average passenger car.

Comprehension check

To ensure that we have explained the decision task comprehensibly, we ask you to answer the following questions.

Please assume that you selected "Choice 3 trees".

- How much money in GBP do you invest to fight climate change? (numeric values only, without unit sign; "." as decimal separator)
- How much money in GBP do you keep for yourself? (numeric values only, without unit sign; "." as decimal separator)
- How many trees are planted with the money you invest to fight climate change?
- How much CO_2 do you offset in kg? (numeric values only, without unit sign)

Cost and CO_2 offset per tree

The table below displays a preview of the costs and CO_2 offset per tree for each of the three decision tasks.

Decision task 1	Each tree costs **GBP 0.13** and **offsets 20 kg CO_2**
Decision task 2	Each tree costs **GBP 0.25** and **offsets 20 kg CO_2**
Decision task 3	Each tree costs **GBP 0.25** and **offsets 40 kg CO_2**

Comprehension Check
To ensure that we have explained the costs and CO_2 offset per tree comprehensibly, we ask you to answer the following questions.

- In Decision task 1 and Decision task 2, each tree offsets 20 kg CO_2. In Decision task 2, a tree costs GBP 0.25, how much does a tree cost in Decision task 1? (numeric values only, without unit sign; "." as decimal separator)

- In Decision task 2 and Decision task 3, each tree costs GBP 0.25. In Deicison task 2, a tree offsets 20 kg CO_2, how much does a tree offset in Decision task 3 (numeric values only, without unit sign)
- Please insert your e-mail if you want to receive a confirmation that the trees have been planted.

—Page Break—

Decision task 1

Decision task 1	Each tree costs **GBP 0.13** and **offsets 20 kg CO_2**
Decision task 2	Each tree costs **GBP 0.25** and **offsets 20 kg CO_2**
Decision task 3	Each tree costs **GBP 0.25** and **offsets 40 kg CO_2**

For this decision task, you will receive **GBP 2.50** to decide on.

The price to plant one tree that offsets **20 kg of carbon dioxide (CO_2)** over its lifetime is **GBP 0.13.** This corresponds to an offset of about 80 car kilometers of an average passenger car (also see "Choice 1 tree" in the table below).

Choice	Your investment to fight climate change	Your remaining balance	Number of planted trees	Lifetime CO_2 offset	Lifetime CO_2 offset in car kilometers
Choice 0 trees	£ 0	£ 2.50	0	0 kg	0 km
Choice 1 tree	£ 0.13	£ 2.37	1	20 kg	80 km
Choice 2 trees	£ 0.26	£ 2.24	2	40 kg	160 km
Choice 3 trees	£ 0.39	£ 2.11	3	60 kg	240 km
Choice 4 trees	£ 0.52	£ 1.98	4	80 kg	320 km
Choice 5 trees	£ 0.65	£ 1.85	5	100 kg	400 km
Choice 6 trees	£ 0.78	£ 1.72	6	120 kg	480 km
Choice 7 trees	£ 0.91	£ 1.59	7	140 kg	560 km
Choice 8 trees	£ 1.04	£ 1.46	8	160 kg	640 km
Choice 9 trees	£ 1.17	£ 1.33	9	180 kg	720 km
Choice 10 trees	£ 1.30	£ 1.20	10	200 kg	800 km

Keep in mind: The following decision could be randomly selected and implemented. Thus, the decision is about real money and consequences for the environment.

Please select your "Choice" that will be implemented (dropdown menu ranging from Choice 0 trees to Choice 10 trees).

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Decision task 2

Decision task 1	Each tree costs **GBP 0.13** and **offsets 20 kg CO_2**
Decision task 2	Each tree costs **GBP 0.25** and **offsets 20 kg CO_2**
Decision task 3	Each tree costs **GBP 0.25** and **offsets 40 kg CO_2**

For this decision task, you will receive **GBP 2.50** to decide on.

The price to plant one tree that offsets **20 kg of carbon dioxide (CO_2)** over its lifetime is **GBP 0.25.** This corresponds to an offset of about 80 car kilometers of an average passenger car (also see "Choice 1 tree" in the table below).

Choice	Your investment to fight climate change	Your remaining balance	Number of planted trees	Lifetime CO_2 offset	Lifetime CO_2 offset in car kilometers
Choice 0 trees	£ 0	£ 2.50	0	0 kg	0 km
Choice 1 tree	£ 0.25	£ 2.25	1	20 kg	80 km
Choice 2 trees	£ 0.50	£ 2.00	2	40 kg	160 km
Choice 3 trees	£ 0.75	£ 1.75	3	60 kg	240 km
Choice 4 trees	£ 1.00	£ 1.50	4	80 kg	320 km
Choice 5 trees	£ 1.25	£ 1.25	5	100 kg	400 km
Choice 6 trees	£ 1.50	£ 1.00	6	120 kg	480 km
Choice 7 trees	£ 1.75	£ 0.75	7	140 kg	560 km
Choice 8 trees	£ 2.00	£ 0.50	8	160 kg	640 km
Choice 9 trees	£ 2.25	£ 0.25	9	180 kg	720 km
Choice 10 trees	£ 2.50	£ 0	10	200 kg	800 km

Keep in mind: The following decision could be randomly selected and implemented. Thus, the decision is about real money and consequences for the environment.

Please select your "Choice" that will be implemented (dropdown menu ranging from Choice 0 trees to Choice 10 trees).

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Decision task 3

Decision task 1	Each tree costs **GBP 0.13** and **offsets 20 kg CO_2**
Decision task 2	Each tree costs **GBP 0.25** and **offsets 20 kg CO_2**
Decision task 3	Each tree costs **GBP 0.25** and **offsets 40 kg CO_2**

For this decision task, you will receive **GBP 2.50** to decide on.

The price to plant one tree that offsets **40 kg of carbon dioxide (CO_2)** over its lifetime is **GBP 0.25.** This corresponds to an offset of about 1600 car kilometers of an average passenger car (also see "Choice 1 tree" in the table below).

Choice	Your investment to fight climate change	Your remaining balance	Number of planted trees	Lifetime CO_2 offset	Lifetime CO_2 offset in car kilo-meters
Choice 0 trees	£ 0	£ 2.50	0	0 kg	0 km
Choice 1 tree	£ 0.25	£ 2.25	1	40 kg	160 km
Choice 2 trees	£ 0.50	£ 2.00	2	80 kg	320 km
Choice 3 trees	£ 0.75	£ 1.75	3	120 kg	480 km
Choice 4 trees	£ 1.00	£ 1.50	4	160 kg	640 km
Choice 5 trees	£ 1.25	£ 1.25	5	200 kg	800 km
Choice 6 trees	£ 1.50	£ 1.00	6	240 kg	960 km
Choice 7 trees	£ 1.75	£ 0.75	7	280 kg	1120 km
Choice 8 trees	£ 2.00	£ 0.50	8	320 kg	1280 km
Choice 9 trees	£ 2.25	£ 0.25	9	360 kg	1440 km
Choice 10 trees	£ 2.50	£ 0	10	400 kg	1600 km

Keep in mind: The following decision could be randomly selected and implemented. Thus, the decision is about real money and consequences for the environment.

Please select your "Choice" that will be implemented (dropdown menu ranging from Choice 0 trees to Choice 10 trees).

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Survey

To conclude this study, we ask you to answer a final survey. Please answer honestly; you are reminded that all questions are for research purposes only. Your answers will be entirely anonymised and will not influence the terms of any future studies offered to you on Prolific. At the end, you will receive your completion code. Please make sure to copy the code and enter it on Prolific.

Here, we ask you about your behavior in the forthcoming month. Please rate the following statements on the 7-point scale: (Answering options: *extremely unlikely, moderately unlikely, somewhat unlikely, neither likely nor unlikely, somewhat likely, moderately likely, extremely likely*)

- I will try to reduce my carbon footprint in the forthcoming month.
- I intend to engage in environmentally friendly behavior in the forthcoming month.
- I plan to stop wasting natural resources in the forthcoming month.

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Listed below are statements about the relationship between humans and the environment. For each one, please indicate how much you agree with it. (Answering options on a 5-point Likert scale: *strongly disagree, somewhat disagree, unsure, somewhat agree, totally agree*)

- We are approaching the limit of the number of people the earth can support.
- Humans have the right to modify the natural environment to suit their needs.
- When humans interfere with nature it often produces disastrous consequences.
- Human ingenuity will ensure that we do NOT make the earth unlivable.
- Humans are severely abusing the environment.
- The earth has plenty of natural resources if we just learn how to develop them.
- Plants and animals have as much right as humans to exist.
- The balance of nature is strong enough to cope with the impacts of modern industrial nations.
- Despite our special abilities humans are still subject to the laws of nature.
- Please select "totally agree".
- The so-called ecological crisis facing humankind has been greatly exaggerated.
- The earth is like a spaceship with very limited room and resources.
- Humans were meant to rule over the rest of nature.
- The balance of nature is very delicate and easily upset.
- Humans will eventually learn enough about how nature works to be able to control it.
- If things continue on their present course, we will soon experience a major ecological catastrophe.

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Below you will find 16 values. Behind each value there is a short explanation concerning the meaning of the value. Please rate how important each value is for you AS A GUIDING PRINCIPLE IN YOUR LIFE? You can use the values in-between to indicate where you fall on the scale. In the following scale: -1 means *opposed to my principles*, 0 means *not important*, 7 means *extremely important*. (Answering options on a 9-point Likert scale ranging from *-1* to *7*).

- EQUALITY: equal opportunity for all
- RESPECTING THE EARTH: harmony with other species
- SOCIAL POWER: control over others, dominance

- PLEASURE: joy, gratification of desires
- UNITY WITH NATURE: fitting into nature
- A WORLD AT PEACE: free of war and conflict
- WEALTH: material possessions, money
- AUTHORITY: the right to lead or command
- SOCIAL JUSTICE: correcting injustice, care for the weak
- ENJOYING LIFE: enjoying food, sex, leasure, etc.
- Please select "opposed to my principles"
- PROTECTING THE ENVIRONMENT: preserving nature
- INFLUENTIAL: having an impact on people and events
- HELPFUL: working for the welfare of others
- PREVENTING POLLUTION: protecting natural resources
- SELF-INDULGENT: doing pleasant things
- AMBITIOUS: hard working, aspiring

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- To what extent do you agree with this statement: The occurrence of climate change is caused by human activities and will bring largely negative consequences. You can use the values in-between to indicate where you fall on the scale. In the following scale: -5 means *strongly disagree*, 5 means *strongly agree.*
- How effective do you consider tree planting to be as a climate protection measure? (Answering options: *not effective at all, not very effective, effective, very effective*)

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- What is your gender? (Answering options: *female, male, prefer not to say, prefer to self-describe*)
- How old are you?
- What is the highest degree or level of education you have completed? (Answering options: *less than High School diploma, High School or equivalent, Bachelor degree (e.g., BA, BSc), Master degree (e.g., MA, MS, MEd), Doctorate (e.g., PhD, EdD, DBA), other education*)
- In political matters, people talk of "the left/progressive" and "the right/conservative". How would you place your views on a scale of 1 (*completely left/progressive*) to 10 (*completely right/conservative*)? You can use the values in-between to indicate where you fall on the scale.

- Are you generally a person who is willing to take risks or do you try to avoid taking risks? In the following scale: 1 means *not at all willing to take risks*, 10 means *very willing to take risks*. You can use the values in-between to indicate where you fall on the scale.
- What is your household income per year? Please estimate your answer in British pounds.
- What is your Prolific ID?

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Thank you very much for your participation in this study.

Decision task XX is randomly selected for payment. In decision task XX you invested GBP XX to plant XX trees to fight climate change. Thus, your additional payment is GBP XX. We will transfer this payment to you within the next week. Please note that this additional payment might arrive later than the flat payment (GBP 1.50) and might be listed as a separate transaction.

To confirm that you have completed this study, please copy and paste the following completion code manually into the Prolific app upon your return: XX

Essay 3: Let's think about the future – The effect of positive and negative future primes on pro-environmental behavior

Andrea Essl, David Hauser, Frauke von Bieberstein*

Abstract

In an online experiment (N = 810), we examine whether primes on positive and negative future events unrelated to an environmental context affects pro-environmental behavior measured with an incentivized decision task. In this task, individuals decide between keeping money for themselves and investing part or the entire amount in planting trees. The results show that participants primed on future events plant significantly more trees and have higher pro-environmental intentions than participants in the control group, who were primed on leisure activities unrelated to the future. However, we find no statistically significant difference between the positive and negative future priming conditions. Exploring different potential mechanisms behind our results, we find that both future primes activated greater concern for the future and the environment, whereas the leisure prime triggered present concerns. While these results align with our research question, we cannot rule out that the leisure priming may have activated other concerns, unrelated to the present or future, potentially leading to fewer trees planted.

Keywords: priming, future orientation, pro-environmental behavior, experiment
JEL classification: C91, D90, Q50

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3.1 Introduction

When dealing with environmental problems, decision-makers often face a trade-off between immediate self-interest (e.g., saving time or saving money by choosing the less environmentally friendly option) and longer-term collective interests (e.g., mitigating climate change or protecting the environment). This trade-off is particularly strong when the temporal lag between actions and consequences is large (Zhu et al., 2020). Consequently, temporal distance is viewed as a major psychological barrier that hinders pro-environmental behavior in many areas, including climate change mitigation (Joireman, 2005, Zaval et al., 2015). Previous research has shown that decision-makers perceive temporal distance differently and that time perspectives affect pro-environmental behavior (Arnocky et al., 2014). Future orientation leads individuals to attach importance to future consequences and invest in the future (Joireman, 2005). Therefore, shifting people's temporal orientation toward the future could be an effective way to increase pro-environmental behavior.

In this study, we examine whether priming on future events can increase future orientation and therefore, enhance pro-environmental behavior. Priming refers to subtly highlighting specific cues that unconsciously influence people's behavior in subsequent tasks (Alempaki et al., 2019, Cohn and Maréchal, 2016). Although several studies in environmental behavioral research examine the effect of environmental priming on pro-environmental attitudes and self-reported behavior (e.g., Bimonte et al. 2020, Johe and Bhullar 2016, Lutzke et al. 2019), we investigate whether primes on future events unrelated to an environmental context influence pro-environmental behavior measured by an incentivized decision task with true environmental consequences.

In addition, we investigate whether individuals behave differently depending on whether the framing of the primes on future events is positive or negative. Framing refers to the presentation of the same information in two different ways – as a gain (positive) or a loss (negative). According to prospect theory, loss frames are powerful because given loss aversion, losses loom larger than gains of equal size, which, in turn, motivates decision-makers to avoid losses (Kahneman and Tversky, 1979). Therefore, priming on negative future events may create a sense of potential loss among participants, which may lead to increased investment to address climate change. However, there are also valid explanations for the positive effects of gain framing on pro-environmental decisions. For example, loss frames may evoke greater psychological reactance than gain frames, leading people to resist the social influence of others (Nabi et al., 2018). In addition, several pro-environmental behaviors such as climate change mitigation can be viewed as preventive behavior, and research in the fields of health and behavioral decision theory

has found that gain frames are more effective in triggering preventive actions (Spence and Pidgeon, 2010). Therefore, positive primes could also increase pro-environmental behavior.

To answer our main research question of whether priming on positive and negative future events influences pro-environmental behavior, we conducted a between-subject online experiment (N = 810) with two treatment groups and one control group. The two treatment groups varied in terms of whether the framing of the priming questions on future events is positive or negative. The study consisted of four parts. The first part comprised our key experimental manipulation. Participants in the positive future treatment (PF) and the negative future treatment (NF) answered six questions about positive or negative events, respectively, that might happen in the future (e.g., "What are the three best (worst) things that could happen to you in the next 10 years? or "How will people change the world for the better (the worse) in the next 30 years?"). Participants in the control group answered six questions about leisure activities that are unrelated to the future (e.g., "What are the three most important criteria for experiencing a perfect vacation?" or "How can people make the most of their leisure time?"). In the second part, we administered word-stem completion tasks to assess the mental accessibility of future orientation. In the third part, participants received an endowment and had to decide to keep the money or invest all or part of it in planting trees. Therefore, this incentivized decision task represents a trade-off between individual short-term financial rewards and long-term environmental gains. In the fourth part, we assessed the participants' pro-environmental intentions using established self-reporting scales, sociodemographic variables, and environmental attitudes.

The results show that participants primed on positive and negative future events plant significantly more trees than those primed on leisure activities. However, we find no statistically significant difference between the positive and negative future priming conditions. Priming on both positive and negative future events results in a statistically significant increase in the number of trees planted of about 10% (equivalent to one additional tree planted) compared to priming on leisure activities. In addition, we consider the effect of future primes on pro-environmental intentions and find that individuals who were primed on positive or negative future events have significantly higher pro-environmental intentions than those who were primed on leisure activities.

The word-stem completion task in the second part of the experiment allows us to explore the potential mechanisms behind the observed treatment effects. We find that the frequency of future-related words is statistically significantly higher in the future treatments compared to the control group, primed on future-unrelated leisure activities. Conversely, present-related words were more frequently observed in the control group

than in the future treatments. Importantly, the focus on leisure activities in the control treatment may also have activated other concerns unrelated to the present or future. In particular, the mental accessibility of seriousness might be lower in our leisure-related control treatment compared to the future treatments, potentially leading to fewer trees planted. However, we observe a higher frequency of serious-related words only in the negative future treatment compared to both other treatments, but not when comparing the positive future treatment and the leisure-related control treatment. Although this aligns with present- and future-related concerns driving our results, based on our design, we cannot rule out the possibility that the leisure treatment may have activated other concerns influencing behavior. In addition, we observe that thinking about the future implicitly triggers environmental concerns. The findings reveal that participants in both future treatments mentioned environment-related words significantly more frequently compared to participants in the control group.

Our results contribute to the existing literature in several ways. First, the results show that making a future-related context more salient may increase pro-environmental intentions and behavior. Therefore, priming people on future events can be an effective, low-cost, and easy-to-implement way to encourage pro-environmental behavior. Second, we extend environmental research by activating future orientation through priming questions about positive and negative future events that are independent of an environmental context. This can be beneficial because some people feel pessimistic and hopeless when thinking about environmental issues, which can cause them to remain inactive (Moser, 2007). Third, this study adds to previous work that examined the impact of gain and loss framing on pro-environmental behavior (Ropret Homar and Knežević Cvelbar, 2021, Nabi et al., 2018). We find that compared to the leisure-related control condition, positive and negative future priming lead to a statistically significant increase in pro-environmental behavior, but with no significant difference in the effect between them. Fourth, we aim to provide preliminary insights into whether the observed priming effects actually operate through the proposed mechanism of future orientation. Interestingly, we find that the questions on future events activate not only future orientation as a mental concept but also environmental concerns. Furthermore, we show that people primed on leisure activities develop a more present-related mental concept than people primed on future events and that serious-related thoughts are most frequent when primed on negative future events. Finally, from a methodological point of view, we measure pro-environmental behavior with an incentivized decision task with true environmental consequences (Essl et al., 2023). Thus far, environmental priming experiments have often relied on self-reports and questionnaires as dependent variables.

3.2 Related literature

This study contributes to three streams of literature: (1) research on priming interventions in environmental behavioral research, (2) literature addressing the relation between future orientation and pro-environmental behavior, and (3) research on positive (gain) and negative (loss) framing in the context of environmental research.

3.2.1 Priming in environmental behavioral research

Priming is a well-established tool in behavioral research that refers to subtly highlighting a specific context (e.g., climate change or work environment) or identity (e.g., job identity or race) (Alempaki et al., 2019, Cohn and Maréchal, 2016). The prime often consists of meanings that activate associated memories (norms, stereotypes, attitudes, etc.) and unconsciously influence people's behavior in a subsequent task (Tulving et al., 1982). Priming is a low-cost manipulation tool that can be easily implemented using versatile techniques (e.g., word primes, visual primes, writing tasks, or questionnaires; Cohn and Maréchal 2016).

In environmental behavioral research, several studies have examined the effect of conceptual priming on pro-environmental attitudes. For example, Johe and Bhullar (2016) prime participants on organic identity through videos and text mining and demonstrate that organic identity priming leads to significantly higher intentions to purchase organic products compared to pro-environmental identity and control conditions. Bimonte et al. (2020) prime participants with video clips on different visual stories of a smartphone's lifecycle and show that people primed on pro-environmental attitudes state a higher hypothetical willingness to pay for an eco-friendly smartphone. Danner and Thøgersen (2022) use pro-environmental online primes and show that primes with high salience are more effective for promoting pro-organic behavior in a hypothetical choice experiment than primes with low salience. Most environmental research on priming largely uses non-incentivized, self-reported constructs, such as attitudes, willingness to pay, and intentions. An exception is Clot et al. (2022), who show that individuals primed by green product evaluations are more likely to recycle than individuals in the control group. In addition, previous environmental priming studies have in common that they use primes to highlight an environmental context. We contribute to this literature by priming participants on future events without explicitly mentioning the environmental context and analyzing the effects of this induced priming on pro-environmental behavior measured with an incentivized task.

3.2.2 Future orientation and pro-environmental behavior

Decisions that affect environmental issues, such as climate change, pose a combination of a temporal and a social dilemma expressed by a conflict between individual benefits in the present (e.g., eating meat) and benefits for society and the environment in the distant future (e.g., mitigating global warming) (Joireman and Liu, 2014, Khachatryan et al., 2013, Milfont et al., 2012). Therefore, in addition to social distance, temporal distance is viewed as one of the key psychological barriers that hinder pro-environmental behavior (Joireman, 2005, Zaval et al., 2015). As the long-term benefits of pro-environmental behavior often involve immediate costs, time perspectives might influence an individual's decision to act in a pro-environmental way (Arnocky et al., 2014). Future orientation is associated with attaching importance to the future consequences of present actions and attempting to restrain from fulfilling immediate desires by investing in the future, such as through pro-environmental behavior (Joireman, 2005).

Previous researchers have shown that future orientation correlates with pro-environmental attitudes (Milfont and Gouveia, 2006), intentions (Gu et al., 2020), and engagement in sustainable behavior (Carmi and Arnon, 2014, Joireman et al., 2001, 2004). For example, Joireman et al. (2001) show that higher future orientation is positively related to the intention to engage and to actual engagement in pro-environment activism. Furthermore, Joireman et al. (2004) find that preferences for public transportation are positively associated with future orientation. Gu et al. (2020) demonstrate that perceived ecological resource scarcity has a positive effect on pro-environmental behavior and environmental donation intentions only when sufficient future orientation is present. Recent work from Hoffmann et al. (2022) finds significant interaction effects of future orientation and gender on pro-environmental behavior. More future-negative-oriented males behave significantly more environmentally friendly compared to less future-negative-oriented males and future-negative-oriented females.

If sustainable behavior change can be achieved through an increased future orientation, then methods and tools are needed to activate future orientation. Recent experimental research has explored approaches to increase individuals' future orientation to trigger pro-environmental behaviors. Most of these studies use environmental issues to activate future orientation. For example, several studies try to increase future orientation by encouraging individuals to consider the impact of climate change on future generations (Milfont et al., 2012). Pahl and Bauer (2013) show that taking the perspective of a person being affected by negative environmental changes in the future increases environmental engagement. Relatedly, Hurlstone et al. (2020) activated environmental legacy motives by presenting three text passages. These passages were either about leaving a positive legacy, addressing the imbalance of power between current and future generations, or emphasizing

intergenerational reciprocity, all of which were interconnected with environmental issues. Their results indicate that primes that activate the desire to build a positive legacy can increase the willingness to make sacrifices for future generations. Shrum (2021) used two writing tasks, an essay and a letter to a person living in the future, focusing on the future risks of climate change, and finds that both writing tasks increase the willingness to donate to an environmental charity compared to a control group. In addition, instead of focusing on future generations, Lee et al. (2020) reveal that projecting the self into the future to pre-experience climate change is associated with a greater tendency to perform pro-environmental behavior. Svenningsen and Thorsen (2021) find that framing climate policy actions in terms of avoiding losses for future generations leads to a higher hypothetical willingness to pay for additional climate policies than framing them in terms of regaining income for future generations.

More closely related to the present study, Zaval et al. (2015) suggest that the positive effect of future orientation on pro-environmental behavior is also identified when the individual's legacy is made salient independently of environmental issues. Furthermore, Arnocky et al. (2014) experimentally manipulated the time perspective with a concept prime in which participants have to think about a typical day in their lives either now or in the future. The authors find that in the future priming condition, individuals express significantly more environmental concern and environmental behavioral motivation than those in the present condition. In this study, we extend the literature by activating future orientation through priming questions about future events that affect the participants and society but are independent of the environmental context. In addition, we focus on actual behavior and examine whether individuals behave differently depending on whether the framing of the priming questions of future events is positive or negative.

3.2.3 Positive (gain) and negative (loss) framing and pro-environmental behavior

While priming focuses on activating mental associations, framing involves presenting the same information in different ways to influence people's behavior. The framing effect is a cognitive bias where "decision-makers respond differently to different but objectively equivalent descriptions of the same problem" (Levin et al., 1998). Framing often refers to the presentation of the same information in either a positive or a negative way. According to prospect theory, the seminal work by Kahneman and Tversky (1979), people tend to give more weight to losses than to gains of the same magnitude, and that therefore people try harder to avoid a loss than to make a gain. Building on this cognitive bias, environmental research has examined whether loss aversion can also be applied to pro-environmental decision making. Thus far, the findings for context framing effects

in environmental research are mixed. Although the results of several theoretical and empirical studies are consistent with prospect theory, suggesting that negative framing has a greater effect on pro-environmental decision making than positive framing (Grazzini et al., 2018, Kragt and Bennett, 2012, White et al., 2011), other studies indicate the opposite (Bimonte et al., 2020, Hurlstone et al., 2020, Spence and Pidgeon, 2010), while still others find no significant difference between the two frames (Ahn et al., 2015, Ghesla et al., 2020). One explanation for the positive effect of gain framing on pro-environmental decisions is that loss framing might be more likely to lead to psychological reactance (Nabi et al., 2018). Another explanation indicates that pro-environmental behaviors such as climate change mitigation can be viewed as a preventive behavior, and as the evidence from health and behavioral decision theory shows, gain frames are more effective in triggering preventive behavior (Spence and Pidgeon, 2010).

Based on a systematic literature review of framing and pro-environmental behavior, Ropret Homar and Knežević Cvelbar (2021) conclude that real behavior has been largely neglected as an outcome variable. The authors identify a tendency that loss framings are usually equally or more effective in studies examining pro-environmental behaviors and intentions, while gain framings are more successful in changing people's beliefs or attitudes toward environmental issues (Ropret Homar and Knežević Cvelbar, 2021). Focusing on pro-environmental behavior, Grazzini et al. (2018), for example, find that hotel guests are more likely to put waste in appropriate recycling bins when a concrete message is paired with a loss-framed message. Similarly, White et al. (2011) find that compared to gain frames, loss frames lead to higher recycling behavior, even when both frames increase recycling intentions. Nabi et al. (2018) show that loss framing is more effective in inducing advocacy behavior, while gain framing leads to more green attitudes. In contrast, Ahn et al. (2015) find that gain and loss frames are equally effective in increasing pro-environmental behavior, measured as reduced paper consumption.

With few exceptions[1], most of these studies use outcome framing that claims a certain behavior will result in either a desirable environmental gain or avoidance of a detrimental environmental loss (Ahn et al., 2015, Hurlstone et al., 2014, Nabi et al., 2018, Spence and Pidgeon, 2010, White et al., 2011). At the same time, researchers examining gain–loss framing effects in the context of environmental research base their framing mainly on environmental issues. The present study differs from previous research on the effect of framing on pro-environmental behavior in that we consider a manipulation with positively and negatively framed questions on future events unrelated to outcomes and environmental context.

[1]For example, Bimonte et al. (2020) show that making a positive attribute salient (nature prime) significantly increases the probability of the willingness to pay for environmental protections and the size of the price one is willing to pay.

3.3 Methodology

3.3.1 Experimental design and procedure

To examine how priming on positive and negative future events influences pro-environmental behavior, we implemented a between-subject design with two treatment groups and one control group. The two treatment groups varied in terms of priming on future events; that is, they were primed on either positive future or negative future events. The experimental details were pre-registered with the American Economic Association's registry for randomized controlled trials with the unique identifying numbers AEARCTR-0007529 (for the positive future treatment) and AEARCTR-0007527 (for the negative future treatment). The ethical standard was approved by the Ethics Committee of the Faculty of Business Administration, Economics and Social Sciences at the University of Bern (serial number 042021).

The study consisted of four parts.[2] The first part comprised our key experimental manipulation. We used questions to prime participants in the two treatment groups on future events. For the control questions, we have built on the papers by Cohn et al. (2014, 2015), who employed leisure-related questions in their control conditions while priming participants in the experimental treatments on their professional banking identity (Cohn et al., 2014) and prisoner identity (Cohn et al., 2015), respectively. Leisure-related questions have been used multiple times in control conditions (e.g., Balafoutas et al. 2020, Feldhaus et al. 2022), suggesting their potential efficacy. Therefore, in the control group, we adopted six questions unrelated to the future, focused on leisure activities. Based on these questions, we then developed questions about the negative and positive future. To ensure consistency, answer types were consistent across the control and treatment groups and varied from inserting a number to raising single terms and writing a specified number of full sentences. Participants in the positive (negative) future treatment answered six questions about positive (negative) events that might happen in the future. Table 3.1 shows the priming questions for the three different groups. In all three treatments, the six manipulation questions were posed without specifically mentioning the environmental context.

In the second part, we used word-stem completion tasks as a manipulation check. For example, participants could complete the word fragment "__ment" with a future-related word like "investment", a present-related word such as "moment", or an unrelated word like "segment." This allowed us to test whether the questions increased future or present salience. Note that the manipulation check for the activation of future orientation is

[2]See in the Appendix B for the experimental material.

TABLE 3.1: Priming questions for the three different treatments

Control Group (CG)	**Positive Future (PF)**	**Negative Future (NF)**
On average, how many minutes a day do you spend on your smartphone? (Minutes)	How many years do you think it will be until artificial intelligence will be able to save the lives of many people with rare diseases by diagnosing them correctly? (Years)	How many years do you think it will be until many people are unemployed because artificial intelligence has taken over their jobs? (Years)
Which activity do you enjoy most when you do not have to work? (Text)	Where would you like to live in 5 years if you could freely choose?	Where would you never like to live in 5 years from now, if you could avoid it?
What are the three most important criteria for experiencing a perfect vacation? Name and describe them (1-2 sentences per criterion).	What are the three best things that could happen to you in the next 10 years? Name and describe them (1-2 sentences about each thing).	What are the three worst things that could happen to you in the next 10 years? Name and describe them (1-2 sentences about each thing).
Name three leisure facilities that you would like to have in your area (answer in bullet points).	Name three inventions/things that will change our society positively in the next 10 years (answer in bullet points).	Name three inventions/things that will change our society negatively in the next 10 years (answer in bullet points).
In your opinion, what are three criteria for a good TV show? (answer in bullet points)	In your opinion, what would be three advantages if in the future only self-driving cars were on the road? (answer in bullet points)	In your opinion, what would be three disadvantages if in the future only self-driving cars were on the road? (answer in bullet points)
How can people make the most of their leisure time? (2-3 sentences).	How will people change the world for the better in the next 30 years? (2-3 sentences).	How will people change the world for the worse in the next 30 years? (2-3 sentences).

presented in Section 3.4.3 as one potential mechanism behind our results. In addition, we checked whether future and leisure primes activate thoughts related to seriousness and environmental concerns.

In the third part, we used an incentivized experimental task to measure pro-environmental behavior (Essl et al., 2023). Participants received an endowment of GBP 0.86 (about USD 1.15) and had to decide to keep the money or invest all or part of it in planting trees. Therefore, this so-called *Tree Task* consists of a decision tradeoff between individual short-term financial rewards and long-term environmental gains. The task put individual financial rewards against people's motives for capturing carbon dioxide (CO_2) emissions by planting trees. We use planting trees as an action to mitigate climate change because trees absorb CO_2, making reforestation one of the most effective carbon capture solutions (IPCC, 2022). In the experimental instructions, we also highlighted that planting trees is a proven instrument for capturing CO_2 emissions. In this task, participants could spend any amount between zero and the total endowment in increments of GBP 0.086 to plant trees. The price to plant one tree that absorbs 20 kg of CO_2 over its lifetime was GBP 0.086. This was the actual price charged by an international forest restoration organization that planted the trees within four weeks after the participants made their

decisions. Participants could select one of 11 options, that is, plant zero to 10 trees. For each option, the different investments, the amount of money that participants kept for themselves, and the corresponding number of trees planted, CO_2 absorption in kilograms, and CO_2 compensation translated in car kilometers were provided (Table 3.2). To ensure that the participants correctly understood all financial and ecological consequences, we asked them four comprehension questions before they made their choice.

TABLE 3.2: Choice table of the Tree Task

Choice	Your investment to fight climate change	Your remaining balance	Number of planted trees	Lifetime CO_2 offset	Lifetime CO_2 offset in car kilometers
Choice 0 trees	£ 0	£ 0.86	0	0 kg	0 km
Choice 1 tree	£ 0.086	£ 0.774	1	20 kg	80 km
Choice 2 trees	£ 0.17	£ 0.69	2	40 kg	160 km
Choice 3 trees	£ 0.26	£ 0.60	3	60 kg	240 km
Choice 4 trees	£ 0.34	£ 0.52	4	80 kg	320 km
Choice 5 trees	£ 0.43	£ 0.43	5	100 kg	400 km
Choice 6 trees	£ 0.52	£ 0.34	6	120 kg	480 km
Choice 7 trees	£ 0.60	£ 0.26	7	140 kg	560 km
Choice 8 trees	£ 0.69	£ 0.17	8	160 kg	640 km
Choice 9 trees	£ 0.774	£ 0.086	9	180 kg	720 km
Choice 10 trees	£ 0.86	£ 0	10	200 kg	800 km

In the fourth part, we assessed participants' pro-environmental intentions because research has shown that intentions can predict behavior (e.g., De Leeuw et al. 2015) and much prior research in the field is based on intentions as an outcome measure (e.g., Ahn et al. 2015, Bimonte et al. 2020). To capture pro-environmental intentions, we relied on Fujii's (2006) and Mancha and Yoder's (2015) self-reporting scales, both measured on a 7-point Likert scale ranging from 1 (*extremely unlikely*) to 7 (*extremely likely*). Mancha and Yoder's (2015) three items measure intentions related to reducing carbon footprints, performing environmentally friendly behaviors, and stopping the waste of natural resources. The four items from Fujii (2006) were used to examine intentions related to electricity use reduction, gas use reduction, garbage reduction, and automobile use reduction. We build a composite pro-environmental intention score by taking the average of all seven items from Fujii's (2006) and Mancha and Yoder's (2015). The reliability of the measure is good (Cronbach's $\alpha = 0.86$). In addition, we utilized self-report measures to capture pro-environmental attitudes through Tam and Chan's (2017) six-item scale, a shorter and simpler version than, for example, the New Environmental Paradigm by Dunlap et al. (2000). Participants answered all six items on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). In line with Tam and Chan (2017), we formed a composite measure of environmental attitudes by taking the average of all six items, where

higher scores indicate stronger pro-environmental attitudes. The reliability of the measure is sufficient (Cronbach's $\alpha = 0.69$). To elicit beliefs in climate change, we used the three questions on trend skepticism, attribution skepticism, and perceived impacts of climate change (Poortinga et al., 2019). Following Poortinga et al. (2019), the 4-point response scale on trend skepticism (i.e., whether the climate is changing) was dichotomized to 0 (*probably/definitely changing*) and 1 (*probably/definitely not changing*). Responses regarding attribution skepticism (i.e., whether climate change is caused by nature or humans) were coded as 1 (*entirely/mainly by natural processes*) and 0 (*entirely/mainly by human activity/about equally by natural processes and human activity*). The perception of climate change — how good or bad the impact of climate change is on people across the world — was measured on a scale ranging from –5 (*extremely bad*) to +5 (*extremely good*). The experiment ended with questions eliciting demographics including gender, age, education, race, political orientation, whether they have children or not, and income.

The study was conducted online on Prolific[3] between June and July 2021. On average, participants needed 13 min ($SD = 7.7$) to complete the study and received a flat payment of GBP 2.2 plus an additional variable payment stemming from the Tree Task averaging GBP 0.27 ($SD = 0.31$, range = GBP 0 – GBP 0.86). Participants were paid a day after the study using the tools provided by Prolific. We also provided the option for participants to receive a confirmation email once the trees were planted in Madagascar, and 24 participants chose this option.

3.3.2 Sample description

We determined the target sample for this study to be at least 810 (targeting 270 participants per condition) using a two-sided Wilcoxon-Mann-Whitney test, an error probability of 0.05, and a power of 0.80 to detect an effect of Cohen's d of 0.25. In total, we recruited 912 participants on Prolific. Most participants are from Europe (54%) followed by North America (30%) and other countries (16%). We followed the pre-registered protocol and removed 25 participants from the recruited sample because they failed crucial attention checks, gave invalid responses to the priming questions ($n = 10$), or answered the survey too quickly (< 5 min, $n = 38$) or too slowly (> 60 min, $n = 2$). In accordance with the pre-registered protocol, we also excluded participants who believed that the climate is probably or definitely not changing, measured by trend skeptical beliefs ($n = 11$). Further, we removed participants who believe that climate

[3]Prolific is an established crowd working online platform (Palan and Schitter, 2018).

change is a natural process, as measured by attribution skepticism ($n = 30$).[4] The reason to exclude participants who believe that the climate is not changing or who believe that climate change is a natural process is that these participants are unlikely to be willing to plant trees regardless of treatment. As shown in the robustness checks in the Appendix A, including all or some of these participants does not considerably alter the results.[5]

The main sample included 810 participants (63.8% female, mean age: 27.8 years), of whom 294 participated in the PF treatment, 254 in the NF treatment, and 262 in the control group. Randomization between the NF treatment and the control group was successful with respect to all variables, except for the variable *Children*. Additionally, participants in the PF treatment exhibit differences from both the control group and the NF treatment in several variables. Table 3.7 in the Appendix A provides descriptive statistics for sociodemographic variables, beliefs in climate change, and environmental attitudes for the main sample and for each treatment group separately. In the analysis, we control for all variables that show significant differences.

3.4 Results

3.4.1 Future priming and pro-environmental behavior

In this section, we examine the influence of the two different future primes on individual pro-environmental behavior measured by the *Tree Task*. Table 3.3 presents for each treatment group the average number of trees planted, the corresponding standard deviations, effect sizes, and p-values based on Wilcoxon-Mann-Whitney tests. The results show that participants in the PF and NF treatments plant significantly more trees than participants in the control group, who were primed on leisure activities ($p < .001$ for the PF treatment and $p < .002$ for the NF treatment compared to the control group, Wilcoxon-Mann-Whitney tests).[6] However, there is no statistically significant difference between the results for the PF and NF treatments. Figure 3.1 shows the relative frequency of the planted trees by treatment.

[4] There are overlaps regarding participants who answered the survey too quickly and gave invalid responses to the priming questions ($n = 1$), answered the survey too quickly and failed attention checks ($n = 4$), trend skepticism and failed attention checks ($n = 1$), attribution skepticism and failed attention checks ($n = 3$), invalid responses to the priming questions ($n = 1$), answered the survey too quickly ($n = 2$), and trend skepticism ($n = 3$). Note that regarding attribution skepticism, one ($n = 1$) overlap occurs between answering the survey too quickly and failing the attention checks.

[5] We present the robustness of the results for three different samples in Tables 3.10 and 3.11 in the Appendix A. First, we include participants ($n = 22$) who believe that climate change is not caused by humans, measured with attribution skepticism. Second, we include participants ($n = 10$) who believe that the world's climate is probably or definitely not changing, measured with trend skeptical beliefs. Finally, we conduct the analysis for the total sample, including all respondents who participated in the experiment.

[6] All statistical tests are two-sided.

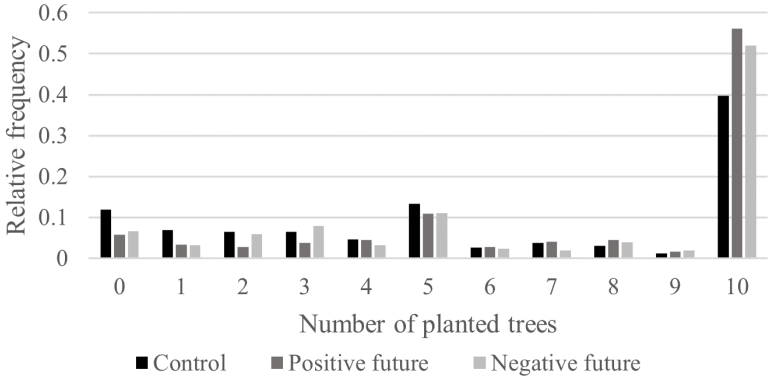
TABLE 3.3: Descriptive statistics: Number of planted trees

	CG	**PF**	**NF**
Mean	5.99	7.49	7.03
SD	3.82	3.34	3.57

	PF vs. CG	**NF vs. CG**	**PF vs. NF**
Cohen's d	-0.42	-0.28	0.13
p-values	$p < .001$	$p < .002$	$p < .156$

Notes: CG = Control Group, PF = Positive future treatment, NF = Negative future treatment. p-values were obtained from Wilcoxon-Mann-Whitney tests. All statistical tests are two-sided.

FIGURE 3.1: Relative frequency of number of planted trees by treatment



To consider the robustness of the descriptive results, we use the following OLS regression model:

$$y_i = \beta_0 + \beta_1 PF_i + \beta_2 NF_i + \beta_3' \boldsymbol{E}_i + \beta_4' \boldsymbol{X}_i + \epsilon_i \ ,$$

where the dependent variable y_i is the number of trees planted by individual i, and PF_i and NF_i are binary variables indicating whether individual i was primed on positive future or negative future events, respectively. We further estimated model specifications where we control for beliefs about climate change and environmental attitude measures $\boldsymbol{E}_i$ and sociodemographic variables $\boldsymbol{X}_i$. ϵ_i is the idiosyncratic error term. In all model specifications, robust standard errors were estimated.

TABLE 3.4: Effects of priming on pro-environmental behavior: OLS regression

	(1) No. of planted trees	(2) No. of planted trees	(3) No. of planted trees
PF	1.501***	1.170***	1.078***
	(0.307)	(0.297)	(0.330)
NF	1.043***	1.088***	1.021***
	(0.326)	(0.307)	(0.307)
Pro-environmental attitues		1.197***	1.068***
		(0.188)	(0.193)
Perceived impact of CC		-0.334***	-0.295***
		(0.087)	(0.089)
Female			0.519*
			(0.282)
Age			0.026
			(0.017)
Liberal			0.264
			(0.264)
Education (> High school)			0.147
			(0.255)
Income (> GBP 50,000)			-0.119
			(0.250)
White or caucasian			0.341
			(0.277)
Children			-0.736*
			(0.376)
Intercept	5.989***	0.174	-0.486
	(0.236)	(0.716)	(0.808)
Observations	810	810	810
R-squared	0.030	0.124	0.138

Notes: The table presents estimates from ordinary least squares (OLS) regressions. Robust standard errors are shown in parentheses. The dependent variable is the number of trees planted. PF and NF are dummy variables equal to 1 for individuals in the positive or negative future priming treatment, respectively, and 0 otherwise. Children indicates whether having children (= 1) or not (= 0). Pro-environmental attitudes are measured on a 5-point Likert scale. Perceived impact of climate change (CC) is measured on a scale from –5 *extremely bad* to +5 *extremely good*. *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 3.4 presents the estimated coefficients of the OLS regression analysis. In line with the descriptive statistics, Specification 1 confirms the large and significant priming effects. In Specifications 2 and 3, we additionally control for attitudes toward climate change and the environment and important sociodemographic variables, respectively.[7] Whereas the magnitude of the treatment coefficients drops slightly, they stay highly statistically significant $p < .001$). This shows that both future primes play an important role over

[7]Whether we first add the demographic or environmental control variables does not affect the significance level and the magnitude of the treatment coefficients. Results upon request.

and above other individual characteristics and pro-environmental attitudes. Furthermore, we cannot reject the null hypothesis that positive and negative future primes have the same impact on planting trees (Wald test: $p = .124$ for Specification 1; $p = .774$ for Specification 2; $p = .856$ for Specification 3). Not surprisingly, stronger environmentally friendly attitudes and the view that climate change has a negative impact on people around the world lead to statistically significantly more planted trees.[8] In addition, we analyzed whether there is an interaction effect between the future primes and having children. The results of an OLS regression analysis suggest that when primed on the future, participants with children plant on average more trees compared to participants without children (see Table 3.9 in the Appendix A).

3.4.2 Future priming and pro-environmental intentions

In addition to the main outcome variable (the number of trees planted), we investigate the effect of future primes on pro-environmental intentions. Descriptive statistics for the different experimental groups are presented in Table 3.5. The Wilcoxon-Mann-Whitney tests reveal that individuals who were primed on positive or negative future events have significantly higher pro-environmental intentions than those in the control group, who were primed on leisure activities ($p < .001$ or, respectively, $p = .038$). In addition, the difference between the PF and NF treatments is statistically significant ($p = .009$).

TABLE 3.5: Descriptive statistics: Pro-environmental intentions

	CG	**PF**	**NF**
Mean	5.13	5.56	5.31
SD	1.10	1.06	1.15

	PF vs. CG	**NF vs. CG**	**PF vs. NF**
Cohen's d	-0.40	-0.16	0.23
p-values	$p < .001$	$p < .038$	$p < .009$

Notes: CG = Control Group, PF = Positive future treatment, NF = Negative future treatment, p-values were obtained from a Wilcoxon-Mann-Whitney test. All statistical tests are two-sided.

Furthermore, we examine the effect of positive and negative future priming on pro-environmental intentions by applying an OLS regression model, similar to Model 1, where the dependent variable y_i is the intentions score of individual i rather than the number of trees planted. All specifications in Table 3.6 show a positive and statistically significant effect of the positive and negative future primes on pro-environmental intentions. Whereas

[8] As a robustness check, we also run a negative binomial regression model. Estimates are presented in Table 3.8 in Appendix B.

the magnitude of the PF treatment effect decreases when controlling for environmental attitudes (Specification 2) and sociodemographic variables (Specification 3), the statistical significance of the PF dummy variable remains stable. In contrast, the magnitude of the NF dummy increases slightly, and it is now much more precisely estimated and significant at the 5% level. In addition, when controlling for environmental attitudes and sociodemographic variables, the observed priming effects do not differ. Furthermore, for Specifications 2 and 3, we cannot reject the null hypothesis that positive and negative future primes have the same impact on planting trees (Wald test: $p = .008$ for Specification 1; $p = .302$ for Specification 2; $p = .932$ for Specification 3).[9]

TABLE 3.6: Effects of priming on pro-environmental intentions: OLS regression

	(1) Intentions	(2) Intentions	(3) Intentions
PF	0.428***	0.291***	0.202**
	(0.092)	(0.087)	(0.098)
NF	0.176*	0.203**	0.194**
	(0.100)	(0.092)	(0.093)
Pro-environmental attitues		0.557***	0.543***
		(0.062)	(0.062)
Perceived impact of CC		-0.104***	-0.101***
		(0.029)	(0.030)
Female			0.208***
			(0.079)
Age			-0.004
			(0.005)
Liberal			0.024
			(0.080)
Education (> High school)			-0.011
			(0.078)
Income (> GBP 50,000)			-0.011
			(0.077)
White or caucasian			-0.135
			(0.082)
Children			0.090
			(0.118)
Intercept	5.136***	2.611***	2.776***
	(0.0684)	(0.246)	(0.269)
Observations	810	810	810
R-squared	0.026	0.197	0.209

Notes: The table presents estimates from ordinary least squares (OLS) regressions. Robust standard errors are shown in parentheses. The dependent variable is self-reported pro-environmental intentions. PF and NF are dummy variables equal to 1 for individuals in the positive or negative future priming treatment, respectively, and 0 otherwise. Pro-environmental attitudes are measured on a 5-point Likert scale. Perceived impact of climate change (CC) is measured on a scale ranging from –5 *extremely bad* to +5 *extremely good*. *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

[9]We present the robustness of the results for different samples in Table 3.11 in the Appendix A.

3.4.3 Activation of future orientation and environmental concerns

To detect potential mechanisms behind the results, we test several mental constructs that we could have released with our priming. We do this by letting research assistants, who were blind to all experimental conditions, independently categorize the words of the word-stem completion task to compare participants' mental accessibility across the treatments.[10] First, our prior suspected mechanism behind the observed treatment effects on sustainable behavior is increased future orientation. Thus, two research assistants categorized the words into future-related, present-related, and unrelated words. Compared to the control group primed on leisure activities, the frequency of future-related words is 53.06% higher in the PF treatment and 38.82% higher in the NF treatment. These differences are statistically significant (CG vs. PF, $p < .001$, CG vs. NF, $p < .001$, PF vs. NF, $p = .08$, Wilcoxon-Mann-Whitney test). Additionally, present-related words are more frequent in the control group compared to PF (33.65%) and NF (29.50%) treatments (CG vs. PF, $p = .005$, CG vs. NF, $p = .052$, Wilcoxon-Mann-Whitney test). There is no difference in the frequency of present-related words between the PF and NF treatment groups (PF vs. NF, $p = .421$, Wilcoxon-Mann-Whitney test). Together, these findings suggest that our manipulation was successful.

Second, priming on future events might incorporate aspects of seriousness compared to a control group primed on leisure activities. To test the mental accessibility of seriousness, two research assistants categorized the words as serious-related or unrelated words. Results show no statistically significant differences in the frequency of serious-related words between the control group and PF treatment (CG vs. PF, $p = .848$, Wilcoxon-Mann-Whitney test). However, participants in the NF treatment mentioned 16.86% more serious-related words compared to the control group (CG vs. NF, $p = .010$), and 1.52% more serious-related words than in PF treatment (PF vs. NF, $p = .007$). Third, thinking about the future might implicitly trigger environmental concerns. To analyze whether this is the case, two research assistants categorized the words from the word completion task into environment-related and unrelated words. The results reveal that participants in both treatments mentioned environment-related words significantly more frequently compared to participants in the control group (PF vs. CG, $p = .001$; NF vs. CG, $p < .001$, Wilcoxon-Mann-Whitney tests). Furthermore, participants in the PF treatment mentioned significantly more environment-related words than participants in the NF treatment (PF vs. NF, $p < .001$, Wilcoxon-Mann-Whitney test).

[10] See Appendix C for the entire coding process.

3.5 Discussion and conclusion

This paper examines whether people primed on positive or negative future events alter their pro-environmental behavior and intentions compared to a control group primed on leisure activities. In contrast to previous studies, the priming on future events is independent of any environmental context. We measure pro-environmental behavior with an incentivized task in which participants can waive a financial bonus to act environmentally friendly by planting up to 10 trees. The results reveal that participants primed on future events plant significantly more trees and show significantly stronger pro-environmental behavior compared to participants primed on leisure activities. Two interpretations arise from these results: In accordance with our research question, these findings may suggest that future priming leads to an increase in tree planting. Conversely, the results could also be interpreted as indicating that leisure priming results in fewer trees planted. To gain deeper insights into the drivers of our results, we used the word-stem completion tasks to examine different mental concepts that may have been triggered by the different primes. In line with our research question, we observe that both future primes activated greater concern for the future, whereas the leisure prime triggered present concerns. As thoughts about the future are more salient in the treatment groups, people might refrain from fulfilling their immediate desires by investing in the future through tree planting. Furthermore, we investigate whether leisure and future priming differ in activating the mental accessibility of seriousness. We observe a higher frequency of serious-related words only in the negative future treatment compared to both other treatments, but not when comparing the positive future treatment and the leisure-related control treatment. Although these results are encouraging in the sense that future versus present concerns might be driving our findings, we cannot rule out that there are other mental concepts activated by leisure and future priming that influenced pro-environmental behavior in form of tree planting.

Moreover, the results show that participants primed on future events mention significantly more environment-related words than participants in the control group. This suggests that thoughts about the future implicitly trigger concerns about the environment. This finding could prove helpful to encourage environmentally friendly behavior, as some people might feel hopeless when they are explicitly asked to think about environmental issues, which can lead to passivity (Moser, 2007). However, further research is needed to examine the relation between environmental and future thoughts.

When comparing the two future treatments, we find no significant difference between the positive and negative future primes. The literature shows mixed findings on framing effects in environmental research. Some studies find that negative framing works better

(Grazzini et al., 2018, White et al., 2011), others that positive framing is more effective (Hurlstone et al., 2020, Spence and Pidgeon, 2010), and still others, like us, find no difference between framings (Ahn et al., 2015). One possible reason for these inconsistent findings is the wide range of experimental designs that examine the effects of positive and negative framings in the pro-environmental behavior context. In particular, the way in which framing is induced differs across studies.

Several limitations inherent in this study raise interesting questions for future research. First, this study, like many other priming studies, faces the challenge of identifying the exact mental concept that is activated. Although our manipulation checks support that our induced priming was successful, we cannot exclude that no other specific context or feelings are more salient than future-related ones. Second, and relatedly, our control group questions building on Cohn et al. (2014, 2015) cover leisure topics that may be perceived differently in other than time-related dimensions. Thus, rather than priming on leisure activities, future research could implement a control condition where the priming involves similar topics as the PF and NF treatments, with the only difference being that the control condition concerns the present instead of the future (e.g., Arnocky et al. 2014). Third, major concerns in priming research are replicability and persistency. Future research would benefit from analyzing the effect of making a future-related context more salient on pro-environmental behavior using different priming techniques, including videos, images, or text. Moreover, given the call for research on the long-term effects of behavioral interventions (e.g., Steg et al. 2014, Steinhorst and Klöckner 2018), it remains an open question whether the observed priming effects on pro-environmental behavior persist. To address this issue, conducting a similar experiment with a greater time gap between the priming and the pro-environmental decision task could provide insightful results. Fourth, we observe a high number of trees planted across all treatments that may be triggered by the low cost of planting a tree. It remains speculative whether comparable effects of priming on tree planting will be observed with higher stakes at hand. Furthermore, the way we presented the tree task might have made it easy for participants to see that this would be the task we are analyzing. Although the presentation was the same in all three treatments, it may have created an experimenter demand effect to encourage participants to plant more trees. Therefore, future research could explore if future priming remains as effective in fostering tree planting with increased endowments in the tree task and a more subtle way of presenting the task. Finally, the Tree Task asks for a specific pro-environmental behavior, namely, planting trees. Therefore, future studies could test whether future primes are similarly effective for other pro-environmental behaviors.

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Appendix A: Additional analysis

TABLE 3.7: Sample characteristics and randomization check

	Sample ($n = 810$)	CG ($n = 262$)	PF ($n = 294$)	NF ($n = 254$)	PF vs. CG p-values	NF vs. CG p-values	PF vs. NF p-values
Demographics							
Gender (% female)	63.83	50.76	82.99	55.12	$< .001$	.322	$< .001$
Age in years	27.79	30.16	24.18	29.52	$< .001$	.998	$< .001$
	(9.08)	(10.30)	(6.53)	(8.98)			
Party orientation (% liberal)	61.36	55.73	67.69	59.84	.004	.344	.056
Education (% higher than high school)	55.80	58.02	47.62	62.99	.014	.248	$< .001$
Income (% earn more than GBP 50,000)	36.42	31.68	42.52	34.25	.008	.534	.048
Ethnicity (% White or caucasian)	70.62	75.19	63.61	74.02	.003	.759	.009
Children (% of having children)	18.64	28.24	7.14	22.05	$< .001$	.105	$< .001$
Climate Change (CC) related variables							
Pro-environmental attitudes	3.93	3.89	4.07	3.81	.007	.212	$< .001$
	(0.70)	(0.27)	(0.63)	(0.74)			
Perceived impact of CC	-3.63	-3.48	-3.80	-3.60	.002	.187	.076
	(1.46)	(1.47)	(1.40)	(1.52)			

Notes: The table reports means and standard deviations for continuous variables and percentage frequencies for categorical variables for the full sample and for each treatment group individually. Standard deviations are given in parentheses. For categorical variables, the p -values were obtained from a χ^2-test. For continuous variables, the p-value were obtained from Wilcoxon-Mann-Whitney tests.

TABLE 3.8: Effects of priming on pro-environmental behavior: Negative binomial model

	(1) No. of planted trees	(2) No. of planted trees	(3) No. of planted trees
PF	0.224***	0.184***	0.174***
	(0.047)	(0.046)	(0.051)
NF	0.161***	0.170***	0.161***
	(0.051)	(0.049)	(0.049)
Pro-environmental attitues		0.194***	0.177***
		(0.033)	(0.034)
Perceived impact of CC		-0.052***	-0.045***
		(0.015)	(0.015)
Female			0.074*
			(0.044)
Age			0.004*
			(0.003)
Liberal			0.037
			(0.041)
Education (> High school)			0.027
			(0.038)
Income (> GBP 50,000)			-0.025
			(0.038)
White or caucasian			0.042
			(0.043)
Children			-0.120**
			(0.060)
Intercept	1.790***	0.836***	0.730***
	(0.039)	(0.135)	(0.146)
Ln alpha	-1.456***	-1.650***	-1.683***
	(0.133)	(0.154)	(0.157)
Pseudo R-squared	0.004	0.018	0.021

Notes: The table presents estimates from negative binomial regressions. Robust standard errors are shown in parentheses. The dependent variable is the number of trees planted. PF and NF are dummy variables equal to 1 for individuals in the positive or negative future priming treatment, respectively, and 0 otherwise. Children indicates whether having children (= 1) or not (= 0). Pro-environmental attitudes are measured on a 5-point Likert scale. Impact of climate change (CC) is measured on a scale from –5 *extremely bad* to +5 *extremely good*. *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

TABLE 3.9: Interaction effects of future primes and having children on pro-environmental behavior: OLS regression

	(1) No. of planted trees	(2) No. of planted trees	(3) No. of planted trees
PF	1.083***	0.799**	0.787**
	(0.343)	(0.328)	(0.354)
NF	0.684*	0.713**	0.658*
	(0.376)	(0.353)	(0.350)
Children	-1.302**	-1.232**	-1.517***
	(0.522)	(0.499)	(0.534)
PF # Children	2.006**	1.598*	1.574*
	(0.895)	(0.919)	(0.953)
NF # Children	1.262*	1.362*	1.410**
	(0.752)	(0.710)	(0.718)
Pro-environmental attitudes		1.204***	1.068***
		(0.189)	(0.193)
Perceived impact of CC		-0.323***	-0.288***
		(0.0880)	(0.0901)
Female			0.529*
			(0.281)
Age			0.0245
			(0.0171)
Liberal			0.284
			(0.263)
Education (> High school)			0.183
			(0.255)
Income (> GBP 50,000)			-0.0962
			(0.253)
White or caucasian			0.332
			(0.276)
Intercept	6.356***	0.533	-0.226
	(0.276)	(0.735)	(0.816)
Observations	810	810	810
R-squared	0.040	0.131	0.143

Notes: The table presents estimates from ordinary least squares (OLS) regressions. Robust standard errors are shown in parentheses. The dependent variable is the number of trees planted. PF and NF are dummy variables equal to 1 for individuals in the positive or negative future priming treatment, respectively, and 0 otherwise. Children is a dummy variable that takes 1 for having children and 0 for not having children. Pro-environmental attitudes are measured on a 5-point Likert scale. Perceived impact of climate change (CC) is measured on a scale ranging from –5 *extremely bad* to +5 *extremely good*. *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

Robustness checks

We replicate the main findings of Specifications 1 to 3 of Table 3.4 and Table 3.6 for three different samples in Table 3.10 and Table 3.11. First, we include participants ($n = 22$) who believe that climate change is not caused by humans, measured with attribution skepticism. The results show that including these individuals has no major bearing on the findings. The treatment dummy coefficients remain highly significant and comparable in size. As a second robustness check, we include participants ($n = 10$) who believe that the world's climate is probably or definitely not changing, measured with trend skeptical beliefs. Including these participants does not affect the main results of the PF treatment either. In the NF treatment, the magnitude and statistical significance drop only marginally. Finally, we conduct the analysis for the total sample, including all respondents who participated in the experiment. Again, the results show that including all participants does not considerably alter the significance level and size of the treatment regression coefficients.

Access to raw data and statistical codes

Raw data and statistical codes for the manuscript "Let's think about the future: The effect of positive and negative future primes on pro-environmental behavior" by Andrea Essl, David Hauser, and Frauke von Bieberstein can be found under the following Link.

TABLE 3.10: Robustness check for Specification 1-3: Dependent variable number of planted trees

	(1) Spec 1	(2) Spec 1	(3) Spec 1	(4) Spec 1	(5) Spec 2	(6) Spec 2	(7) Spec 2	(8) Spec 2	(9) Spec 3	(10) Spec 3	(11) Spec 3	(12) Spec 3
PF	1.501***	1.549***	1.601***	1.597***	1.170***	1.165***	1.204***	1.186***	1.078***	1.058***	1.086***	1.041***
	(0.307)	(0.305)	(0.304)	(0.297)	(0.297)	(0.296)	(0.294)	(0.284)	(0.330)	(0.328)	(0.325)	(0.312)
NF	1.043***	1.054***	1.076***	1.078***	1.088***	1.106***	1.123***	1.095***	1.021***	1.046***	1.065***	1.074***
	(0.326)	(0.323)	(0.322)	(0.309)	(0.307)	(0.302)	(0.300)	(0.285)	(0.307)	(0.302)	(0.300)	(0.284)
Pro-environmental attitudes					1.197***	1.244***	1.279***	1.313***	1.068***	1.113***	1.138***	1.172***
					(0.188)	(0.184)	(0.182)	(0.172)	(0.193)	(0.189)	(0.187)	(0.178)
Perceived impact of CC					-0.334***	-0.340***	-0.323***	-0.341***	-0.295***	-0.303***	-0.283***	-0.312***
					(0.087)	(0.083)	(0.084)	(0.078)	(0.089)	(0.086)	(0.087)	(0.080)
Female									0.519*	0.556**	0.617**	0.731***
									(0.282)	(0.277)	(0.276)	(0.265)
Age									0.026	0.024	0.023	0.019
									(0.017)	(0.017)	(0.017)	(0.016)
Liberal									0.264	0.244	0.283	0.161
									(0.264)	(0.261)	(0.260)	(0.248)
Education (> High School)									0.147	0.123	0.137	0.147
									(0.255)	(0.252)	(0.251)	(0.242)
Income (> GBP 50,000)									-0.119	-0.020	-0.018	-0.001
									(0.250)	(0.247)	(0.246)	(0.239)
White or caucasian									0.341	0.342	0.333	0.355
									(0.277)	(0.273)	(0.273)	(0.264)
Children									-0.736*	-0.622*	-0.539	-0.535
									(0.376)	(0.372)	(0.370)	(0.352)
Intercept	5.989***	5.900***	5.830***	5.760***	0.174	-0.072	-0.189	-0.412	-0.486	-0.705	-0.826	-1.013
	(0.236)	(0.234)	(0.233)	(0.224)	(0.716)	(0.681)	(0.658)	(0.605)	(0.808)	(0.778)	(0.763)	(0.715)
Observations	810	832	842	912	810	832	842	912	810	832	842	912
R-squared	0.030	0.032	0.033	0.032	0.124	0.135	0.142	0.156	0.138	0.148	0.156	0.169

Notes: The table presents estimates from ordinary least squares (OLS) regressions. Column (1) to (4) show coefficients for Specification 1, column (5) to (8) for Specification 2, and column (9) to (12) for Specification 3. Robust standard errors are shown in parentheses. The dependent variable is the number of planted trees. PF and NF is a dummy variable equal to 1 for individuals in the positive or negative future priming treatment, respectively, and 0 otherwise. Children indicates whether having children (=1) or not (=0). Pro-environmental attitudes are measured on 5-point Likert scale. Impact of climate change (CC) is measured on a scale from -5 *extremely bad* to +5 *extremely good*. *, **, and *** document statistical significance at the 10%, 5%, and 1% levels.

TABLE 3.11: Robustness check for Specification 1-3: Dependent variable pro-environmental intentions

	(1) Spec 1	(2) Spec 1	(3) Spec 1	(4) Spec 1	(5) Spec 2	(6) Spec 2	(7) Spec 2	(8) Spec 2	(9) Spec 3	(10) Spec 3	(11) Spec 3	(12) Spec 3
PF	0.428***	0.442***	0.451***	0.459***	0.291***	0.289***	0.287***	0.306***	0.202**	0.206**	0.198**	0.234**
	(0.092)	(0.092)	(0.093)	(0.091)	(0.087)	(0.086)	(0.086)	(0.084)	(0.098)	(0.097)	(0.097)	(0.094)
NF	0.176*	0.183*	0.181*	0.213**	0.203**	0.215**	0.210**	0.227***	0.194**	0.206**	0.200**	0.222**
	(0.100)	(0.099)	(0.100)	(0.094)	(0.092)	(0.090)	(0.091)	(0.087)	(0.093)	(0.092)	(0.092)	(0.088)
Pro-environmental attitudes					0.557***	0.569***	0.589***	0.537***	0.543***	0.554***	0.569***	0.512***
					(0.062)	(0.060)	(0.060)	(0.061)	(0.062)	(0.061)	(0.061)	(0.060)
Perceived impact of CC					-0.104***	-0.099***	-0.104***	-0.095***	-0.101***	-0.096***	-0.101***	-0.089***
					(0.029)	(0.027)	(0.027)	(0.028)	(0.030)	(0.029)	(0.028)	(0.029)
Female									0.208***	0.200***	0.228***	0.209***
									(0.079)	(0.077)	(0.077)	(0.074)
Age									-0.004	-0.004	-0.005	-0.003
									(0.005)	(0.005)	(0.005)	(0.005)
Liberal									0.024	0.030	0.025	0.088
									(0.080)	(0.079)	(0.079)	(0.077)
Education (> High School)									-0.011	-0.002	0.013	0.037
									(0.078)	(0.077)	(0.077)	(0.075)
Income (> GBP 50'000)									-0.011	-0.023	-0.020	0.038
									(0.077)	(0.076)	(0.076)	(0.075)
White or caucasian									-0.135	-0.144*	-0.137*	-0.113
									(0.082)	(0.081)	(0.081)	(0.079)
Children									0.089	0.091	0.109	0.119
									(0.118)	(0.116)	(0.116)	(0.113)
Intercept	5.136***	5.119***	5.098***	5.088***	2.611***	2.579***	2.477***	2.713***	2.776***	2.748***	2.657***	2.790***
	(0.0684)	(0.0687)	(0.0695)	(0.0666)	(0.246)	(0.236)	(0.234)	(0.236)	(0.269)	(0.257)	(0.254)	(0.253)
Observations	810	832	842	912	810	832	842	912	810	832	842	912
R-squared	0.026	0.027	0.027	0.027	0.197	0.209	0.226	0.205	0.209	0.221	0.240	0.218

Notes: The table presents estimates from ordinary least squares (OLS) regressions. Column (1) to (4) show coefficients for Specification 1, column (5) to (8) for Specification 2, and column (9) to (12) for Specification 3. Robust standard errors are shown in parentheses. The dependent variable are self-reported pro-environmental intentions. PF and NF is a dummy variable equal to 1 for individuals in the positive or negative future priming treatment, respectively, and 0 otherwise. Pro-environmental attitudes are measured on 5-point Likert scale. Perceived impact of climate change (CC) is measured on a scale from -5 *extremely bad* to +5 *extremely good*. *, **, and *** document statistical signifiance at the 10%, 5%, and 1% levels.

Appendix B: Experimental material

Priming questions for the three different treatments

In the first part of the study, we ask you to answer six questions completely and conscientiously. (See all question in Table 3.1 in the main text)

Word-stem task (manipulation check)

In the following part 2, please try to fill the gaps with letters to form existing words. Examples: house household or ma machine

__ration

__ment

__ture

__ution

pl__

con__

Tree Task

In this Part 3, you will receive an additional GBP 0.86 to the flat fee of GBP 2.2. You will be asked to make a decision that may affect your final payment.

Your task

- You will decide whether you want to keep all of the GBP 0.86 for yourself, or whether you want to invest parts or all of it as a contribution to fight climate change.
- The money that you decide NOT to keep will be invested to plant trees and thus, offset carbon dioxide (CO_2). An international forest restoration organization will plant the trees within the next two months.
- The price to plant one tree that offsets 20 kg of carbon dioxide (CO_2) over its lifetime is GBP 0.086. This corresponds to an offset of about 80 car kilometers of an average passenger car (also see "Choice 1 tree" in the table below).
- Your decision will have an actual and true consequence for the environment. It is NOT a hypothetical decision.

Why plant trees to fight climate change?
The climate crisis will have an increasingly negative impact in the coming decades. Carbon dioxide (CO_2) is regarded as a key contributor to climate change, and scientists around the globe agree that climate change can be mitigated only if carbon emissions

are dramatically reduced and captured. Trees absorb CO_2, making reforestation one of the most efficient and affordable carbon capture solutions. A research team from the Swiss Federal Institute of Technology in Zurich (ETH Zurich) found that restoring the world's lost forests in areas where no humans live would remove two thirds of all CO_2 that is in the atmosphere because of human activity. Therefore, planting more trees will lead to a great offset of CO_2 emissions and, thus, to a great contribution to the fight against climate change.

The table below shows different choices and their consequences. The first column is the number of the choice. The second column shows the different investments that you can make to fight climate change. The third column shows the amount of money that you will keep for yourself (your remaining balance). For each investment, the corresponding number of trees that will be planted is shown in column 4. Column 5 shows the total amount of CO_2 that will be offset by the planted trees during their lifetime. To help you better understand the positive environmental effect of your investment, in column 6 the lifetime CO_2 offset is translated into how many car kilometers travelled by an average passenger car can be offset by your choice.

Choice	Your investment to fight climate change	Your remaining balance	Number of planted trees	Lifetime CO_2 offset	Lifetime CO_2 offset in car kilometers
Choice 0 trees	£ 0	£ 0.86	0	0 kg	0 km
Choice 1 tree	£ 0.086	£ 0.774	1	20 kg	80 km
Choice 2 trees	£ 0.17	£ 0.69	2	40 kg	160 km
Choice 3 trees	£ 0.26	£ 0.60	3	60 kg	240 km
Choice 4 trees	£ 0.34	£ 0.52	4	80 kg	320 km
Choice 5 trees	£ 0.43	£ 0.43	5	100 kg	400 km
Choice 6 trees	£ 0.52	£ 0.34	6	120 kg	480 km
Choice 7 trees	£ 0.60	£ 0.26	7	140 kg	560 km
Choice 8 trees	£ 0.69	£ 0.17	8	160 kg	640 km
Choice 9 trees	£ 0.774	£ 0.086	9	180 kg	720 km
Choice 10 trees	£ 0.86	£ 0	10	200 kg	800 km

Your choice
You are asked to select ONE of the choices.

Example
Suppose you select "Choice 8 trees"

- You invest GBP 0.69 (column 2) of your GBP 0.86 to fight climate change.
- Thus, you keep GBP 0.17 for yourself (column 3).
- The money that you invest to fight climate change will be used to plant 8 trees (column 4) that lead to the trees' lifetime CO_2 offset of 160 kg (column 5).
- This means that the lifetime CO_2 absorption of the 8 trees planted will offset about 640 car kilometers (column 6) travelled by an average passenger car.

Comprehension Questions
Please assume that you selected "Choice 3 trees"

- How much money in GBP do you invest to fight climate change?
- How much money in GBP do you keep for yourself?
- How many trees are planted with the money you invest to fight climate change?
- How much CO_2 do you offset in kg?

Your decision

- Please select your "Choice" that will be implemented. (Dropdown menu ranging from Choice 0 trees to Choice 10 trees)
- How much money in GBP do you keep for yourself based on your selected "Choice"?
- How much CO_2 do you offset in kg based on your selected "Choice"?

If you would like a confirmation e-mail after the trees for this study have been planted, please write us an e-mail.

Scales

Green intentions: 1-3 scale according to Mancha and Yoder (2015) and 4-7 according to Fujii (2006)
Participants responded on a 7-point Likert scale ranging from *extremely unlikely* to *extremely likely*. We took the mean of all seven items to capture pro-environmental intentions.

1. I will try to reduce my carbon footprint in the forthcoming month.
2. I intend to engage in environmentally friendly behavior in the forthcoming month.
3. I plan to stop wasting natural resources in the forthcoming month.
4. (Electricity): I intend to turn off lights as much as possible in the forthcoming month.
5. (Gas): I intend to spend less time in the shower in the forthcoming month.
6. (Package): I intend to buy goods with less packaging in the forthcoming month.
7. (Transportation): I intend to use more environmentally friendly means of transport in the forthcoming month.

Environmental attitudes: Scale according to Tam and Chan (2017)
Participants responded on a 5-point Likert scale ranging from *strongly disagree* to *strongly agree*. In line with Tam and Chan (2017), we took the mean of all six items meaning that the higher the score the more pro-environmental view a participant has.

1. People worry too much about human progress harming the environment.
2. We worry too much about the future of the environment and not enough about prices and jobs.

3. There are more important things to do in life than protect the environment.
4. There is no point in doing what I can for the environment unless others do the same.
5. It is too difficult for someone like me to do much about the environment.
6. Modern science will solve our environmental problems with little change to our way of life.

Climate change beliefs: Scale according to Poortinga et al. (2019)

- You may have heard the idea that the world's climate is changing due to increases in temperature over the past 100 years. What is your personal opinion on this? Do you think the world's climate is changing?
  (Answering options on a 4-point Likert-scale: *definitely not changing, probably not changing, probably changing, definitely changing*)
- Do you think that climate change is caused by natural processes, human activity, or both?
  (Answering options: *entirely by natural processes, mainly by natural processes, entirely by human activity, mainly by human activity, about equally by natural processes and human activity, I don't think climate change is happening*)
- Please indicate how good or bad the impact of climate change is on people across the world?
  (In the following scale: -5 means *extremely bad*, 5 means *extremely good*. You can use the values in-between to indicate where you fall on the scale.)

Appendix C: Coding process of the word-stem completion task

The instructions to the research assistants for coding the words of the word-stem task read as follows:

> "As part of our research project, we would appreciate your assistance. Your task is to code words and includes the following (see Excel):
>
> - Sheet Wording Task: Here the task is to code each word whether it has a reference to the future [environment] (1) or not (0). Please write 1 or 0 in the yellow marked fields.
> - Sheet Code: Please indicate here which words you have categorized as future [environment]-related."

The words from the word-stem task were displayed in a separate Excel-File as below, and research assistants had to code the words using 1 for future[environment]-related and 0 for unrelated words.

FIGURE 3.2: Example of the word-stem coding process

	E	F	G	H	I	J	K	L	M	N	O	P
1	word1	Codeword1	word2	Codeword2	word3	Codeword3	word4	Codeword4	word5	Codeword5	word6	Codeword6
2	Generation		Torment		Future		Tution		plural		constituant	
3	operation		fulfilment		furniture		pollution		platitude		confusion	
4	concertration		movement		torture		evelution		please		confused	
5	Moderation		Moment		Future		Caution		plEase		conVert	
6	orchestration		contentment		torture		dilution		pluto		conservatory	
7	hydration		torment		torture		polution		place		conservative	
8	generation		judgment		furniture		solution		plural		conection	

Research assistants coded for example the following words as future-related:
future, investment, retirement, plan

Research assistants coded for example the following words as present-related:
moment, duration, commencement

Research assistants coded for example the following words as serious-related:
concentration, argument, immigration, separation

Research assistants coded for example the following words as environmental-related:
environment, nature, temperature, pollution, plant

Essay 4: Saving the world voluntarily – Experimental evidence of gain-loss framing on voluntary pro-environmental behavior

David Hauser, Daniel Bregulla[*]

Abstract

Empirical research shows that loss framing appears to be a promising tool to promote pro-environmental behavior. However, only a limited amount of experimental research has examined the effect of loss framing on actual behavior. Here, we use a variation of the Work for Environmental Protection Task by Lange and Dewitte (2022) to study voluntary pro-environmental behavior. In an online experiment (N = 897), we find a trend of higher working efforts in the *LOSS* frame. However, this effect is small and marginally statistically significant. Interestingly, as explorative analyses suggest, the effect of the *LOSS* frame is more substantial and statistically significant for people with low intrinsic motivation to protect the environment. This finding opens a novel avenue for future researchers to tailor gain and loss framing according to people's environmental values.

Keywords: framing, loss aversion, pro-environmental behavior, experiment
JEL classification: C91, D90, Q50

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4.1 Introduction

People's voluntary engagement in pro-environmental behavior (PEB) plays an essential role in future climate change mitigation (Bergquist et al., 2023). Demand-side strategies, including PEB, can potentially reduce greenhouse gas emissions by 40-70% by 2050, according to the latest report of the Intergovernmental Panel on Climate Change (IPCC, 2022). This remarkable potential puts PEB at the forefront of strategies for tackling climate change. One way for governments, companies, or NGOs to promote voluntary PEB is to frame environmental decisions as losses — an approach that has shown potential to boost environmentally friendly behavior (Ropret Homar and Knežević Cvelbar, 2021). In this paper, we build on the literature of voluntary pro-environmental behavior and loss framing by addressing the following research question: How do gain and loss framing influence people's voluntary working behavior to mitigate climate change?

In our experiment, we measure individual voluntary working behavior to mitigate climate change by applying a variation of the *Work for Environmental Protection Task* (WEPT) (Lange and Dewitte, 2022). In the WEPT, participants can voluntarily work on a WEPT page, a number identification task, to generate a donation to an environmentally friendly organization by the researcher. Alternatively, participants can refuse to work on a given WEPT page. In total, there are 15 randomly presented number identification tasks, and each task varies along the amount donated to the environmentally friendly organization and the required working effort (e.g., size of numbers to be identified). In our *GAIN* frame, participants start with zero donations and can increase their donations to mitigate climate change with every completed WEPT page. In contrast, participants in the *LOSS* frame see the total number of remaining possible donations before deciding whether to work on the task or not. With every WEPT page left incomplete, the total amount of donation decreases.

Our results imply higher working performance under a loss frame for our pre-registered sample. However, the effect size is small (Cohen's $d = 0.12$) and marginally statistically significant ($p = .069$, Wilcoxon-Mann-Whitney test). Nevertheless, robustness checks including additional data from the pilot study ($n = 50$) suggest a tendency towards an increased working performance under a *LOSS* frame. Interestingly, our *LOSS* framing significantly affects people with low biospheric values ($p = .028$, Wilcoxon-Mann-Whitney test). Biospheric values emphasize an individual's intrinsic value of nature and environment (Steg and de Groot, 2012). Additionally, results indicate that age and political ideology drive voluntary working behavior. In line with previous research (Lange and Dewitte, 2022), we find that pro-environmental intentions, environmental concern,

and biospheric as well as altruistic values are positively correlated with pro-environmental behavior.

Previous empirical evidence testing the effect of loss framing on PEB is mixed. Some studies suggest a significant effect (e.g., Nabi et al. 2018, Poortinga and Whitaker 2018), while others find no discernible effect (e.g., Ahn et al. 2015, Essl et al. 2023a). However, experimental designs and the measurement of PEB vary widely across studies. While some are conducted as field experiments, others still measure self-reported willingness to pay or environmental intentions as the dependent variable, and only a limited number of experiments use actual environmental behavior as their outcome measure (Ropret Homar and Knežević Cvelbar, 2021). We contribute to this literature by conducting an online experiment and measuring pro-environmental behavior with a task including actual environmental consequences.

Closely related to our experimental design are experiments testing participants' working behavior under gain or loss contracts. Under a gain-framed contract, people work to receive an incentive, whereas under a loss-framed contract, people work to avoid losing an incentive (Imas et al., 2017). Given that incentives for gain and loss-framed contracts are economically equivalent (i.e., monetary incentives are the same), prospect theory by Kahneman and Tversky (1979) would predict enhanced working effort under a loss contract due to loss aversion around a reference point. Findings from online experiments about gain-loss contracts[1] are mixed, ranging from no effects (DellaVigna and Pope, 2018, Grolleau et al., 2016) to medium (de Quidt, 2018, Goldsmith and Dhar, 2013) or strong effects (Hochman et al., 2014) of loss-framed contracts. The variability in these findings may stem from differences in experimental designs, the nature of real-effort tasks used, or the types of incentives provided (Essl et al., 2023b). We advance this research by incentivizing participants to work voluntarily on a real-effort task to gain donations to mitigate climate change. Hence, participants do not receive any immediate benefit for themselves by working on the task.

4.2 Methods

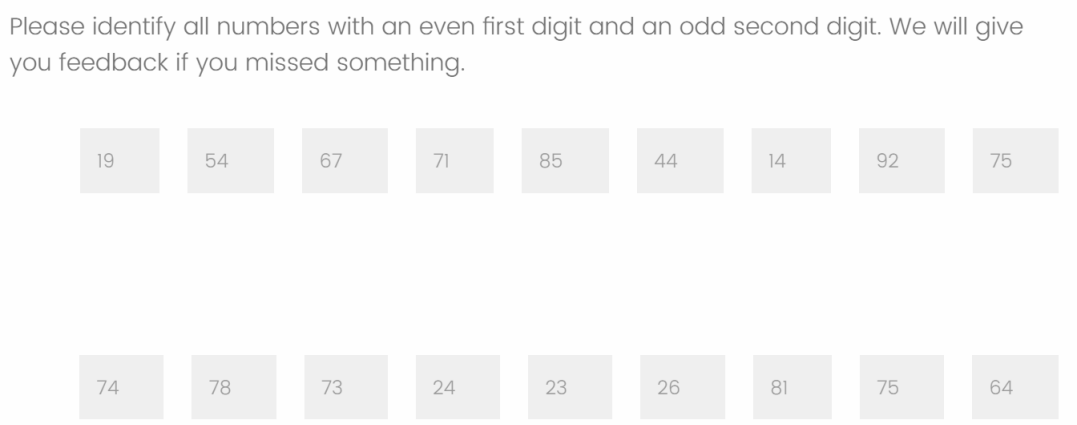
We pre-registered our study on the Open Science Framework (OSF) and received ethical approvement from the Faculty of Business Administration, Economics and Social Sciences of the University of Bern (serial Number: 292022). We provide a survey template to test gain-loss framing online via Qualtrics, data, and R code to facilitate future analyses of the WEPT on OSF.

[1] See Essl et al. (2023b) for an overview.

4.2.1 Experimental design

We designed a between-subject experiment with two parts.[2] In the first part, after giving informed consent, participants familiarized themselves with the number identification task of the WEPT. We decided to use the WEPT because this validated task has been widely used (e.g., Vlasceanu et al. 2023) and allows us to assess PEB through repeated measures, presenting participants with different variations over multiple periods. As a trial page of the WEPT (see Figure 4.1), participants had to identify all numbers out of 20 two-digit numbers with an even first digit and an odd second digit. Participants received feedback if they failed to detect all numbers correctly. No specific knowledge or skills were required to complete the task. After completing the trial page, participants were randomly assigned to a *GAIN* or a *LOSS* treatment and could voluntarily complete up to 15 WEPT pages.

FIGURE 4.1: Trial page of the WEPT task



Following Lange and Dewitte (2022), we varied the quantity of numbers and donations per page to measure different effort levels of participants. The quantity of numbers in the identification task was 40, 80, 120, 160, or 200, and the donations for completing a WEPT page were GBP 0.10, GBP 0.20, or GBP 0.30. All these factors together led to 15 different combinations of WEPT pages that were randomly presented to participants. In the *GAIN* treatment, participants were informed that "with every complete page, you increase the amount of donations to an international, non-profit forest restoration organization that plants trees to mitigate climate change. If you complete every page, you can achieve possible donations of GBP 3.0." In contrast, participants in the *LOSS* treatment received the following information: "If you complete every page, you can achieve possible donations of GBP 3.0 to an international, non-profit forest restoration organization that plant trees to mitigate climate change. With every incomplete page,

[2]See in the Appendix B for the entire survey questionnaire.

you reduce the amount of donations to mitigate climate change." In both conditions, participants were instructed that the total amount of donation would be displayed on each WEPT page before deciding to work on it. Additionally, participants were informed about the maximum of 15 WEPT pages and on each page about the quantity of numbers to be checked to trigger a specific donation. The total amount of donation was economically equivalent in both conditions. While in the *GAIN* treatment, the total amount started with GBP 0, the total amount of donation started with GBP 3.0 in the *LOSS* treatment. We highlighted that completing a WEPT page is voluntary and that participants' working effort has true consequences for the environment. Furthermore, we emphasized that only pages completed with at least 90% accuracy would result in a donation and that participants would not receive any feedback on their performance. To avoid potential bias, we did not disclose the name of the organization that would receive the donations. Participants were briefed that planting trees is an effective method to mitigate climate change. A comprehension question ensured that participants understood the instructions correctly. Finally, participants could provide their e-mail addresses to receive a confirmation e-mail as soon as we made the donation. In the second part of the experiment, participants completed self-reported questionnaires assessing pro-environmental intentions, environmental concern, value orientation, and belief about climate change. We used the New Environmental Paradigm (NEP) (Dunlap et al., 2000) to capture participants' environmental concern, a 15-item scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The 16-item E-SVS scale by Steg and de Groot (2012) was employed to measure biospheric, hedonistic, altruistic, and egoistic values. This scale ranges from -1 (*opposition to a value*) to 7 (*supreme importance*). We also administered a single item introduced by Berger et al. (2023) to measure participants' belief in climate change. As an exclusion criterion, we asked participants about the effectiveness of tree planting to mitigate climate change. The experiment concluded with a questionnaire about gender, age, education, political affiliation, risk attitude, and income.

4.2.2 Theoretical model and behavioral prediction

We present a simple model that aims to explain why people tend to work more when potential environmental donations are framed as losses than as gains. Our model is based on a model by Imas et al. (2017) about working effort under loss contracts and the seminal work on Prospect theory by Kahneman and Tversky (1979). We make three essential assumptions in our model. First, depending on environmental values, people experience a utility of acting environmentally friendly to a reference point. This means that people, depending on their environmental values, derive a positive utility from donating and a negative utility from not donating. Second, we assume that environmental losses

(e.g., forgone donation to an environmental organization) loom larger for people than equivalent gains. Third, we assume that the reference point is determined by the status quo. In our context this means that participants update their reference point each time before deciding to accept or reject a working contract.

Consider an individual deciding whether to accept a contract to work on a real-effort task and generate donation d to an environmentally friendly organization or to reject the contract. Let $c(e)$ be the costs (e.g., forgone time) of completing the real-effort task depending on the required effort e. We assume that an individual receives a utility $u(d)$ from generating a donation if she has at least some pro-environmental values p. Taken together, we formalize an individual's utility function V as follows:

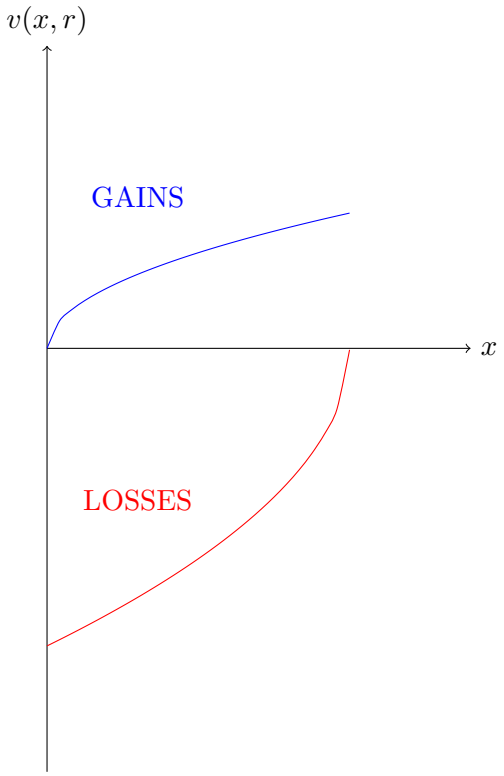
$$V = V(e, d, p, r) = e \cdot p[u(d) + \nu(d|r)] + (1 - e) \cdot p[\nu(0|r)] - c(e) \tag{4.1}$$

where an individual receives a utility $u(d)$ of generating a donation $d > 0$ to an environmentally friendly organization depending on environmental values $p \in (0, 1)$ with probability equal to effort $e \in (0, 1)$. We assume that u is an increasing and concave function of d and normalized to $u(0)$=0. Contrary, an individual generates a donation of 0 with probability $1 - e$. As described below, $v(\cdot|r)$ corresponds to the gain-loss prospect theory value function. Let c be an increasing, convex function of e ($c'(e) > 0$, $c''(e) > 0$). Further, we define the utility derived in relation to reference point r as follows:

$$v(x|r) = \begin{cases} (x - r)^{\alpha}, & x \geq r \\ -\lambda(r - x)^{\beta}, & x \leq r \end{cases}$$

where $\lambda > 1$ captures the loss aversion parameter, α is the risk aversion parameter in the $GAIN$ frame, and β is the risk aversion parameter in the $LOSS$ frame. Following Imas et al. (2017), we assume that $\alpha = \beta$. We illustrated this value function $v(x|r)$ in Figure 4.2. In the $GAIN$ treatment, participants' reference point of donation displayed on the x-axis is 0 and the value depending on donation and reference point increase with every generated donation. Contrary participants in the $LOSS$ treatment start with the total amount of donation as reference point and their value of the donation decreases with every forgone of donation.

FIGURE 4.2: An individual's value function



Notes: An individual's value function $v(x|r)$ is displayed on the y axis. Donations correspond to the outcome measure on the x-axis.

As in Kahneman and Tversky (1979), an individual chooses optimal effort e^* to maximize overall utility V.

$$\max_e V(e, d, p, r) = \max_e \{e \cdot p[u(d) + \nu(d|r)] + (1 - e) \cdot p[\nu(0|r)] - c(e)\} \tag{4.2}$$

We derive the first-order condition for the optimal effort e_G^* under a $GAIN$ frame ($r = 0$) and optimal effort e_L^* in a $LOSS$ frame ($r = d$).

$$c'(e_G^*) = p(u(d) + d^\alpha) \tag{4.3}$$

$$c'(e_L^*) = p(u(d) + \lambda d^\beta) \tag{4.4}$$

Given that $\alpha = \beta$, $\lambda > 1$, and $p \in (0, 1)$ leads to $p(u(d) + d^\alpha) < p(u(d) + \lambda d^\alpha)$. Hence, optimal effort in the $LOSS$ frame will be greater $e_G^* < e_L^*$ than optimal effort in the

GAIN frame if an individual has at least some environmental values $p > 0$. This leads us to our main hypothesis predicted by our model:

Hypothesis 1: Participants in the LOSS treatment will exhibit higher effort (e.g., more completed WEPT pages) than participants in the GAIN treatment if they have some environmental values.

Similar to Lange and Dewitte (2022), we assume that the amount of completed WEPT pages is linked to established self-reported environmental measures.

Hypothesis 2: The number of completed WEPT correlates positively with self-reports measuring participants' pro-environmental intentions, environmental concern, belief in climate change, and environmental values (i.e., altruistic, biospheric values).

4.2.3 Data collection

Overall, we recruited 998 participants on Prolific.[3] We adhered to the protocol in our pre-registration and excluded participants with incomplete responses ($n = 63$) or who failed crucial attention checks ($n = 23$). Further, we excluded participants ($n = 15$) who did not believe that planting trees is an effective way to mitigate climate change since we could not be sure that these participants were incentivized.[4] Beyond our pre-registered criteria, we did not exclude participants who took longer than one hour to complete the survey, as we received e-mails from participants informing us that they required more time to complete the number identification tasks. This left us with a total sample of 897 participants (51% female, mean age: 40.4). See Table 4.1 for a full description of the sample and randomization check. Randomization between *GAIN* and *LOSS* treatment was successful except for the variables income and biospheric values.

Participants received a flat fee of GBP 1.5 for completing the survey. On average, it took participants nearly 18 minutes to finish the survey.

[3] See power analysis in our pre-registration on OSF.

[4] In a robustness check (see Table 4.8 in the Appendix A), we included these participants. Including participants who did not believe that planting trees is an effective way to mitigate climate change improves the statistical significance of our treatment.

TABLE 4.1: Sample characteristics and randomization check

	Sample (n = 897)	*GAIN* (n = 460)	*LOSS* (n = 437)	*GAIN* vs. *LOSS* p-values
Demographics				
Gender (% female)	51	52	49	.275
Age in years (range 18 – 79)	40.44 (SD=13.48)	40.75 (SD=13.30)	40.12 (SD= 13.69)	.407
Political affiliation (% liberal)	49	50	48	.476
Education (% higher than high school)	78	80	75	.076
Income (% earn more than GBP 50'000)	35	0.31	0.39	.022
Risk	4.6 (SD=2.58)	4.63 (SD=2.60)	4.58 (SD= 2.56)	.792
Environmental concern	3.79 (SD=0.55)	3.80 (SD=0.55)	3.78 (SD=0.56)	.625
Belief in climate change	3.38 (SD=1.87)	3.41 (SD=1.81)	3.34 (SD=1.94)	.959
Biospheric values	5.47 (SD=1.31)	5.55 (SD=1.28)	5.38 (SD=1.36)	.056
Altruistic values	5.70 (SD=1.10)	5.73 (SD=1.12)	5.67 (SD=1.09)	.365
Egoistic values	2.75 (SD=1.43)	2.78 (SD=1.43)	2.72 (SD=1.42)	.545
Hedonistic values	4.94 (SD=1.30)	5.0 (SD=1.34)	4.89 (SD=1.26)	.107

Notes: The table reports means and standard deviations for continuous variables and percentage frequencies for categorical variables for the full sample and for participants in the *GAIN* and *LOSS* sample. Standard deviations are given in parentheses. For categorical variables, the p-values were obtained from a χ^2-test. For continuous variables, the p-values were obtained from Wilcoxon-Mann-Whitney tests. Two participants (1 *GAIN* treatment, 1 *LOSS* treatment) are removed for income calculations because they did not state their income.

4.3 Results

Our study aimed to investigate the impact of gain and loss frames on pro-environmental behavior, specifically the completion of WEPT pages. In line with our pre-registered Hypothesis 1, we compare the average number of completed WEPT pages (e.g., a complete WEPT page is defined as correctly identifying at least 90 percent of the numbers on a

given page).[5] As presented in Table 4.2, results reveal that the number of completed WEPT pages is greater for participants in the *LOSS* treatment ($M = 5.16$, $SD = 4.11$) than for participants in the *GAIN* treatment ($M = 4.66$, $SD = 4.41$). The difference between the *GAIN* and *LOSS* treatment is marginally significant ($p = .068$, Wilcoxon-Mann-Whitney test). In contrast, we find no statistically significant difference in total donations generated by individual participants between the two treatment groups.[6]

TABLE 4.2: Descriptive and inferential statistics: WEPT pages

	WEPT Pages (0–15)	
	GAIN ($n = 460$)	*LOSS* ($n = 437$)
Mean	4.66	5.16
SD	4.11	4.41
	GAIN vs. *LOSS*	
Cohen's d	-0.12	
95% CI	[-0.25, 0.01]	
p-value	0.068	

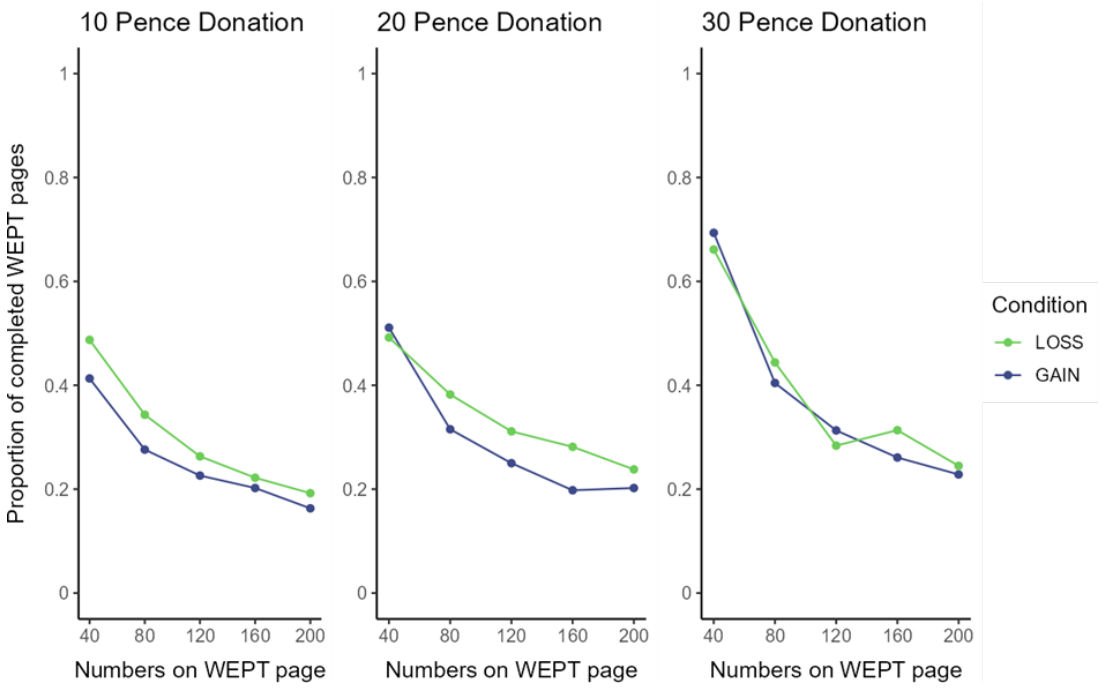
Note: p-values were obtained from a one-sided Wilcoxon-Mann-Whitney test.

Figure 4.3 shows the proportion of completed WEPT pages for all 15 combinations of numbers and donations for the *GAIN* and *LOSS* frame.

[5] The total number of pages completed by all participants, meeting the 90% accuracy criterion, is 4,397. For the more lenient 80% accuracy criterion, the sum is 5,541 pages. Including all pages, even those solved incorrectly, the overall total is 6,073. The difference in the proportion of incorrectly solved pages between the treatment groups is marginally significant ($p = .059$, Wilcoxon-Mann-Whitney test), the error rate being larger in the *GAIN* group ($M = 0.33$, $SD = 0.31$) than in the *LOSS* group ($M = 0.29$, $SD = 0.29$).

[6] See Table 4.6 in the Appendix A for the analysis of total amount of donation.

FIGURE 4.3: Proportion of completed WEPT pages



Note: Proportion of completed WEPT pages as a function of treatment condition, donation amount, and the numbers to be solved on a given WEPT page.

To investigate the effects and the robustness of the results in more detail, we use the following OLS regression model:

$$y_i = \beta_0 + \beta_1 LOSS_i + \beta_2' \mathbf{E}_i + \beta_3' \mathbf{X}_i + \epsilon_i$$

where the dependent variable y_i represents the number of completed WEPT pages by individual i, and $LOSS_i$ is a dummy variable indicating whether the individual was in the *LOSS* (1) or *GAIN* (0) treatment, respectively. We also estimate model specifications $\mathbf{E}_i$ to control for factors such as intentions to act environmentally friendly, environmental concern, belief about climate change, and environmental values. $\mathbf{X}_i$ accounts for sociodemographic variables, i.e., age, gender, education, political ideology, income, and risk attitudes. Lastly, ϵ_i is the idiosyncratic error term.

Table 4.3 presents the estimated coefficients of the OLS regression analysis about effects of the *LOSS* treatment on completed WEPT pages.[7] In Specification 1, the result for the effect of the *LOSS* treatment is marginally significant for a two-tailed t-test.[8]

[7] See Table 4.7 in the Appendix A for OLS regressions for donation as dependent variable.

[8] However, for our directional hypothesis, the effect of the *LOSS* treatment is statistically significant for a one-sided t-test ($t(882.12) = -1.766$, $p = .039$, Cohen's $d = -0.12$).

The treatment coefficient increases and reaches statistical significance at the 5%-level in Specification 2 and Specification 3 when controlling for pro-environmental intentions, environmental concern and values, and sociodemographic variables, respectively. As expected in Specification 2, an increase in pro-environmental intentions and biospheric values leads to a greater number of completed WEPT pages. Furthermore, in Specification 3, we find that an individual's age increases the number of completed WEPT pages.

TABLE 4.3: Effects of *LOSS* treatment on completed WEPT pages: OLS regression

	(1) WEPT pages	(2) WEPT pages	(3) WEPT pages
LOSS treatment	0.50*	0.60**	0.67**
	(0.29)	(0.28)	(0.28)
Pro-environmental intentions		0.49***	0.49***
		(0.16)	(0.16)
Environmental concern		-0.16	-0.15
		(0.19)	(0.20)
Belief in climate change		-0.10	0.00
		(0.17)	(0.18)
Biospheric values		0.62***	0.44**
		(0.20)	(0.21)
Altruistic values		0.19	0.21
		(0.18)	(0.18)
Egoistic values		-0.38**	-0.24
		(0.15)	(0.16)
Hedonistic values		-0.03	0.13
		(0.16)	(0.16)
Female (1 = female)			0.03
			(0.14)
Age			0.67***
			(0.16)
Education (> High school)			-0.37
			(0.34)
Liberal (1 = liberal)			0.26
			(0.30)
Income (> GBP 50,000)			-0.24
			(0.29)
Risk			0.08
			(0.14)
Intercept	4.66***	4.61***	4.82***
	(0.19)	(0.19)	(0.40)
Observations	897	897	895
R-squared	0.00	0.06	0.09

Notes: The table presents estimates from ordinary least squares (OLS) regressions. Robust standard errors are shown in parentheses and all continuous predictors are mean-centered and scaled by 1 standard deviation. Dependent variable is completed WEPT pages according to the 90% criterion. Pro-environmental intentions are measured on a 7-point Likert scale. Environmental concern is assessed on a 5-point Likert scale. Belief in climate change is measured on a scale from -5 (*strongly disagree*) to +5 (*strongly agree*). Biospheric, altruistic, egoistic, and hedonistic values are assessed with a scale from -1 (*opposed to my principles*) to 7 (*extremely important*). Female indicates being female (1) or not (0), education whether having a higher education than high school (1) or not (0), being liberal (1) or not (0), or having a higher than annual income GBP 50'000 (1) or not (0). In Specification 3, two participants (1 *GAIN* treatment, 1 *LOSS* treatment) are removed because they did not state their income. *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

We replicated our findings for different samples in Table 4.4 for Specifications 1 to 3 considering completed WEPT pages (see Table 4.8 in the Appendix A for donations). Specifically, we included participants that were skeptical about tree planting and found

that results remained robust and are statistically significant at the 5%-level. The same is true if we add data from our pilot study ($n = 50$), which had exactly the same experimental design as our main study. Contrarily, the effect of the loss framing disappears if we include all WEPT pages without accounting for a minimum of 90% correctly identified numbers. Interestingly, the *LOSS* treatment is more effective for those participants with low biospheric values as determined by a median split ($n = 432$). Participants with low biospheric values completed 0.73 WEPT pages more in the *LOSS* treatment ($M = 4.47$, $SD = 4.06$, $n = 227$) than in the *GAIN* treatment ($M = 3.74$, $SD = 3.72$, $n = 205$). This difference is statistically significant ($p = .028$, one-sided Wilcoxon-Mann-Whitney test).

TABLE 4.4: Robustness check of WEPT pages for different samples

Dependent variable	WEPT pages		
	(1)	(2)	(3)
Main sample	0.50*	0.60**	0.67**
	(0.29)	(0.28)	(0.28)
n	897	897	895
incl. tree planting skeptic	0.56**	0.64**	0.71**
	(0.28)	(0.28)	(0.28)
n	912	912	910
incl. pilot study	0.55**	0.64**	0.72***
	(0.28)	(0.28)	(0.27)
n	927	927	925
incl. all WEPT pages	0.32	0.44	0.53*
	(0.30)	(0.30)	(0.29)
N	897	897	895
Low biospheric values	0.73*	0.77**	0.80**
	(0.37)	(0.38)	(0.38)
n	432	432	432

Notes: The table displays the coefficients of the loss treatment as dummy variable of Specifications 1 to 3 of Model 1. Robust standard errors are shown in parentheses. The dependent variable is completed WEPT pages according to the 90% criterion. In Specification 3, two participants (1 *GAIN* treatment, 1 *LOSS* treatment) are removed because they did not state their income (except in sample 'low biospheric values'). In the sample 'including tree planting skeptics', one participant is removed from Specification 1 to 2 because the participant did not state their belief in climate change and two participants are removed because they did not state their income. The sample 'low biospheric values' is based on the median split. Only participants below the median of biospheric values are considered. 'Main sample' is the sample used after the exclusion of participants according to the pre-registered protocol. *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

In line with our pre-registered Hypothesis 2, we conducted Spearman correlational analyses, which are presented in Table 4.5. Consistent with the OLS regression analysis, we identified highly statistically significant correlations between the number of completed WEPT pages and pro-environmental intentions ($r = .18$, 95% CI [0.12, 0.24], $p < .001$),

environmental concern ($r = .10$, 95% CI [0.03, 0.16], $p < .05$), biospheric values ($r = .20$, 95% CI [0.14, 0.26], $p < .001$), altruistic values ($r = .15$, 95% CI [0.09, 0.21], $p < .001$), and age ($r = .15$, 95% CI [0.09, 0.21], $p < .001$). Overall, we find similar correlations to those reported by Lange and Dewitte (2022).

Table 4.5: Descriptive statistics and Spearman correlations for study variables (N = 897)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	Mean	SD
(1) WEPT	—													4.90	4.27
(2) PE intentions	.18***	—												5.19	1.21
(3) Env. concern	.10***	.33***	—											3.79	0.55
(4) Belief in CC	.08**	.32***	.59***	—										3.38	1.87
(5) Biospheric	.20***	.54***	.48***	.40***	—									5.47	1.35
(6) Altruistic	.15***	.41***	.26***	.37***	.62***	—								5.70	1.10
(7) Egoistic	-.07**	-.01	-.33***	-.21***	-.04	-.00	—							2.75	1.43
(8) Hedonistic	.00	.06*	-.05	.14***	.17***	.28***	.27***	—						4.94	1.30
(9) Female	.05	.08**	.14***	.02	.11***	.18***	-.00	.05	—					0.51	0.50
(10) Age	.15***	.04	.05	-.12***	.13***	-.05	-.23***	-.32***	-.04	—				40.44	13.48
(11) Education	-.04	.06*	.07**	.06*	-.05	.02	-.03	-.04	.00	-.05	—			2.92	0.92
(12) Political Id.	-.03	-.18***	-.31***	-.42***	-.16***	-.35***	.21***	-.13***	-.09***	.26***	-.13***	—		4.40	2.01
(13) Income	-.02	-.01	-.02	-.01	-.08**	-.05	.17***	.06*	.01	-.04	.23***	.05	—	4.89	2.61

Notes: WEPT are based on 90% accuracy criterion. PE = Pro-environmental, Env. = Environmental, CC = Climate change, Id = Ideology. Pro-environmental intentions are measured on a 7-point Likert scale and environmental concern is measured on a 5-point Likert scale. Belief in climate change is measured on a scale from -5 (*extremely bad*) to +5 (*extremely good*). Biospheric, altruistic, egoistic and hedonistic values range form -1 (*opposed to my principles*) to 7 (*extremely important*). Besides age, which is a continuous variable, we included the remaining demographical variables as dummy variables. See Table 4.3 for explanation of dummy variables. *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

4.4 Discussion

Our experiment examines the effects of a *GAIN* and a *LOSS* frame on voluntary pro-environmental behavior. Results indicate higher levels of pro-environmental behavior under a *LOSS* frame; however, the effect size is relatively small and marginally statistically significant. With our model, we predict that the effect of loss aversion also depends on environmental (e.g., biospheric) values. Interestingly for future research, a robustness check for people with low biospheric values shows that the effect of the *LOSS* frame statistically significantly increases pro-environmental behavior.

Since we observe generally higher biospheric value scores of participants in the *GAIN* frame, their intrinsic motivation to mitigate climate change appears to reduce the difference in the average number of WEPT pages completed across both frames, thereby diminishing the impact of loss aversion. Given that individuals with high biospheric values are already inclined toward pro-environmental behavior, our findings suggest that loss framing could be particularly effective for engaging those with lower biospheric values, even if the effect size is small. Future research could focus on biospheric values to unlock greater improvements in pro-environmental behavior. Additionally, Essl et al. (2023b) argue that paying participants cash upfront leads to higher effort provision than simply informing participants about an upfront payment, as in our experiment. Together, this evidence may also explain the weak effects of our *LOSS* framing. Although the *LOSS* frame seems to motivate more effort in terms of completed WEPT pages, this does not translate to a corresponding increase in the generated donations. This suggests that participants are not optimizing their choices of which pages to complete based on the potential donations and required effort. To optimize individual choices, a possible variant of our design could be to let participants choose if they prefer a *GAIN* or a *LOSS* frame (Milkman et al., 2021).

We find similar correlation coefficients and statistical significance to Lange and Dewitte (2022) between completed WEPT pages and biospheric and egoistic values, albeit correlation coefficients are smaller for environmental concerns in our study. Overall, these results serve as further evidence of the relationship between specific self-reported and behavioral measures. Because we incentivized a specific form of pro-environmental behavior (e.g., a donation to a tree reforestation organization), we do not expect this behavior to generalize to every pro-environmental behavior (Lange, 2023).

Comparing our results with findings on gain and loss contracts, in particular online experiments, we align with de Quidt (2018) and Imas et al. (2017) by finding weak effects of loss framing on effort provision from a Prolific sample. In comparison to experiments about loss aversion with a focus on energy-saving behavior (e.g., Ghesla et al. 2020) or

investments in energy-efficiency (e.g., Heutel 2019), our experiment was purely based on altruistic incentives. Specifically, participants in our experiment expended effort with no personal financial gain, motivated solely by the prospect of contributing positively to the environment through tree planting. Surprisingly, participants dedicated a substantial amount of time, an average of 11.5 minutes ($SD = 10$ minutes), to complete the real effort tasks to secure an average donation of GBP 1.03.

Lastly, our study is complementary to the broader research landscape on promoting pro-environmental behavior. Many people want to mitigate climate change, but do not exactly know how, do not have the necessary instruments, or are prevented from doing so by psychological barriers. The objective should be to cultivate the most conducive environment to unleash the potential of voluntary pro-environmental behavior, which may also include gain-loss framings tailored to individuals' intrinsic motivation for mitigating climate change.

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Appendix A: Additional analysis

TABLE 4.6: Descriptive and inferential statistics: Donations

	Donations (in £)	
	GAIN ($n = 460$)	*LOSS* ($n = 437$)
Mean	0.99	1.08
SD	0.84	0.89
	GAIN vs. LOSS	
Cohen's d	-0.10	
95% CI	[-0.23, 0.04]	
p-value	.109	

Note: p-values were obtained from a one-sided Wilcoxon-Mann-Whitney test.

Table 4.7: Effects of loss treatment on donation: OLS regression

	(1) Donation	(2) Donation	(3) Donation
LOSS treatment	0.08	0.10*	0.11**
	(0.06)	(0.06)	(0.06)
Pro-environmental intentions		0.10***	0.10***
		(0.03)	(0.03)
Environmental concern		-0.02	-0.02
		(0.04)	(0.04)
Belief in climate change		-0.02	-0.01
		(0.03)	(0.04)
Biospheric values		0.11***	0.08*
		(0.04)	(0.04)
Altruistic values		0.04	0.04
		(0.04)	(0.04)
Egoistic values		-0.08**	-0.05
		(0.03)	(0.03)
Hedonistic values		-0.00	0.03
		(0.03)	(0.03)
Female (1 = female)			0.01
			(0.03)
Age			0.13***
			(0.03)
Education (> High school)			-0.08
			(0.07)
Liberal (1 = liberal)			0.06
			(0.06)
Income (> GBP 50,000)			-0.04
			(0.06)
Risk			0.02
			(0.03)
Intercept	0.99***	0.98***	1.03***
	(0.04)	(0.04)	(0.08)
Observations	897	897	895
R-squared	0.00	0.06	0.08

Notes: The table presents estimates from ordinary least squares (OLS) regressions. Robust standard errors are shown in parentheses and all continuous predictors are mean-centered and scaled by 1 standard deviation. Dependent variable are donations in GBP based on the 90% criterion of correct WEPT pages. Pro-environmental intentions are measured on a 7-point Likert scale. Environmental concern is assessed on a 5-point Likert scale. Belief in climate change is measured on a scale from -5 *strongly disagree* to +5 *strongly agree*. Biospheric, altruistic, egoistic, and hedonistic values are assessed with a scale from -1 *opposed to my principles* to 7 *extremely important*. Female indicates being female (1) or not (0), education whether having a higher education than high school (1) or not (0), being liberal (1) or not (0), or having a higher than annual income GBP 50'000 (1) or not (0). Two participants (1 *GAIN* treatment, 1 *LOSS* treatment) from Specification 2 to 3 are removed because they did not state their income. *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4.8: Robustness check for WEPT pages and donations

Dependent variable	WEPT pages			Donations		
	(1)	(2)	(3)	(1)	(2)	(3)
Main sample	0.50*	0.60**	0.67**	0.08	0.10*	0.11**
	(0.29)	(0.28)	(0.28)	(0.06)	(0.06)	(0.06)
n	897	897	895	897	897	895
incl. tree planting	0.56**	0.64**	0.71**	0.09*	0.11*	0.12**
skeptic	(0.28)	(0.28)	(0.28)	(0.06)	(0.06)	(0.06)
n	912	912	910	912	912	910
incl. pilot study	0.55**	0.64**	0.72***	0.09*	0.11**	0.13**
	(0.28)	(0.28)	(0.27)	(0.06)	(0.06)	(0.06)
n	927	927	925	927	927	925
incl. all WEPT pages	0.32	0.44	0.53*	0.05	0.07	0.09
	(0.30)	(0.30)	(0.29)	(0.06)	(0.06)	(0.06)
N	897	897	895	897	897	895
Low biospheric values	0.73*	0.77**	0.80**	0.14*	0.15*	0.15**
	(0.37)	(0.38)	(0.38)	(0.08)	(0.08)	(0.08)
n	432	432	432	432	432	432

Notes: The table displays the coefficients of the loss treatment as dummy variable of Specifications 1 to 3 of Model 1. In Specification 3, two participants (1 gain treatment, 1 loss treatment) are removed because they did not state their income (except in sample 'low biospheric values'). While all four samples ('Main sample', 'incl. tree planting skeptic','incl. pilot study', 'low biospheric values') do account for failed attention check, the sample 'incl. all WEPT pages' does not. Robust standard errors are shown in parentheses. The sample 'low biospheric values' is based on the median split. Only participants below the median of biospheric values are considered. In columns (1), (2) and (3) the dependent variable is completed WEPT pages according to the 90% criterion and total generated donation per participant in column (4), (5) and (6). 'Main sample' is the sample used after the exclusion of participants according to the pre-registered protocol. *, **, and *** document statistical significance at the 10%, 5%, and 1% levels, respectively.

Appendix B: Experimental instructions

Informed consent for study for participation

Thank you very much for supporting our research!
Please read the study information below and click "I CONSENT" if you want to take part in this study.

Purpose and methodoly of this study:
This study aims to examine the mechanisms of human decision-making in a computer task. Please complete this study on a computer, not on a smartphone. Thank you!

Duration of this study:
In part 1 of this study, you have the opportunity to work on a task. In part 2, we ask you several questions. The study takes about 11 minutes to complete, but may take longer based on participants' responses. Participants will receive GBP 1.5 for their participation.

Participant rights:
You participate voluntarily in this study. You keep the right to end your participation at any moment during the study by closing your browser and you know that this will not have negative consequences for you. The study does not entail any known risks.

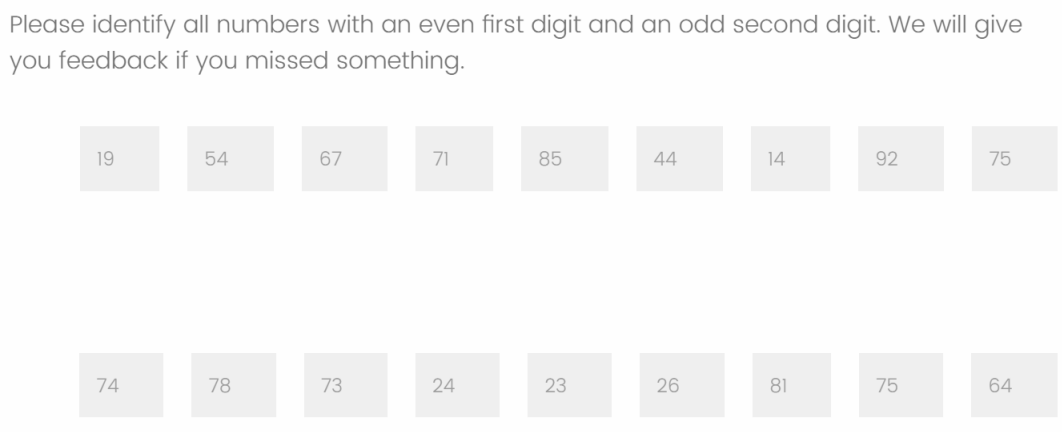
Data confidentiality:
All tasks and questions are for research purposes only. Your decisions and answers will be anonymised and will not influence the terms of any future studies offered to you on Prolific.

Please click "I CONSENT" (I wish to participate in the study) to start the study.

—Page Break—

Part 1

First, we would like you to complete a number identification task. Below, you see a series of two-digit numbers. Please click the box below each target number. Target numbers are all numbers that consist of an **even first digit** (i.e., 2, 4, 6, 8) and an **odd second digit** (i.e., 1, 3, 5, 7, 9). For example, "25" or "83" would be target numbers, but "17", "42", or "56" would not be target numbers.



—Page Break—

In the following, you have the opportunity to complete up to **15 pages** of the number-identification task.

(*GAIN* condition)
With every complete page, you increase the amount of donations to an international, non-profit forest restoration organization that plant trees to mitigate climate change. If you complete every page, you can achieve possible donations of GBP 3.0.

(*LOSS* condition)
If you complete every page you can achieve possible donations of GBP 3.0 to an international, non-profit forest restoration organization that plants trees to mitigate climate change. With every incomplete page, you reduce the amount of donations to mitigate climate change.

For each page, we will tell you how many numbers you will have to check (so that you can estimate the effort) and how much money we will donate if you complete the task. You can then decide, for each page separately, if you want to do this additional effort or not. Doing this task is completely voluntary. You can decide, for each page separately, if you want to do this additional effort or not. If you want, you can decline checking the numbers (by clicking "no") every time and go directly to the next part of the study. However, please do not simply close the survey before you have reached the end of it (otherwise we do not know whom to pay for their participation).

Why plant trees to fight climate change?
The climate crisis will have an increasingly negative impact in the coming decades. Carbon dioxide (CO_2) is regarded as a key contributor to climate change, and scientists around the globe agree that climate change can be mitigated only if carbon emissions are dramatically reduced and captured. Trees absorb CO_2, making reforestation one of the most effective carbon capture solutions (Intergovernmental Panel on Climate Change, 2022). Therefore, planting more trees will lead to a great offset of CO_2 emissions and to a great contribution to the fight against climate change. With a donation of GBP 3.0 to the forest restoration organization, 10 trees are planted which leads to a carbon emission offset of 400 kg CO_2 (equivalent to driving an average passenger car 993 km).

The total amount of donations will always be displayed before you decide to work on a page.

The trees for this study will be planted within the next two months. If you would like to receive a confirmation e-mail, you have the opportunity to register yourself below.

Thus, your working effort has real consequences for the environment.

—*Page Break*—

What happens if you decide to complete the page?

- The total amount of donations increases.
- The total amount of donations decreases.
- The total amount of donations stays the same.

What happens if you decide not to complete the page?

- The total amount of donations increases.
- The total amount of donations decreases.
- The total amount of donations stays the same.

Does your behavior have real consequences for the environment?

- Yes.
- No.

Please insert your e-mail if you want to be updated and receive a confirmation that the trees have been planted.

—*Page Break*—

(*GAIN* condition)
Amount of donation: GBP 0

The next page will contain **40 numbers** and **we will add a donation** of **GBP 0.1** to a non-profit forest restoration organization to plant trees if you complete this page.

(*LOSS* condition)
Amount of donation: GBP 3.0

The next page will contain **40 numbers** and **we will reduce the donation** by **GBP 0.1** to a non-profit forest restoration organization to plant trees if you do not complete this page.

(*GAIN* and *LOSS* condition)
If you decide to complete this page, please do so thoroughly because we can only count pages that are at least 90% correct. We will not give you feedback, so please check whether your answers are correct before proceeding to the next page.

Do you want to complete this page?

- Yes.
- No.

(In the following, participants had to click through 15 different combinations of donations and required effort as described in the manuscript)

—Page Break—

Survey

To conclude this study, we ask you to answer a final survey. Please answer honestly; you are reminded that all questions are for research purposes only. Your answers will be entirely anonymised and will not influence the terms of any future studies offered to you on Prolific. At the end, you will receive your completion code. Please make sure to copy the code and enter it on Prolific.

Here, we ask you about your behavior in the forthcoming month. Please rate the following statements on the 7-point scale: (Answering options: *extremely unlikely, moderately unlikely, somewhat unlikely, neither likely nor unlikely, somewhat likely, moderately likely, extremely likely*)

- I will try to reduce my carbon footprint in the forthcoming month.
- I intend to engage in environmentally friendly behavior in the forthcoming month.
- I plan to stop wasting natural resources in the forthcoming month.

—Page Break—

Listed below are statements about the relationship between humans and the environment. For each one, please indicate how much you agree with it. (Answering options on a 5-point Likert scale: *strongly disagree, somewhat disagree, unsure, somewhat agree, totally agree*)

- We are approaching the limit of the number of people the earth can support.
- Humans have the right to modify the natural environment to suit their needs.
- When humans interfere with nature it often produces disastrous consequences.
- Human ingenuity will ensure that we do NOT make the earth unlivable.
- Humans are severely abusing the environment.
- The earth has plenty of natural resources if we just learn how to develop them.
- Plants and animals have as much right as humans to exist.
- The balance of nature is strong enough to cope with the impacts of modern industrial nations.
- Despite our special abilities humans are still subject to the laws of nature.

- Please select "totally agree".
- The so-called ecological crisis facing humankind has been greatly exaggerated.
- The earth is like a spaceship with very limited room and resources.
- Humans were meant to rule over the rest of nature.
- The balance of nature is very delicate and easily upset.
- Humans will eventually learn enough about how nature works to be able to control it.
- If things continue on their present course, we will soon experience a major ecological catastrophe.

—Page Break—

Below you will find 16 values. Behind each value there is a short explanation concerning the meaning of the value. Please rate how important each value is for you AS A GUIDING PRINCIPLE IN YOUR LIFE? You can use the values in-between to indicate where you fall on the scale. In the following scale: -1 means *opposed to my principles*, 0 means *not important*, 7 means *extremely important*. (Answering options on a 9-point Likert scale ranging from *-1* to *7*)

- EQUALITY: equal opportunity for all
- RESPECTING THE EARTH: harmony with other species
- SOCIAL POWER: control over others, dominance
- PLEASURE: joy, gratification of desires
- UNITY WITH NATURE: fitting into nature
- A WORLD AT PEACE: free of war and conflict
- WEALTH: material possessions, money
- AUTHORITY: the right to lead or command
- SOCIAL JUSTICE: correcting injustice, care for the weak
- ENJOYING LIFE: enjoying food, sex, leasure, etc.
- Please select "opposed to my principles"
- PROTECTING THE ENVIRONMENT: preserving nature
- INFLUENTIAL: having an impact on people and events
- HELPFUL: working for the welfare of others
- PREVENTING POLLUTION: protecting natural resources
- SELF-INDULGENT: doing pleasant things
- AMBITIOUS: hard working, aspiring

—Page Break—

Further questions:

- To what extent do you agree with this statement: The occurrence of climate change is caused by human activities and will bring largely negative consequences. You can use the values in-between to indicate where you fall on the scale. In the following scale: -5 means *strongly disagree*, 5 means *strongly agree*.
- How effective do you consider tree planting to be as a climate protection measure? (Answering options: *not effective at all, not very effective, effective, very effective*)
- What is your gender? (Answering options: *female, male, prefer not to say, prefer to self-describe*)
- How old are you?
- What is the highest degree or level of education you have completed? (Answering options: *less than High School diploma, High School or equivalent, Bachelor degree (e.g., BA, BSc), Master degree (e.g., MA, MS, MEd), Doctorate (e.g., PhD, EdD, DBA), other education*)
- In political matters, people talk of "the left/progressive" and "the right/conservative". How would you place your views on a scale of 1 *(completely left/progressive)* to 10*(completely right/conservative)*? You can use the values in-between to indicate where you fall on the scale.
- Are you generally a person who is willing to take risks or do you try to avoid taking risks? In the following scale: 1 means *not at all willing to take risks*, 10 means *very willing to take risks*. You can use the values in-between to indicate where you fall on the scale.
- What is your household income per year? Please estimate your answer in British pounds.
- What is your Prolific ID?

—Page Break—

Thank you for participating in our study

With your work in the decision task you generated GBP (amount of generated donations is displayed) of donations to fight climate change. Because we can only count pages that are at least 90% correct, we will correct your pages before we make the donation. Thus, the final amount of donation might deviate.

The flat payment for this survey is GBP 1.5 and will paid in the next days.

To confirm that you have completed this study, please click "Finish the study" and you will be redirected to Prolific.

Selbstständigkeitserklärung

Ich erkläre hiermit, dass ich diese Arbeit selbstständig verfasst und keine anderen als die angegebenen Quellen benutzt habe. Alle Koautorenschaften sowie alle Stellen, die wörtlich oder sinngemäss aus Quellen entnommen wurden, habe ich als solche gekennzeichnet. Mir ist bekannt, dass andernfalls der Senat gemäss Artikel 36 Absatz 1 Buchstabe o des Gesetzes vom 5. September 1996 über die Universität zum Entzug des aufgrund dieser Arbeit verliehenen Titels berechtigt ist.

Signed: 

Date: 06.12.2023