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Promoting ecological efforts of individuals and organizations: Insights from behavioral experiments

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Manuel Suter

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Executive Summary

Environmental problems require solutions at various levels to achieve an ecological restructuring of the economy and society. Key players in this transformation are companies, whose actions have an enormous impact on individuals, society, and the environment. The pressure on companies to curb environmental degradation and climate change is growing, for example due to increasing pressure from civil society. Despite the growing awareness and recognition of the need for ecological sustainability, putting this awareness into practice is a major challenge for companies. One reason for this are cognitive biases, which can prevent decision-makers in companies and consumers from taking more environmentally friendly decisions and actions. Cognitive biases refer to systematic patterns of deviation from rational judgment that can lead individuals to make consistently irrational decisions or interpretations of information. Taking cognitive biases into account offers an opportunity to promote more environmentally friendly behavior within companies as well as among consumers. Behavioral ecological economics may help to pursue this endeavour due to its integration of behavioral economics into ecological economics. This interdisciplinary approach makes it possible to empirically test, validate, and ultimately develop behavioral strategies supporting companies in addressing relevant environmental problems within and outside the organization. One specific tool that is suitable for addressing cognitive barriers is framing, which experiments with the way information is presented. The focus of this dissertation is to investigate the influence of different framing approaches on environmentally relevant decisions and behaviors. The thesis addresses how pro-environmental behavior can be measured in lab or online experiments (essay 1), how pro-environmental behavior can be promoted through different framing strategies in communication (essay 2 and 3), and shows the possible implications of different framings in communication on preferences regarding policy making with a large environmental impact (essay 4). The insights are relevant for ecological endeavors of organizations and policy makers.

Essay 1 investigates an approach to measure pro-environmental behavior in the lab or online. The study introduces the so-called *Tree Task*, which is an incentivized, one-shot task measuring 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. The study participants must decide between spending money to plant trees or keeping the money for themselves. Thus, the degree of pro-environmental behavior is captured with the number of trees planted. In line with our pre-registered hypotheses, we find that higher tree costs lead to fewer planted trees and that higher carbon dioxide offsets lead to more planted trees. Additionally, the findings show a correlation between the number of planted trees and self-reports that measure values in line with pro-environmental behavior, general environmental attitudes and intentions, and the belief in climate change. The *Tree Task* can be used in future research as a short, vivid, simple, and validated task measuring incentivized pro-environmental behavior.

Essay 2 investigates whether the way a language encodes time has an influence on speakers' pro-environmental behavior. The German language allows speakers to use either the future tense or present tense to refer to an event in the future. In a controlled experimental setting with German mother tongue speakers, we take advantage of this linguistic feature. In one treatment the participants read a text about the future impacts of climate change and tree planting written in the present tense and in the other treatment participants read the same text written in future tense. Subsequently, we measured pro-environmental behavior with the *Tree Task*. The results show a positive effect of future tense marking on the number of trees planted. Construal level theory, timing precision, future orientation, and certainty of the occurrence of future climate events are discussed as potential mechanisms that may explain why future-time referencing affects individual pro-environmental behavior.

Essay 3 addresses the limited knowledge on how to promote voluntary consumption reduction at the individual level. In an online experiment, we examine the effect of providing information about different benefits of reduced consumption to nature, society, or the individual on subsequent consumption behavior. The behavioral outcome of the experiment was participants' voluntary consumption reduction in an incentivized task. Participants' voluntary consumption reduction was measured on the basis of their decision between an Amazon voucher and a donation to a project promoting reduced consumption. The results show that among the three types of sufficiency gain framing, the individual sufficiency gain framing is the most promising approach to reduce consumption. The results further show that informing about individual benefits of a lifestyle with less consumption such as more free time and better mental health may be fruitful in promoting reduced consumption especially among individuals with higher income, a rather left-leaning political ideology, and higher level of education.

Essay 4 examines the psychological implications of different Gross Domestic Product (GDP) development framings among academic experts. GDP reflects the market value of all final goods and services produced in a specific time period by a country and is the most commonly applied wealth indicator globally. Large institutions such as the European Central Bank often put emphasis on growth rates. However, the psychological consequences of framing GDP development as an annual growth rate has rarely been addressed. Based on data from an online experiment involving academic researchers, we show that prompting academic researchers to state optimal GDP growth rates leads to significantly larger GDP sizes compared to the desired growth factors over a period of 100 years. This phenomenon can be observed among non-economists as well as among economists. The results highlight how the psychological framing of economic growth influences individuals' perceptions and preferences. Moreover, the study unveils variations in preferences for economic development across academic disciplines and between evaluations of low-income and high-income countries.

Essay 1: 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, 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 measuring pro-environmental behavior in the form of tree planting. The *Tree Task* involves a trade-off between individual immediate financial rewards and long-term environmental gains. Participants have to decide between spending money to plant trees or keeping the money for themselves. As expected, we find that 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 as a short, vivid, and easy-to-explain task.

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

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*Andrea Essl, Institute for Organization and HRM, University of Bern, Bern, Switzerland, email: andrea.essl@unibe.ch; David Hauser, Institute for Organization and HRM, University of Bern, Bern, Switzerland, email: david.hauser@unibe.ch; Manuel Suter, Institute for Organization and HRM, University of Bern, Bern, Switzerland, email: manuel.suter@unibe.ch; Frauke von Bieberstein, Institute for Organization and HRM, University of Bern, Bern, Switzerland, email: frauke.vonbieberstein@unibe.ch;

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1.1 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 & Hsiang, 2016). One way to mitigate climate change is through demand-side strategies, including behavioral changes. To examine strategies that target individual behavior, scientists need a toolbox of measures to assess pro-environmental behavior. However, there is a lack of validated incentivized tasks (Homar & 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: the cost and the 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.

The *Tree Task* makes several contributions. 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 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 for studies with children. Finally, the *Tree Task* complements recent research that has provided validated measures for behavioral economists conducting lab or online experiments (Buso et al., 2021; Kent, 2020).

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 part of their experimental earnings, an additional fixed endowment, an endowment people have to work for, or their show-up fee to an environmental organization (see, e.g., Goff et al., 2017; Lange & Dewitte, 2022; Vesely et al., 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 and may bias the measurement of pro-environmental behavior.

To measure self-reported pro-environmental intentions, researchers use proxies, such as intentions to purchase green products (Yadav & Pathak, 2017) or the hypothetical willingness to pay for

environmental protection, such as ecotourism (Meleddu & 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 (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 (Homar & 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) or signing up for a sustainability event like beach cleaning (L.-C. Ho et al., 2020). Most of these paradigms have in common that they depend on the products and events chosen and may be difficult to compare and transfer to other settings.

Only a few behavioral paradigms are more generally applicable. 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. Furthermore, there are several studies 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 & Goeschl, 2014, 2017, 2018; Löschel et al., 2017; Löschel et al., 2013; Uehleke & Sturm, 2017). An example is the validated Carbon Emission Task by Berger and Wyss (2021), where participants make 25 of these decisions. Compared to the *Tree Task*, 25 decisions can take up a substantial amount of time and some participants might find it hard to envision the concept of carbon dioxide emission certificates. The *Tree Task* complements existing tasks by being a monetary incentivized, vivid, and one-shot task for assessing pro-environmental behavior.

1.2 Methodology

1.2.1 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. Participants receive an endowment and must decide whether they want to keep the money for themselves or spend part or all of it as a contribution to mitigate climate change by planting trees. Trees are planted with the help of an international forest restoration organization—in this case, the non-profit organization

tree-nation.[1] The name of the organization was not explicitly communicated to the participants to avoid any associations based on the organization's name. Trees were planted within a few weeks after the experiment, participants were aware of this information and could choose to receive a confirmation email once the trees were planted.

Choice	Your investment to mitigate 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	£ 2.00	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

Fig. 1.1. Exemplary presentation of the Tree Task options and their 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 Fig. 1.1 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, the participants decide how many trees they want to plant. 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.

[1] We bought the trees on tree-nation.com. 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.

1.2.2 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 (tree-nation, 2022). 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. We test for the following:

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

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

In addition, we test whether the number of trees planted in the *Tree Task* 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 & Yoder, 2015), environmental attitudes (Dunlap et al., 2000), belief in climate change (Berger et al., 2023), and biospheric values (de Groot & Steg, 2010).

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

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

1.2.3 Treatments

We conducted a within-subject experiment with three different treatments. The baseline (BASE) treatment presents a tree with a relatively high cost per tree and a relatively low carbon dioxide offset per tree. The Low Price (LP) treatment has the same carbon dioxide offset but a lower price per tree. The High Offset (HO) treatment has the same price as the BASE treatment, but a higher carbon dioxide offset per tree. Table 1.1 presents an overview. All treatments were based on real tree planting projects offered by tree-nation.

Table 1.1. 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

1.2.4 Procedure

After giving informed consent, the participants received information about the *Tree Task*. They were informed that they had to make three decisions; one of them would be randomly drawn and paid out. The participants received the same amount of 2.50 GBP for each of the three treatments. 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 to measure participants' pro-environmental intentions (Mancha & Yoder, 2015, Cronbach's alpha = 0.91), environmental attitudes (Dunlap et al., 2000, Cronbach's alpha = 0.87), biospheric (Cronbach's alpha = 0.91), altruistic (Cronbach's alpha = 0.79), egoistic (Cronbach's alpha = 0.77), and hedonistic (Cronbach's alpha = 0.84) values (de Groot & Steg, 2010), belief in climate change (Berger et al., 2023), and demographics including gender, age, education, political ideology, and household income.

1.2.5 Sample

The study was pre-registered on the Open Science Framework (OSF) (https://osf.io/va9nh) 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 pre-registered power analysis on hypothesis 3, as this hypothesis was likely to be the least powerful. An adjusted alpha level for multiple hypotheses testing of 1.25% resulted in a sample size of 289 participants that allowed for detecting Pearson correlations of r = 0.24 (Lange & Dewitt, 2022) with high statistical power of 95%. However, to be more robust against potential outliers, we used a non-parametric Spearman correlation analysis which increased the sample size to a total sample size of 318 participants. Given this sample size and the Wilcoxon signed-rank test, we could detect a minimum effect size of d = 0.2 for hypotheses 1 and 2.

Participants were recruited on the established crowdsourcing platform Prolific (Palan & Schitter, 2018) on September 29, 2022.[2] Expecting an attrition rate of 20%, we collected 378 completed surveys from the UK. In accordance with the pre-registered protocol, we excluded participants who did not complete the study within 45 minutes of starting (n = 2), failed crucial attention checks (n = 6), and did not consider tree planting to be an effective climate protection measure (n = 7).[3] The sample for the main analysis consisted of 364 participants (50% female; mean age 39 years, SD = 12). The experimental sessions for this sample lasted, on average, 11 minutes. Participants received a flat payment of GBP 1.50. The mean of the additional payment from the *Tree Task* was GBP 1.52 (range: GBP 0 to 2.5, SD = 0.79).

1.3 Results

The descriptive statistics are reported in Table 1.2. We found that decision-makers reacted to the financial costs of a tree, as well as to the environmental impact. Participants planted significantly fewer trees in the BASE treatment compared to the LP and HO treatments ($p < 0.001$ for both LP and HO compared to BASE, Wilcoxon rank-sum test).[4] Thus, hypotheses 1 and 2 are supported.

Table 1.2. Descriptive statistics: Number of trees planted per treatment

	BASE	**LP**	**HO**
Mean	4.06	5.74	4.70
SD	3.45	3.89	3.56

	BASE vs. LP	**BASE vs. HO**	**LP vs. HO**
z score	–12.57	5.82	10.15
p value	p<0.001	p<0.001	p<0.001

Note: P values were obtained from Wilcoxon rank-sum tests.

Fig. 1.2 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

[2] We opted for participants from Prolific due to the research findings of Gupta et al. (2021), which indicate that Prolific exhibits lower noise in the data compared to MTurk. Compared to a physical lab, Prolific has the advantage of considerably lower costs per observation.

[3] There were overlaps regarding participants who failed both attention checks (n = 1).

[4] All tests are two-sided.

the different treatments are highly correlated (BASE vs. LP: r = .0.79, 95% CI [0.75, 0.83], p<0.01; BASE vs. HO: r = .83, 95% CI [0.80, 0.86], p<0.01; LP vs. HO: r = .85, 95% CI [0.82, 0.88], p<0.01).[5]

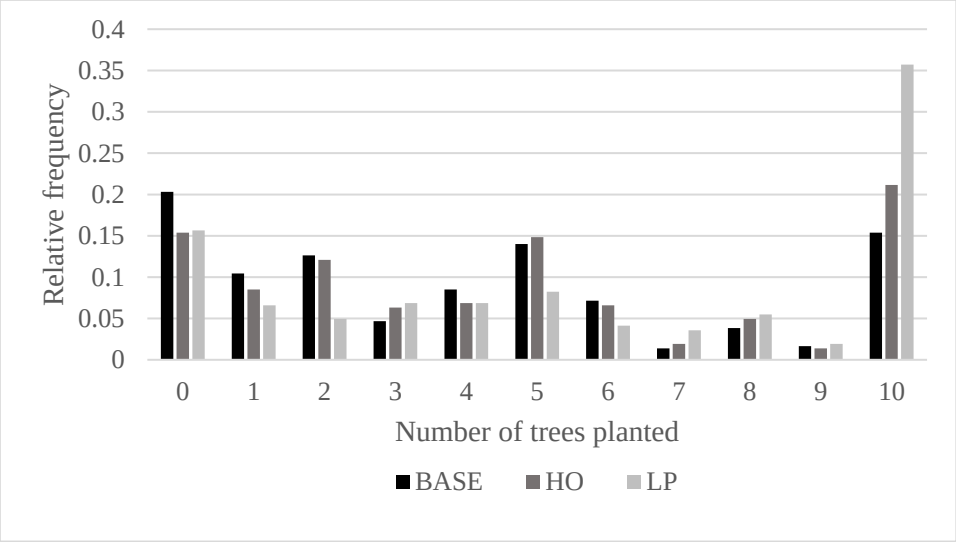

Fig. 1.2. Relative frequency of trees planted

[5] Based on our data we can calculate a mean willingness to pay using a linear demand curve model, with the number of trees as the dependent variable and price and carbon dioxide offset as independent variables. The mean willingness to pay is GBP 2.71 for absorbing one CO2t.

Table 1.3. Effects of cost and carbon emissions offset on the number of trees planted: Random-effects regression model

	No. of trees planted	No. of trees planted	No. of trees planted	No. of trees planted
	(1)	(2)	(3)	(4)
LP	1.681***	1.681***	1.693***	1.702***
	(0.126)	(0.126)	(0.128)	(0.129)
HO	0.640***	0.640***	0.645***	0.649***
	(0.107)	(0.107)	(0.109)	(0.110)
Order		0.246	0.164	0.224
		(0.359)	(0.348)	(0.339)
Pro-environmental intentions			0.592***	0.580***
			(0.150)	(0.151)
Pro-environmental attitudes			0.444	0.305
			(0.409)	(0.402)
Belief in climate change			0.078	0.0896
			(0.106)	(0.110)
Biospheric values			0.024	0.0108
			(0.171)	(0.171)
Altruistic values			0.116	-0.027
			(0.169)	(0.174)
Egoistic values			-0.105	-0.036
			(0.147)	(0.158)
Hedonistic values			-0.024	-0.003
			(0.136)	(0.138)
Female				0.979***
				(0.354)
Age in years				0.0256
				(0.016)
Education				0.537
				(0.366)
Conservative ideology				-0.096
				(0.097)
Income (> GBP 50,000)				0.169
				(0.374)
Constant	4.058***	3.931***	-1.434	-1.853
	(0.181)	(0.267)	(1.555)	(1.787)
Sigma u	3.297	3.300	3.102	3.055
Rho	0.821	0.821	0.801	0.795
Wald chi-square	181.83	182.00	263.48	316.52
R-squared overall	0.035	0.036	0.138	0.168
No. of observations	1,092	1,092	1,074	1,068
No. of participants	364	364	358	356

Note: 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 statistical significance at the 10%, 5%, and 1% levels, respectively.

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

$$y_{i,k} = \beta_0 + \beta'_1 \boldsymbol{T_{i,k}} + \beta_2 O_i + \beta'_3 \boldsymbol{E_i} + \beta'_4 \boldsymbol{X_i} + \varepsilon_{i,k},$$

where $y_{i,k}$ denotes the number of trees planted by individual i in treatment k, and $\boldsymbol{T_{i,k}}$ is the vector of the treatments. 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 otherwise (the BASE treatment was always presented in the middle). The vector of the control variables, $\boldsymbol{E_i}$, encompasses pro-environmental intentions, environmental attitudes, and beliefs about climate change, and $\boldsymbol{X_i}$ captures the sociodemographic variables. β_0 is the intercept, and $\varepsilon_{i,k}$ is the idiosyncratic random error term. In all model specifications, we use robust standard errors clustered on the individual level.

The estimated coefficients of the random-effects regressions are displayed in Table 1.3. 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), environmental-related variables (specification 3), and demographic variables (specification 4). In summary, hypothesis 1 and hypothesis 2 are supported. Furthermore, the effects are driven by a combination of extensive and intensive margin effects (see Table 1.4 in the Appendix A). In addition, we ensure the robustness of our results through various checks including applying different statistical regression models (see Table 1.5 in the Appendix A) and replicating our findings across three different samples (Table 1.6 in the Appendix A).

Next, we tested whether the number of trees planted correlates with self-reported environmental measures and demographic variables. To test hypotheses 3 and 4, we ran Spearman correlation analyses, and the results are displayed in Table 1.7 in Appendix A. For hypothesis 3, the total number of trees planted correlates with pro-environmental intentions (r = 0.31, 95% CI [0.21, 0.41], p<0.001), pro-environmental attitudes (r = 0.23, 95% CI [0.13, 0.33], p<0.001), belief in climate change (r = 0.22, 95% CI [0.12, 0.32], p<0.01), biospheric values (r = 0.24, 95% CI [0.15, 0.34], p<0.001), altruistic values (r = 0.20, 95% CI [0.11, 0.30], p<0.001), egoistic values (r = –0.08, 95% CI [–0.18, 0.02], p = 0.136), and hedonistic values (r = 0.02, 95% CI [–0.08, 0.12], p = 0.727). All correlations, apart from the egoistic and hedonistic values, have medium-sized effects and are highly statistically significant in the expected direction. In line with other research (Lange & Dewitte, 2022), egoistic and hedonistic values are 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 = 0.19, 95% CI [0.09, 0.29], p<0.001), a liberal political ideology (r = –0.17, 95% CI [–0.27, –0.07], p = 0.001), and the number of trees planted. Furthermore, age (r = 0.10, 95% CI [–0.01, 0.20], p = 0.061) and education (r = 0.11, 95% CI [0.01, 0.21], p = 0.032) are weakly correlated with the number of trees planted. Altogether, hypothesis 4 is supported.

1.4 Discussion and conclusion

This study presents the *Tree Task*, an incentivized, one-shot task measuring pro-environmental behavior online and in the lab. 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 correlates 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 (Essl et al., 2023; Essl et al., 2024).

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 a confirmation after the trees have been planted. 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. This allows to test the task on a broad target audience, and to compare the results across different audiences. Third, due to the brevity of the *Tree Task*, the task can be easily combined with measurements of other relevant types of pro-environmental behavior, such as the acceptance of environmental policies.

The *Tree Task* comes also with some limitations. The task's results may not be generalizable to all pro-environmental behaviors. 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 like a trade-off between time savings and pro-environmental behavior (Lange et al., 2018).

Detailed instructions and oTree and Qualtrics templates for the task are available on OSF: osf.io/f5zpc/?view_only=bd3048f6188e4724a31e61772e10ed6c

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Appendix A: Additional analysis

Table 1.4. Extensive and intensive margin analysis

	Random effects logit regression model		Random effects regression model	
	Prob. of planting at least one tree	Prob. of planting at least one tree	No. of trees planted cond.	No. of trees planted cond.
	(1)	(2)	(3)	(4)
LP	1.955**	4.709***	1.738***	1.765***
	(0.905)	(1.716)	(0.127)	(0.130)
HO	2.101**	5.005***	0.479***	0.480***
	(0.933)	(1.849)	(0.0979)	(0.101)
Order of treatments		0.611		0.090
		(6.205)		(0.338)
Pro-environmental intentions		0.670		0.511***
		(2.245)		(0.169)
Pro-environmental attitudes		1.756		0.056
		(8.668)		(0.420)
Belief in climate change		0.656		0.019
		(1.663)		(0.116)
Biospheric values		0.266		0.054
		(3.085)		(0.184)
Altruistic values		-0.098		-0.043
		(3.183)		(0.182)
Egoistic values		0.740		-0.135
		(3.169)		(0.155)
Hedonistic values		0.153		-0.052
		(2.499)		(0.131)
Female		3.342		0.430
		(7.514)		(0.346)
Age in years		0.043		0.025
		(0.301)		(0.016)
Education		-0.024		0.472
		(7.098)		(0.369)
Conservative ideology		0.332		-0.117
		(2.053)		(0.097)
Income (> GBP 50,000)		-0.955		0.385
		(6.166)		(0.367)
Constant	13.44	-3.511	5.043***	1.337
	(0.000)	(35.57)	(0.180)	(1.990)
Sigma u	15.86	19.61	2.912	2.769
Rho	0.987	0.992	0.814	0.795
Wald chi-square	5.07	7.92	192.42	264.85
R-squared overall			0.049	0.148
No. of observations	1,092	1,068	905	881
No. of participants	364	356	312	304

Note: Specifications 1 and 2 present estimates from a random-effects logit regression model on the probability of planting at least one tree. Specifications 3 and 4 present estimates from a random-effects 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 1.3. 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.

Robustness checks

We ensure the robustness of our results through various checks. In a first step, we address issues related to count and censored data by applying different regression models. Our results consistently remain robust when we use a panel Poisson model with random effects, a Tobit regression model, and a pooled OLS regression model (see Table 1.5). In a second step, we replicate our findings across three different samples, as shown in Table 1.6. In the first of these samples, we include participants who do not believe in the effectiveness of tree planting (n = 7). This does not alter our findings. The second sample is constructed based on the observation that about 7 % of participants (n = 25) planted no trees in the BASE treatment but at least one tree in the LP or HO treatment. One possible explanation for this behavior is that in the BASE treatment, where costs per tree are high and the carbon dioxide offset per tree is low, it is rational to take the money and invest it outside the experiment (abstracting from the costs of effort and time to find alternative investments). To ensure our results are not influenced by this behavior, we exclude these participants. Table 1.6 confirms that this exclusion does not affect our findings. Finally, we conduct the analysis for the total sample, including all respondents who participated in the experiment. The results demonstrate that including all participants does not significantly alter the significance level and size of the treatment coefficients.

Table 1.5. 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	
	No. of trees planted	No. of trees planted	No. of trees planted	No. of trees planted	No. of trees planted	No. of trees planted
	(1)	(2)	(3)	(4)	(5)	(6)
LP	0.347***	0.355***	1.681***	1.702***	2.755***	2.773***
	(0.027)	(0.028)	(0.126)	(0.129)	(0.231)	(0.233)
HO	0.146***	0.151***	0.640***	0.649***	1.066***	1.056***
	(0.025)	(0.026)	(0.107)	(0.110)	(0.183)	(0.184)
Order of treatments		0.032		0.224		0.290
		(0.080)		(0.339)		(0.554)
Pro-environmental intentions		0.149***		0.580***		0.869***
		(0.047)		(0.151)		(0.249)
Pro-environmental attitudes		0.114		0.305		0.407
		(0.101)		(0.402)		(0.644)
Belief in climate change		0.027		0.090		0.220
		(0.033)		(0.110)		(0.190)
Biospheric values		-0.014		0.011		0.105
		(0.043)		(0.171)		(0.272)
Altruistic values		-0.002		-0.027		-0.126
		(0.046)		(0.174)		(0.290)
Egoistic values		8.42e-05		-0.036		-0.037
		(0.037)		(0.158)		(0.257)
Hedonistic values		-0.006		-0.003		0.011
		(0.031)		(0.138)		(0.235)
Female		0.219**		0.979***		1.700***
		(0.086)		(0.354)		(0.586)
Age in years		0.006		0.026		0.044*
		(0.004)		(0.016)		(0.026)
Education		0.103		0.537		0.866
		(0.090)		(0.366)		(0.596)
Conservative ideology		-0.008		-0.096		-0.124
		(0.024)		(0.097)		(0.154)
Income (> GBP 50,000)		0.055		0.169		0.158
		(0.088)		(0.374)		(0.626)
Constant	1.401***	-0.239	4.058***	-1.853	3.806***	-5.691*
	(0.0445)	(0.510)	(0.181)	(1.787)	(0.294)	(2.921)
Ln alpha	-0.107	-0.219				
	(0.350)	(0.366)				
Wald chi-squared	4802.19	4727.69				
R^2/Pseudo R^2			0.035	0. 168	0.007	0.038
Var(e.tree)					33.515***	28.046***
					(3.462)	(2.951)
No. of observations	1,092	1,068	1,092	1,068	1,092	1,068
No. of participants	364	356	364	356	364	356

Note: The 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 1.3. 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 1.6. Robustness checks for different samples: Random-effects regression model

Sample		No. of trees planted	No. of trees planted
Main sample			
	LP	1.681***	1.702***
		(0.126)	(0.129)
	HO	0.640***	0.649***
		(0.107)	(0.110)
	No. of observations	1092	1068
	No. of participants	364	356
Incl. tree planting skeptics			
	LP	1.660***	1.685***
		(0.124)	(0.127)
	HO	0.628***	0.638***
		(0.105)	(0.108)
	No. of observations	1113	1086
	No. of participants	371	362
Excl. participants			
with 0 trees in BASE &	LP	1.471***	1.488***
>0 trees in LP and/or HO		(0.113)	(0.116)
	HO	0.398***	0.401***
		(0.083)	(0.085)
	No. of observations	1026	1002
	No. of participants	342	334
Total sample			
	LP	1.659***	1.687***
		(0.123)	(0.126)
	HO	0.624***	0.636***
		(0.103)	(0.106)
	No. of observations	1134	1104
	No. of participants	378	368
	Additional controls		
	Order of treatments	NO	YES
	Environmental variables	NO	YES
	Demographic variables	NO	YES

Note: 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, the sample excluding rational participants 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 1.3. 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, as well as 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 1.7. Spearman correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	Mean	SD
(1) Trees	1.000													4.83	3.41
(2) PE intentions	0.300***	1.000												5.14	1.38
(3) PE attitudes	0.230***	0.353***	1.000											3.80	0.60
(4) Belief in CC	0.208***	0.365***	0.629***	1.000										3.20	2.15
(5) Biospheric	0.232***	0.540***	0.541***	0.491***	1.000									5.23	1.43
(6) Altruistic	0.200***	0.389***	0.343***	0.430***	0.617***	1.000								5.38	1.28
(7) Egoistic	–0.076	0.014	–0.339***	–0.137***	–0.076	0.005	1.000							2.42	1.42
(8) Hedonistic	0.010	0.067	–0.002	0.124**	0.112**	0.263***	0.323***	1.000						4.71	1.44
(9) Female	0.199***	0.120**	0.135**	0.082	0.061	0.171***	–0.024	0.105**	1.000					0.50	0.50
(10) Age in years	0.103*	-0.016	0.133**	0.031	0.152***	0.081	–0.303***	–0.231***	0.035	1.000				39.28	12.38
(11) Education	0.112**	0.077	0.146***	0.137***	0.105**	0.070	0.020	–0.060	–0.002	–0.007	1.000			0.66	0.48
(12) Conservative Ideology	–0.149***	–0.170***	–0.232***	–0.374***	–0.202***	–0.354***	0.211***	–0.114**	–0.126**	0.061	–0.007	1.000		4.48	2.01
(13) Income (> GBP 50,000)	0.022	0.044	–0.007	–0.010	0.002	–0.015	0.173***	0.077	–0.014	–0.086	0.143***	–0.003	1.000	0.35	0.48

Note: 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.

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 tasks

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.

--- Page Break ---

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.

--- Page Break ---

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 kilo-meters
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".

1. How much money in GBP do you invest to fight climate change? (numeric values only, without unit sign; "." as decimal separator)

2. How much money in GBP do you keep for yourself? (numeric values only, without unit sign; "." as decimal separator)

3. How many trees are planted with the money you invest to fight climate change?

4. How much CO_2 do you offset in kg? (numeric values only, without unit sign)

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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 2 and Decision task 3, 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 3? (numeric values only, without unit sign; "." as decimal separator)

In Decision task 1 and Decision task 2, each tree costs GBP 0.25. In Decision task 2, a tree offsets 20 kg CO_2, how much does a tree offset in Decision task 1? (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 kilometres 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	£ 0.13	£ 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).

Choice 0 trees
Choice 1 tree
Choice 2 trees
Choice 3 trees
Choice 4 trees
Choice 5 trees
Choice 6 trees
Choice 7 trees
Choice 8 trees
Choice 9 trees
Choice 10 trees

--- Page Break ---

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**

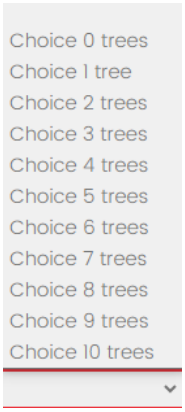
For this decision task, you will receive **GBP 2.50** to decide on.

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 kilometres 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	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 160 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).

Choice 0 trees
Choice 1 tree
Choice 2 trees
Choice 3 trees
Choice 4 trees
Choice 5 trees
Choice 6 trees
Choice 7 trees
Choice 8 trees
Choice 9 trees
Choice 10 trees

--- 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:

	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 behaviour 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.

	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.	○	○	○	○	○

	strongly disagree	somewhat disagree	unsure	somewhat agree	totally agree
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.	○	○	○	○	○

	strongly disagree	somewhat disagree	unsure	somewhat agree	totally agree
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*

	-1	0	1	2	3	4	5	6	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	○	○	○	○	○	○	○	○	○

	-1	0	1	2	3	4	5	6	7
WEALTH: material possessions, money	○	○	○	○	○	○	○	○	○
AUTHORITY: the right to lead or command	○	○	○	○	○	○	○	○	○
SOCIAL JUSTICE: correcting injustice, care for the weak	○	○	○	○	○	○	○	○	○
ENJOYING LIFE: enjoying food, sex, leisure, etc.	○	○	○	○	○	○	○	○	○
Please select "opposed to my principles"	○	○	○	○	○	○	○	○	○
PROTECTING THE ENVIRONMENT: preserving nature	○	○	○	○	○	○	○	○	○

	-1	0	1	2	3	4	5	6	7
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 ---

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.

-5 strongly disagree	-4	-3	-2	-1	0	1	2	3	4	5 strongly agree
○	○	○	○	○	○	○	○	○	○	○

How effective do you consider tree planting to be as a climate protection measure?

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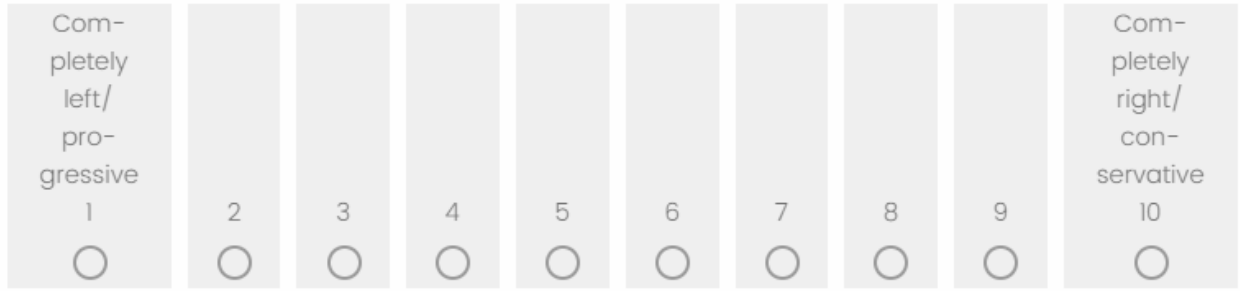
What is your gender?

How old are you? (age in years)

What is the highest degree or level of education you have completed?

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.



What is your household income per year? Please estimate your answer in British pounds.

- ◯ 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–£150,000
- ◯ More than £150,000

What is your Prolific ID?

Please note that this response should auto-fill with the correct ID.

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Thank you very much for your participation in this study.

Decision task 1 is randomly selected for payment. In decision task 1 you invested GBP to plant trees to fight climate change. Thus, your additional payment is GBP . 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.

Access to supplementary materials

Access to all materials including ready-to-use templates for the *Tree Task* for oTree and Qualtrics, data, and statistical cods for the manuscript “The Tree Task: An incentivized, one-shot decision task to measure pro-environmental behavior” by Andrea Essl, David Hauser, Manuel Suter, and Frauke von Bieberstein can be found at the following link:
https://osf.io/f5zpc/?view_only=bd3048f6188e4724a31e61772e10ed6c

Essay 2: The effect of future-time referencing on pro-environmental behavior

Andrea Essl, Manuel Suter, Frauke von Bieberstein*

Abstract

Can the way a language encodes time influence speakers' pro-environmental behavior? In a controlled experimental setting, we take advantage of a linguistic feature of the German language that allows speakers to use either the present or future tense when referring to an event in the future. Depending on the treatment, participants read a text about the future impacts of climate change and tree planting written in either the present or future tense. We then measured pro-environmental behavior using an incentivized task that represents a trade-off between individual immediate financial rewards and planting trees as long-term environmental gains. The results reveal a positive effect of future tense marking on the number of trees planted. We discuss construal level theory, timing precision, future orientation, and certainty of the occurrence of future climate events as potential mechanisms to explain why future-time referencing might affect individual pro-environmental behavior.

Keywords: Linguistic-savings hypothesis, Future-time reference, Pro-environmental behavior, Language, Laboratory experiment

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* Andrea Essl, Institute for Organization and HRM, University of Bern, Bern, Switzerland, email: andrea.essl@unibe.ch; Manuel Suter, Institute for Organization and HRM, University of Bern, Bern, Switzerland, email: manuel.suter@unibe.ch; Frauke von Bieberstein, Institute for Organization and HRM, University of Bern, Bern, Switzerland, email: frauke.vonbieberstein@unibe.ch;

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2.1 Introduction

Interventions such as social norms, reminders, and opt-out policies can successfully promote the pro-environmental behavior of individuals (Allcott, 2011; Ebeling & Lotz, 2015; Essl et al., 2021; Goldstein et al., 2008). All of these interventions are communicated via language and often refer to future impacts of environmentally relevant behaviors. Given the importance of future references in pro-environmental communications, the way we talk about the future must be better understood to optimize existing interventions and create new ones. In this study, we examine whether the grammatical structure we use to refer to the future influences pro-environmental behavior in the form of tree planting.

One important characteristic in which languages differ is the extent to which they contain markers for the future tense (Dahl, 2000; Slobin, 1996). Some languages require speakers to grammatically mark future events (e.g., English and Spanish), while others do not (e.g., German and Dutch). For example, English requires the use of future markers, such as "is going to" or "will", to refer to the future (Example: "It will rain tomorrow"). Consequently, English speakers need to clearly differentiate between present and future events. In contrast, German speakers can predict rain in the present tense, stating "Morgen regnet es", which translates as "It rains tomorrow". However, they can also use the future tense "Morgen wird es regnen", which translates as "It will rain tomorrow".

The linguistic feature of future-time reference (FTR) has attracted attention because it correlates with future-oriented decisions. According to the linguistic-savings hypothesis (K. Chen, 2013), a language that requires speakers to disassociate the future from the present (strong FTR) can make the future appear more distant and thus, due to stronger discounting, devalue future rewards compared to a language with weak future-time referencing (weak FTR). In other words, using the present tense for future events may make people feel that the future is temporally closer, leading to more future-oriented behavior. The correlational evidence in line with this argument comes from different areas, such as saving rates, wealth levels, and health outcomes (K. Chen, 2013). Related studies on patience are also consistent with this hypothesis: Speakers of languages with weak FTR are, on average, more willing to accept delayed but higher payments than speakers of languages with strong FTR (Falk et al., 2018; Herz et al., 2021; Sutter et al., 2018). In the area of pro-environmental behavior, the evidence is mixed. Some studies find support for the linguistic-savings hypothesis, for instance, concerning support for a gas-tax increase (Pérez & Tavits, 2017), while others find opposite results regarding climate change concern and engagement in climate action (Zhu et al., 2020).

The majority of studies examining the effect of language structure on future-oriented behavior are based on correlations (e.g., K. Chen, 2013; Falk et al. 2018, Zhu et al., 2020). Although these correlational studies offer important insights, they cannot draw causal inferences about the effect of future-time referencing on individual behavior. Other studies work with bilingual participants and

randomly vary the study's language (Ayres et al., 2023; Pérez & Tavits, 2017). However, this may trigger cultural cues and lead to selection and attrition bias if participants prefer one language over another. To address these potential shortcomings in the area of patience, J. I. Chen et al. (2019) and Angerer et al. (2021) used controlled experimental settings by randomly referring to future events using the present or future tense within a weak FTR language. Both studies find no causal effect of future marking on incentivized intertemporal choices. The advantage of using variations in the same language is that the researchers can keep cultural cues constant, which may affect behavior when different languages are used. The present paper is the first to investigate the causal effect of future-time reference within a language on pro-environmental behavior in the form of tree planting.

To answer our research question, we conducted a between-subject online experiment in the German language. In German, future events can be referred to in the present or future tense. The participants were randomly assigned to either the FUTURE (German with future tense marking, n = 383) or PRESENT (German with present tense marking, n = 398) treatment. First, the participants read a text about climate change and tree planting in their randomly assigned tense. Then, the participants' pro-environmental behavior was elicited with a recently developed incentivized decision task (Essl et al., 2023) using the same tense. 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 task consists of a decision trade-off between immediate individual financial and long-term environmental rewards.

In contrast to the linguistic-savings hypothesis, the results show that participants in the FUTURE treatment planted significantly more trees than participants in the PRESENT treatment. Specifically, participants in the FUTURE treatment planted an average of 0.57 more trees than participants in the PRESENT treatment. This corresponds to a 7.8% increase in the number of trees planted in the FUTURE treatment compared to the PRESENT treatment. As potential psychological mechanisms behind this result, we discuss construal level theory, timing precision, future orientation, and certainty of the occurrence of future climate events. In an online follow-up survey retargeting the subjects of the first study, we tested these mechanisms (n = 442). We find no statistically significant differences between the two treatments for any of the proposed mechanisms, which may be due to the low response rate (56.6% of the participants in the first study). Only for construal level theory did we find meaningful differences going in the predicted direction. According to construal level theory, events that are psychologically perceived as more distant (in this case, in the temporal dimension) are processed at a more abstract level. This leads to a more analytical mindset that gives more weight to analytical arguments and thus facilitates decision-making regarding more abstract events such as climate change (Liberman & Trope, 2008).

This study makes three main contributions to the literature. First, the study addresses the need for more experimental research regarding the effect of future marking on pro-environmental behavior. By holding the language constant, we show that participants who were exposed to future tense marking planted significantly more trees than those exposed to present tense marking. Therefore, this research is particularly relevant for more effective behavioral interventions and communication strategies to foster pro-environmental behavior. Second, this paper joins a growing body of economic literature that examines how language influences individual decision-making (K. Chen, 2013; He et al., 2020; Lien & Zhang, 2020; Xing, 2021). In particular, we contribute in two ways to the general research on the linguistic-savings hypothesis. This hypothesis has been experimentally investigated in the area of patience regarding delayed but higher payments (Angerer et al., 2021; J. I. Chen et al., 2019); however, similar studies in other domains are desirable. Further, given that the main result is not in line with the linguistic-savings hypothesis, the effect of future-time referencing on future-oriented behavior might be more complex than previously thought. This is among the few studies that have examined the possible underlying mechanisms behind these results. While the results of our follow-up survey go in the direction of the reasoning of construal level theory, no significant differences were found between the FUTURE and the PRESENT treatments. Thus, a more in-depth investigation into these underlying mechanisms is warranted. Furthermore, other important factors, such as the time horizon and the gain and/or loss framing of the mentioned consequences, might also be at play. Third, we address concerns regarding the measurement of pro-environmental behavior by using a consequential environmental decision task. Previous environmental research examining the linguistic structure was based on self-reported and observational pro-environmental behavior. We used an incentivized environmental decision task in a controlled experimental setting.

2.2 Related literature

2.2.1 Future-time referencing and intertemporal preferences

Languages have different requirements for their speakers in terms of encoding time (Dahl, 2000; Slobin, 1996). K. Chen (2013) introduced the linguistic-savings hypothesis, which links language structure and decision-making. The hypothesis states that languages that grammatically separate the present and future lead their speakers to less future-oriented behavior than languages in which speakers can refer to future events by using the present tense. Strong FTR languages, such as English and French, require a dedicated marking of the future, while weak FTR languages, such as German and Mandarin, do not (K. Chen, 2013; Dahl & Velupillai, 2011). Thus, weak FTR languages can use the same grammatical tense for the present and the future.

People tend to discount future costs and rewards, known as temporal discounting (Frederick et al., 2002; Ramsey, 1928; Solnick et al., 1980). Therefore, the further in the future an outcome appears to

be, the more its potential costs and benefits might be discounted. The grammatical distinction between strong FTR and weak FTR languages might influence agents' behavior, particularly future-oriented behavior (K. Chen, 2013). According to the linguistic-savings hypothesis, the use of a separate grammatical form to talk about the future potentially makes future events appear subjectively further away from the speaker's now, resulting in less future-oriented behavior. In contrast, using the present tense to refer to future events leads to less temporal discounting. This may make people feel that the future is temporally closer to the present, fostering future-oriented behavior.

Several correlational studies support the linguistic-savings hypothesis. People who speak a strong FTR language smoke more, are more obese, exercise less, and practice safer sex less often (K. Chen, 2013). They are also less patient in intertemporal choice tasks (Ayres et al., 2023; Falk et al., 2018; Herz et al., 2021; Sutter et al., 2018) and have a lower propensity to save money than people from countries with weak FTR languages (K. Chen, 2013; Guin, 2016). In addition, companies that use strong FTR working languages engage less in future-oriented behaviors, such as corporate social responsibility and research and development investments (Liang et al., 2018). Many of these studies are based on cross-country correlative comparisons with survey data (K. Chen, 2013; Falk et al., 2018; Liang et al. 2018). Other studies compare the behavior of people in bilingual regions, where some inhabitants speak a weak and some a strong FTR language (Guin, 2016; Herz et al., 2021; Sutter et al., 2018). However, these studies do not experimentally vary the language of the study participants. Languages may inherently contain cultural cues that influence future-oriented behavior. Cultural differences that are independent of a language's future-time referencing could therefore be a cause of these effects. Other studies use participants who are bilingual in a weak and a strong FTR language and randomly assign in which language participants read the instructions (Ayres et al., 2023). This experimental setup can also evoke cultural cues through the assigned language. In addition, there is a risk of attrition and selection bias, as participants may prefer one or the other language. Thus, in all of these studies, unobserved cultural differences correlating with the language could affect the results. In fact, a large strand of economic literature uses language as a proxy for culture (Alesina & Ferrara, 2005; Desmet et al., 2012; Hübner & Vannoorenberghe, 2015).

To address this shortcoming, experimental studies have been used to investigate the causal effect of future-time referencing on patience. In a controlled experimental setting, J. I. Chen et al. (2019) and Angerer et al. (2021) test the linguistic-savings hypothesis by using weak FTR languages that allow future-time referencing in the present and future tenses. By keeping the language constant, these studies hold cultural cues constant. In the Chinese language, J. I. Chen et al. (2019) manipulated the use of present versus future tense in the instructions that asked participants to choose between smaller-sooner and larger-later rewards. The authors found no causal effect of language structure on incentivized intertemporal choices. Angerer et al. (2021) replicated these results for the German language.

2.2.2 Future-time referencing and pro-environmental behavior

Further investigation of future-time referencing is particularly relevant for pro-environmental behavior. Pro-environmental behavior is an important area of future-oriented behavior, often involving present individual costs for collective rewards at some undefined point in the future. Building on the linguistic-savings hypothesis, environmental research has examined whether future-time referencing influences pro-environmental decision-making. Thus far, the findings are mixed. In line with the linguistic-savings hypothesis, empirical research has suggested that speakers of a weak FTR language are more likely to choose household products that are perceived as better for the environment (Mavisakalyan et al., 2018), to support a pro-environmental policy in the form of a gas-tax increase (Pérez & Tavits, 2017), and to be concerned about the negative environmental impacts of tourism (Kim & Filimonau, 2017). In contrast, Zhu et al. (2020) indicate that in countries with a higher percentage of speakers of strong FTR languages, the population has on average higher climate concerns, and lower carbon emissions and energy use. The authors argue that the greater temporal distance created by future tense marking improves the understanding of the complexity of climate change and increases perceived timing precision and certainty about climate change, consequently leading to more pro-environmental behavior.

Most environmental research on language structure is correlational. An exception is the study by Pérez and Tavits (2017), in which the interview language was randomly assigned to Estonian (weak FTR language) or Russian (strong FTR language) bilingual participants. The researchers find that respondents who were interviewed in Estonian were significantly more likely to support a gas-tax increase to protect the environment than those who were interviewed in Russian. We contribute to this literature by experimentally testing the causal effect of future-time referencing within the same language on investments in planting trees. Specifically, we make use of the linguistic features of the German language, in which speakers can use the future tense or present tense for future events. We hold cultural cues constant by randomly referring to future events using the present or future tense. Furthermore, this approach prevents attrition and selection bias. In addition, all previous studies investigating the effect of future-time referencing on pro-environmental behavior have in common that they use observational or survey data. In contrast, we use an incentivized environmental decision task to measure actual behavior in a controlled setting.

2.3 Online lab experiment

2.3.1 Experimental design and procedure

We conducted a between-subject online experiment to examine whether there is a causal effect of future-time referencing on individuals' decisions to plant trees. This research question is investigated by using the German language, which allows us to refer to future events using the present or future tense. The

study was pre-registered on the platform of the American Economic Association's (AEA's) registry for randomized controlled trials (AEARCTR-0008477) and received ethical approval from the Faculty of Business Administration, Economics and Social Sciences of the University of Bern (serial number: 222021).

German speakers living in Germany, Austria, or Switzerland were randomly assigned to two treatments, which differed in terms of the tense used in the German instructions. In the PRESENT treatment, we used the present tense to refer to future events (n = 398). In the FUTURE treatment, we used the future tense (n = 383). Because both versions sound natural to German speakers, we eliminate any possible experimenter demand effect (J. I. Chen et al., 2019).

The study consists of three parts.[6] In the first part, participants were asked to read a text about possible negative future impacts of climate change on the planet and humanity, and the benefits of carbon absorption through the planting of trees. Depending on the treatment, the text was in either the present tense (e.g., «Die Klimakrise hat in den nächsten Jahrzenten zunehmend negative Auswirkungen.») or the future tense (e.g., «Die Klimakrise wird in den nächsten Jahrzehnten zunehmend negative Auswirkungen haben.»).[7] To make the grammatical time reference more salient, all verbs were printed in bold in the experimental instructions (see Fig. 2.1). To ensure that the participants read the text carefully, they had to answer a control question.

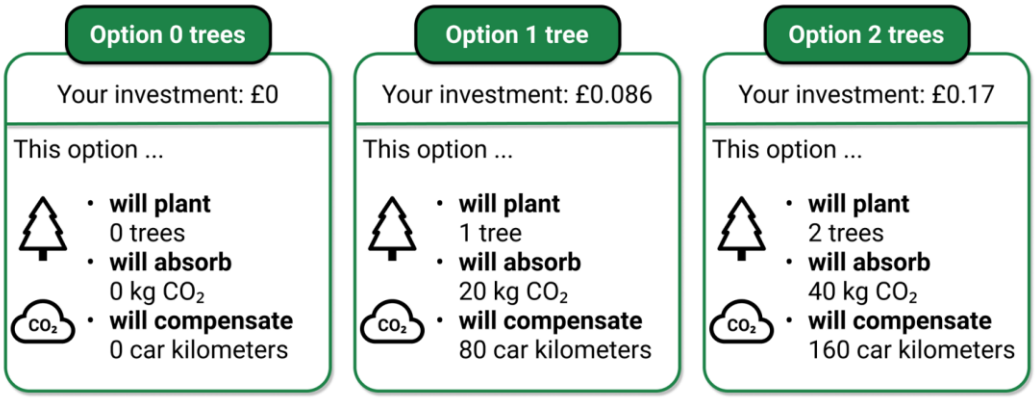

Fig. 2.1. Excerpt from the display of the options of the Tree Task in the FUTURE treatment (translated into English).

[6] Experimental instructions and survey questions are available in the online supplementary material.

[7] Present tense (translated into English): "The climate crisis has an increasingly negative impact in the coming decades" vs. future tense (translated into English): "The climate crisis will have an increasingly negative impact in the coming decades."

In the second part, we used the Tree Task by Essl et al. (2023). The Tree Task is an incentivized decision task used to measure participants' behavior regarding the environment. Participants received an endowment of GBP 0.86 (about USD 1.15) and had to decide whether they wanted to keep the money for themselves or spend some or all of it on planting trees. In the experimental instructions, we mentioned that planting trees could be considered a climate change mitigation measure as it is an effective solution for capturing carbon dioxide emissions (IPCC, 2022). The Tree Task pits individual immediate financial rewards against long-term environmental gains. The cost of planting one tree that absorbs 20 kg of carbon dioxide over its lifetime was GBP 0.086. Participants had to choose one of 11 options for real implementation, that is, plant 0 (= GBP 0) to 10 (= GBP 0.86) trees. For each option, we provided the consequences in terms of the monetary investment, carbon dioxide absorption in kilograms, and carbon dioxide compensation translated into car kilometers (see online supplementary material). To describe the future consequences of the different options, the present tense was used in the PRESENT treatment and the future tense in the FUTURE treatment. The types of future-time referencing used in the PRESENT and FUTURE treatments differed in 58 places across the first and second parts of the study.[8] An international forest restoration organization planted the trees within four weeks after the experiment (participants were aware of this information) in Madagascar. To ensure that the participants correctly understood the financial and ecological consequences of their decision, they were asked to answer several comprehension questions.

In the third part, we used a questionnaire consisting of self-report scales on pro-environmental intentions (Fujii, 2006; Mancha & Yoder, 2015), beliefs about climate change (Poortinga et al., 2019), and general environmental views (ISSP Research Group, 2012). Specifically, behavioral intentions were measured with descriptions of nine behavioral intentions regarding the environment (e.g., "I will turn off lights as much as possible in the forthcoming month"). Three items measuring behavioral intentions were previously used by Mancha and Yoder (2015), three items were previously used by Fujii (2006), and three items were newly formulated.[9] The participants were asked to rate the items on a 7-point Likert

[8] To investigate the impact of future marking on investments in planting trees, it is important to provide some context to participants (i.e., mentioning the consequences of climate change, the benefits of planting trees, etc.). This context naturally contains many future references. Thus, we had to decide which tense to use when referring to the future in the first part. To avoid favoring one or the other tense, we decided to use tense marking consistently in part 1 and part 2. Note that given this decision for consistency, we cannot be sure if both parts or only one of the parts of the text is needed for the results.

[9] In the FUTURE treatment, four behavioral intentions were presented in the future tense, whereas in the PRESENT treatment the identical four items were formulated in the present tense to refer to future events. Additionally, in both treatments five items were formulated tense-neutral using "intend" and "plan". The order of the items was randomized. However, we find no statistically significant difference between the two treatment groups for either the four manipulated items or the five temporally neutral formulated items.

scale ranging from 1 (“extremely unlikely”) to 7 (“extremely likely”). The reliability of the measure is good (Cronbach’s alpha = 0.804). To elicit people’s beliefs about climate change, three questions from Poortinga et al.’s (2019) work were asked. Following Poortinga et al. (2019), the 4-point response scale on the existence of climate change was dichotomized to 0 (“probably/definitely changing”) and 1 (“probably/definitely not changing”). The responses to the question of whether climate change is caused by nature or humanity were coded as 0 (“entirely/mainly by human activity/about equally by natural processes and human activity”) and 1 (“entirely/mainly by natural processes/I don’t think climate change is happening”). Furthermore, participants were asked 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”). The study ended with demographic (including gender, age, education, political ideology, culture, income, country of birth and residence, years in country of birth and residence, education) and language-related questions (German proficiency and frequency).[10]

The experiment was conducted online on the crowdsourcing platform Prolific from November 11 to November 26, 2021. Prolific is an established crowd-working online platform (Palan & Schitter, 2018). The experimental sessions lasted, on average, 16 minutes (median = 10.43 minutes), with a flat payment of GBP 1.24 per participant.[11] The mean additional payment for the Tree Task was GBP 0.23 (range: GBP 0 to 0.86, SD = 0.32). The median minimum payment that has to be guaranteed on Prolific is GBP 6 per hour. Thus, in this experiment, the flat payment secured the median minimum payment with about 7 GBP/hour and the additional endowment for planting trees corresponds to an hourly rate of about 5 GBP/hour.[12] Participants were offered the option of receiving a confirmation email after the trees were planted.

2.3.2 Sample characteristics

We targeted a final sample of 824 subjects (412 participants per treatment group) to detect an effect of Cohen’s d of 0.2 with an error probability of 0.05 and a power of 0.80 (based on a two-sided Wilcoxon-Mann-Whitney test). We used a two-sided test given that the literature on future-time referencing and pro-environmental behavior has not provided clear results. In total, 877 people participated in the experiment. In accordance with the pre-registered protocol, participants who did not complete the Prolific task within 60 minutes of starting (n = 4), who failed crucial attention checks (n = 2) or incorrectly answered a control question (n = 21), who do not believe in climate change (n = 23) or the

[10] Demographic and language-related questions are available in the online supplementary material.

[11] At the time of the experiment, the exchange rate was USD 1 = GBP 0.748.

[12] The exact calculations, given the median time of 10.43 minutes that the participants spent on the task, are 1.24 × 60/10.43 = 7.13 GBP/hour (about 9.5 USD/hour at the time of the experiment) for the flat payment and 0.86 × 60/10.43 = 4.95 GBP/hour for the additional endowment for planting trees (about 6.60 USD/hour at the time of the experiment).

positive impact of planting trees as a climate change mitigation measure (n = 6), and who do not have German as their native language (n = 46) were excluded.[13] The exclusion criteria reduced the main sample to 781 subjects (53% female; mean age: 28 years, SD = 9.36), of whom 383 received the FUTURE treatment, and 398 received the PRESENT treatment. Table 2.1 provides descriptive statistics for the sociodemographic variables, language-related variables, and environmental attitudes for the main sample and the treatment groups separately. Randomization between the two treatment groups was successful for all variables, except the number of years lived in the country of birth. We control for the variable years lived in the participants' countries of birth in the regression analyses.

[13] There are overlaps regarding participants who do not speak German as their native language and do not believe in climate change (n = 3), who do not speak German as their native language and failed the control question (n = 1), who failed the control question and do not believe in climate change (n = 1), and who do not believe in climate change and the positive impact of planting trees (n = 1). In the Table 2.6 in the Appendix, we present the robustness of the results by including participants who do not believe in climate change and/or the positive impact of planting trees as climate change mitigation measure as well as participants who do not speak German as their native language.

Table 2.1. Sample characteristics and randomization check.

	Sample (n = 781)	FUTURE (n = 383)	PRESENT (n = 398)	FUTURE vs. PRESENT p values
Demographics				
Gender (% female)	52.75	54.05	51.51	0.477
Age in years	28.03	27.80	28.30	0.974
	(9.36)	(8.74)	(9.92)	
Conservative ideology	3.48	3.41	3.54	0.268
	(1.64)	(1.62)	(1.66)	
Culture (% German culture)	91.17	91.64	90.70	0.643
Income				0.755
Less than £10,000 (n = 213)	27.66	26.19	29.59	
£10,000–£29,000 (n = 230)	29.87	30.16	29.59	
£29,000–£59,000 (n = 209)	27.14	28.57	25.77	
More than £60,000 (n = 118)	15.32	15.08	15.56	
Country of birth (% of German-speaking country GER, AUT, SUI)	98.08	97.24	98.96	0.679
Germany (n = 689)	88.22	88.77	87.68	
Austria (n = 130)	7.04	7.31	6.78	
Switzerland (n = 22)	2.82	2.87	2.76	
Country of residence (% of German- speaking country GER, AUT, SUI)	100	100	100	0.757
Germany (n = 701)	89.76	89.56	89.95	
Austria (n = 55)	7.04	7.57	6.53	
Switzerland (n = 25)	3.20	2.87	3.52	
Years in country of birth	17.41	17.58	17.26	0.004
	(2.73)	(2.32)	(3.07)	
Years in country of residence	24.52	24.80	24.24	0.196
	(11.02)	(10.47)	(11.53)	
Education				0.666
University (n = 367)	46.99	45.95	47.99	
Vocational training (n = 96)	12.29	13.32	11.31	
Secondary school/high school and less (n = 318)	40.72	40.73	40.70	
Language-related variables				
German proficiency	9.78	9.80	9.77	0.167
	(0.50)	(0.52)	(0.49)	
German frequency	9.78	9.77	9.78	0.579
	(0.73)	(0.75)	(0.71)	
Climate change–related variables				
Pro-environmental attitudes	3.99	4.02	3.96	0.178
	(0.66)	(0.65)	(0.67)	

Note. The table reports the 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 chi-square test. For the continuous variables, the p values were obtained from Wilcoxon-Mann-Whitney tests. Conservative ideology refers to a political ideology and was measured on a 10-point scale ranging from 1 (“completely left/liberal”) to 10 (“completely right/conservative”). Culture was measured by asking participants which culture they see themselves most influenced by. Culture is a binary variable that takes 1 for a culture other than German (non-German culture) and 0 for German culture. German proficiency was measured on a 10-point scale ranging from 1 (“not proficient at all”) to 10 (“very proficient”). German frequency was measured on a 10-point scale ranging from 1 (“very rarely”) to 10 (“very often”). Environmental attitudes were measured with six items on a numerical 5-point Likert scale.

2.4 Results

On average, participants in the PRESENT treatment planted 7.30 trees (SD = 3.59), and those in the FUTURE treatment planted 7.87 trees (SD = 3.45). According to the Mann-Whitney rank sum test, and contrary to the linguistic-savings hypothesis, participants in the FUTURE treatment planted statistically significantly more trees than those in the PRESENT treatment (p = 0.008).[14] Fig. 2.2 shows the cumulative distribution function of the number of trees planted per treatment.

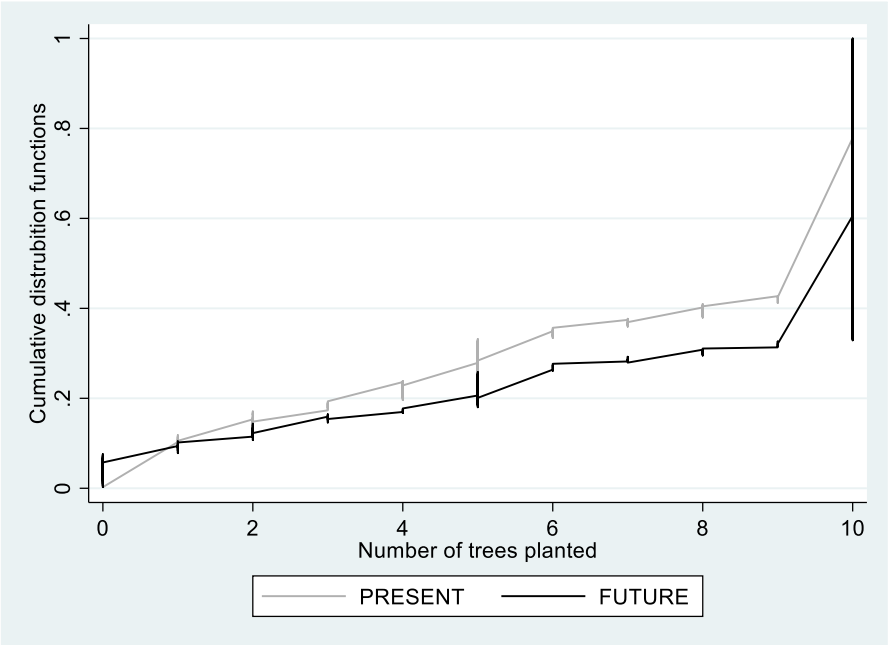

Fig. 2.2. The graph shows the cumulative distribution function of the number of trees planted per treatment.

To examine the stability of the treatment effects, we estimate the following OLS regression model

$$y_i = \beta_0 + \beta_1 FUTURE_i + \beta'_3 \boldsymbol{X_i} + \beta'_4 \boldsymbol{C_i} + \varepsilon_i \,, \qquad (1)$$

where the dependent variable y_i is the number of trees planted by individual i. The dummy variable $FUTURE_i$ takes the value of 1 if individual i is assigned to the FUTURE treatment and 0 if he or she participates in the PRESENT treatment. We also estimated model specifications in which we control for

[14] All statistical tests are two-sided.

sociodemographic $\boldsymbol{X_i}$ and culture and language-related variables $\boldsymbol{C_i}$. ε_i is the idiosyncratic error term. In all model specifications, we estimated robust standard errors.

Table 2.2 presents the regression results. All specifications show a statistically significant positive effect of the FUTURE treatment on the number of trees planted. Specification 1 contains the overall treatment effect. As shown by the descriptive statistics, participants in the FUTURE treatment group planted 0.57 more trees compared to participants in the PRESENT treatment group. This corresponds to a 7.8% increase in the number of trees planted. The magnitude and significance level of the treatment effect remain stable when we control for sociodemographic variables (Specification 2) and for culture and language-related variables (Specification 3). In addition, gender and age have a statistically significant impact on the number of trees planted, with women and older people planting more trees. The size of the FUTURE treatment effect is slightly less than half of the magnitude of the impact observed between identifying as female and identifying with other gender identities. Furthermore, the results reveal a significant negative correlation between conservative political ideology and the number of trees planted. This finding is in line with previous research showing that people with a liberal ideology tend to have higher environmental concerns (Xiao & McCright, 2007) and support more government spending on environmental protection (McCright et al., 2014), compared to their conservative counterparts. In addition, German proficiency and frequency have no significant impact, possibly because we excluded all participants who do not have German as their native language.

Furthermore, we test whether future-time referencing has different effects on the number of trees planted by people with different environmental attitudes. The treatment effects were estimated by restricting the sample to those who have strong environmental attitudes, as described in the pre-registered protocol. Environmental attitudes were measured with six items on a numerical 5-point Likert scale (ISSP Research Group, 2012). Strong environmental attitudes are defined if the mean of the six items is equal to or higher than 3. Specifications 4–6 of Table 2.2 show that the statistical significance of the FUTURE treatment remains the same, whereas the magnitude of the FUTURE treatment coefficient is slightly higher for the restricted sample than for the main sample.

Table 2.2. Effect of the FUTURE treatment on the number of trees planted: OLS regression.

	Main sample			Excl. weak environmental attitudes		
	No. trees	No. trees	No. trees	No. trees	No. trees	No. trees
	(1)	(2)	(3)	(4)	(5)	(6)
FUTURE	0.568**	0.494**	0.472*	0.589**	0.552**	0.519**
	(0.253)	(0.250)	(0.253)	(0.247)	(0.250)	(0.252)
Female		1.157***	1.178***		0.968***	0.954***
		(0.265)	(0.274)		(0.269)	(0.279)
Age in years		0.046***	0.033*		0.031**	0.018
		(0.014)	(0.017)		(0.014)	(0.017)
Income						
£10,000–£29,000		0.369	0.387		0.275	0.312
		(0.338)	(0.339)		(0.339)	(0.339)
£29,000–£59,000		0.341	0.344		0.311	0.294
		(0.361)	(0.364)		(0.360)	(0.363)
More than £60,000		0.553	0.537		0.516	0.501
		(0.450)	(0.455)		(0.443)	(0.449)
Education						
Vocational training		–0.044	–0.082		0.107	0.072
		(0.403)	(0.410)		(0.403)	(0.408)
Secondary school/		0.107	0.078		–0.111	–0.105
high school and less		(0.294)	(0.296)		(0.297)	(0.299)
Conservative ideology		–0.395***	–0.398***		–0.223**	–0.223**
		(0.088)	(0.088)		(0.093)	(0.094)
Non-German culture			–0.530			–0.214
			(0.466)			(0.463)
German proficiency			–0.110			0.164
			(0.270)			(0.281)
German frequency			–0.041			–0.069
			(0.160)			(0.176)
Years in country of birth			0.007			0.029
			(0.048)			(0.0477)
Years in country of			0.016			0.017
residence			(0.015)			(0.015)
Constant	7.302***	6.483***	7.898**	7.579***	6.742***	5.311*
	(0.180)	(0.631)	(3.067)	(0.178)	(0.637)	(3.194)
N	781	768	768	725	712	712
R^2	0.006	0.077	0.081	0.008	0.043	0.047

Note. The table presents ordinary least squares estimates. Robust standard errors are in parentheses. The dependent variable is the number of trees planted, either for the main sample (specifications 1–3) or for the restricted sample, excluding those with weak environmental attitudes (specifications 4–6). Environmental attitudes were measured with six items on a numerical 5-point Likert scale. Weak pro-environmental attitudes are present if the mean is less than 3. The reference group for the FUTURE treatment is the PRESENT treatment. Female is a binary variable that takes a value of 1 for women and 0 for men and non-binary and other individuals. The reference group for the income variable are participants who earn less than GBP 10,000. The reference group for the education are participants with a university degree. Conservative ideology refers to a political ideology and is measured on a 10-point scale ranging from 1 ("completely left/liberal") to 10 ("completely right/conservative"). Culture was measured by asking participants which culture they see themselves most influenced by. Culture is a binary variable taking 1 for a culture other than German (non-German culture) and 0 for German culture. German proficiency was measured on a 10-point scale ranging from 1 ("not proficient at all") to 10 ("very proficient"). German frequency was measured on a 10-point scale ranging from 1 ("very rarely") to 10 ("very often"). Thirteen observations are omitted due to missing observations for income (n = 11) and political ideology (n = 2), which were non-required questions. *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively.

Regarding extensive margin effects, we run a probit regression model on the probability of planting at least one tree. Specifications 1–3 of Table 2.3 provide the corresponding estimates with and without controls for the main sample and specifications 7–9 for those who have strong environmental attitudes. The results show that the FUTURE treatment has no statistically significant effect on the probability of planting a tree. Considering the intensive margin, specifications 4–6 show a statistically significant increase in the number of trees planted conditional on planting at least one tree for participants in the FUTURE treatment compared to the PRESENT treatment. This finding is in line with Fig. 2.2 that shows considerable differences between the FUTURE and the PRESENT treatment for three and more trees planted. In addition, specifications 10–12 confirm the results of specifications 4–6 for participants with strong environmental attitudes, with the FUTURE treatment coefficient even larger. These findings suggest that the significant positive impact of future tense marking on the number of trees planted can be explained by intensive margin effects. Therefore, future tense marking could be particularly useful in increasing the intensity of desired pro-environmental behavior.

We expected self-reported pro-environmental intentions to be in line with actual behavior. Therefore, we consider behavioral intentions to be a secondary outcome of the study, and we examine whether different future-time referencing influences self-reported pro-environmental intentions. Interestingly, even if the mean scores for behavioral intentions are positively correlated with the number of trees planted ($r = 0.273$, $p < 0.001$), we find no statistically significant treatment differences with respect to pro-environmental intentions.[15] Table 2.5 in the Appendix provides estimates obtained from an OLS regression analysis, with the average pro-environmental intentions as the dependent variable. One explanation for this insignificant finding might be that the text in the first part of the experiment mentioned only the positive impact of tree planting to mitigate climate change, not the proposed actions that were used to elicit intentions (e.g., turning off lights or buying goods with less packaging). Thus, tree planting, which represents the behavioral outcome measure, may enable participants to easily make a direct link with climate change mitigation (Ajzen & Fishbein, 1975).

[15] In addition, based on Mann-Whitney rank-sum tests, we do not identify significant treatment differences in the mean of all behavioral intentions ($p = 0.910$), the four behavioral intentions formulated in the respective treatment tense ($p = 0.834$), or the five behavioral intentions formulated in a tense-neutral manner ($p = 0.943$).

Table 2.3. Extensive and intensive margins.

	Main sample						Weak environmental attitudes excluded					
	Prob. of planting trees	Prob. of planting trees	Prob. of planting trees	No. trees cond.	No. trees cond.	No. trees cond.	Prob. of planting trees	Prob. of planting trees	Prob. of planting trees	No. trees cond.	No. trees cond.	No. trees cond.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
FUTURE treatment	–0.002	–0.015	–0.020	0.617***	0.578***	0.555**	–0.039	–0.038	–0.049	0.664***	0.636***	0.606***
	(0.133)	(0.141)	(0.142)	(0.215)	(0.217)	(0.219)	(0.151)	(0.154)	(0.151)	(0.213)	(0.217)	(0.219)
Female		0.626***	0.660***		0.555**	0.539**		0.575***	0.606***		0.476**	0.427*
		(0.153)	(0.155)		(0.234)	(0.241)		(0.168)	(0.171)		(0.236)	(0.242)
Age in years		0.017*	0.016		0.031**	0.019		0.013	0.009		0.020*	0.011
		(0.010)	(0.011)		(0.012)	(0.015)		(0.011)	(0.011)		(0.012)	(0.015)
Income												
£10,000–£29,000		0.378*	0.390**		0.022	0.035		0.363*	0.365*		–0.006	0.036
		(0.195)	(0.194)		(0.299)	(0.300)		(0.214)	(0.212)		(0.299)	(0.299)
£29,000–£59,000		0.103	0.120		0.227	0.219		0.077	0.078		0.259	0.245
		(0.206)	(0.208)		(0.304)	(0.306)		(0.224)	(0.225)		(0.300)	(0.303)
More than £60,000		0.116	0.131		0.485	0.451		0.130	0.140		0.412	0.398
		(0.236)	(0.237)		(0.371)	(0.376)		(0.269)	(0.269)		(0.367)	(0.371)
Education												
Vocational training		0.018	0.034		–0.081	–0.124		0.098	0.100		0.025	–0.001
		(0.215)	(0.218)		(0.341)	(0.346)		(0.264)	(0.266)		(0.341)	(0.346)
Secondary school/		0.160	0.130		–0.064	–0.055		0.010	–0.011		–0.124	–0.089
high school and less		(0.174)	(0.177)		(0.256)	(0.258)		(0.192)	(0.195)		(0.258)	(0.258)
Conservative ideology		–0.140***	–0.140***		–0.248***	–0.251***		–0.093	–0.092		–0.137*	–0.137*
		(0.047)	(0.047)		(0.076)	(0.077)		(0.058)	(0.056)		(0.077)	(0.078)
Non-German culture			–0.258			–0.252			–0.062			–0.203
			(0.218)			(0.407)			(0.257)			(0.415)
German proficiency			–0.184			0.084			–0.095			0.284
			(0.153)			(0.239)			(0.162)			(0.251)
German frequency			–0.125			0.056			–0.056			–0.043
			(0.120)			(0.137)			(0.109)			(0.158)
Years in country of birth			–0.008			0.019			–0.001			0.035
			(0.036)			(0.039)			(0.034)			(0.039)
Years in country of			0.000			0.015			0.005			0.011
residence			(0.009)			(0.013)			(0.009)			(0.013)
Constant	1.437***	1.032***	4.242**	7.897***	7.488***	5.811**	1.604***	1.149***	2.636	8.014***	7.578***	4.631
	(0.093)	(0.384)	(1.867)	(0.159)	(0.542)	(2.767)	(0.107)	(0.433)	(1.846)	(0.159)	(0.545)	(2.922)
N	781	768	768	722	709	709	725	712	712	684	671	671
Pseudo-R^2/R^2	0.001	0.099	0.108	0.011	0.046	0.049	0.001	0.065	0.068	0.014	0.032	0.037

Note. Specifications 1–3 and 7–9 report the estimates of a probit regression on the likelihood of planting at least one tree. Specifications 4–6 and 9–12 present the results of an OLS regression with the number of trees planted conditional on planting at least one tree as the dependent variable. Robust standard errors are in parentheses. The restricted sample excludes those with weak environmental attitudes (specifications 7–12). Environmental attitudes were measured with six items on a numerical 5-point Likert scale. Weak pro-environmental attitudes are present if the mean is less than 3. The reference group for the FUTURE treatment is the PRESENT treatment. All other variables are explained in Table 2.2. Thirteen observations are omitted due to missing observations for income (n = 11) and political ideology (n = 2), which were non-required questions. *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively.

2.5 Potential mechanisms

In this section, we discuss construal level theory, timing precision, future orientation, and certainty of the occurrence of future climate events as potential mechanisms that might explain why using the future tense within a weak FTR language can affect individual pro-environmental behavior in the form of tree planting.

First, according to construal level theory, situations are perceived at different levels of abstractness, from concrete to abstract (Liberman & Trope, 2003; Trope & Liberman, 2010). Events that are psychologically perceived as further away are processed at a more abstract, higher level, while events that are psychologically perceived as close are processed at a more concrete, lower level (Trope & Liberman, 2010). The perception of psychological distance has four dimensions: temporal distance, social distance, spatial distance, and hypothetical distance. Individuals exposed to the future tense might perceive a greater temporal distance of future events such as climate change. Therefore, using the future tense may shift the processing of climate change to an abstract, higher construal level (Wang et al., 2019). Construal level theory-based research argues that abstractness promotes long-term thinking and a focused, analytical mindset that facilitates decision-making for more abstract events (Fujita et al., 2006; Liberman & Trope, 2008). Based on these considerations, individuals in the FUTURE treatment might tend to process information more abstractly and give analytical arguments more weight compared to individuals in the PRESENT treatment. The resulting greater problem awareness could lead to more pro-environmental behavior (Zhu et al., 2020). We measure the construal level of psychological temporal distance by surveying the response category width (RCW) in relation to the earliest and latest expected year of occurrence of irreversible consequences of climate change. Theoretically, abstract perceptions should be broad with a large confidence interval, and concrete perceptions should be specific with a narrow confidence interval (Krüger et al., 2014). Specifically, we asked participants when they expected irreversible consequences of climate change at the earliest and at the latest. They were given a choice of 10 options (1 = today, 2 = from 2030, 3 = from 2040, 4 = from 2050, 5 = from 2060, 6 = from 2070, 7 = from 2080, 8 = from 2090, 9 = from 2090+, 10 = never). The value of the earliest occurrence of irreversible climate impacts is subtracted from the value given for the latest occurrence of irreversible climate impacts. A higher value (i.e., a higher range) corresponds to a higher construal level. In addition, we measure temporal distance to climate change with two items of a semantic differential-type scale (Brügger et al., 2016). Participants were asked to indicate how close or distant climate change felt to them on a 7-point scale (i.e., “very close” (1) to “very distant” (7); “like tomorrow” (1) to “like a thousand years away” (7)).

Second, grammatical marking of the future might lead participants to perceive future events as more precise in terms of timing (Zhu et al., 2020). The impact of climate change is associated with a high degree of uncertainty in the temporal dimension, which has also been shown to harm climate action (Jager et al., 2002). Increasing timing precision could reduce uncertainty in the time dimension, which,

in turn, might lead to more pro-environmental behavior. To measure timing precision, we also use the RCW. Note that reasoning based on construal level theory and timing precision is contradictory. The first mechanism assumes a broad RCW when grammatically marking the future, whereas the second mechanism assumes a narrow RCW. In addition, participants were asked how certain they were about the earliest date of irreversible climate-related consequences (0 = "completely uncertain" to 7 = "completely certain").

Third, using the future tense might increase future orientation (Zhu et al., 2020), which is associated with attaching greater importance to the future consequences of present actions (Joireman, 2005) and has been shown to be positively related to pro-environmental intentions (Gu et al., 2020) and behavior (Arnon & Carmi, 2014; Essl et al., 2022; Joireman et al., 2004). Consequently, if using the future tense activates future orientation, pro-environmental behavior might increase. We measured future orientation with a shortened (six items) validated German version of Kübel & Wittmann's (2020) future consequences scale. Participants were asked to indicate on a 7-point scale the extent to which statements about future and present considerations apply to them. For the statistical test, we took the average value of the six items.

Fourth, speaking about future events in the present tense might indicate a higher certainty of the occurrence of the future event (Ballweg, 1988). People might perceive the negative future consequences of climate change as more certain when they are expressed in the present tense. As a result, participants in the PRESENT treatment might have less hope of mitigating climate change and might perceive the effectiveness of mitigating climate change to be lower, leading to fewer planted trees. We measured certainty perception with the question regarding how much severe climate-related impacts can be mitigated in Central Europe (1 = "not at all" to 7 = "completely"). To measure mitigation perceptions, participants were asked how likely they thought it was that very severe, irreversible climate-related impacts would occur in Central Europe in the coming decades (1 = "extremely unlikely" to 7 = "extremely likely"). For the measurement of climate-related emotions, Steentjes et al.'s (2017) question was used: "When you think about climate change and all the things you associate with it: How strongly does that trigger the following emotions in you?" (1 = "not at all" to 7 = "very much"). We asked about the emotions hope, optimism, despair, fear, and discouragement.

To examine these four mechanisms, we conducted an online follow-up survey on Prolific. We retargeted all 781 participants who participated in the first study and met the criteria for the main analysis. Of these subjects, 460 (59%) participated in the follow-up study. The pre-registered exclusion criteria reduced the sample from 460 to 442 participants.[16] Identical to the first study, we manipulated

[16] The study was pre-registered with the AEA RCT registry with the identifying number AEARCTR-0009132 and took place from March 28 to April 18, 2022. Participants' experiment sessions lasted, on average, 8 minutes, with a flat payment of GBP 0.75. In accordance with the pre-registered protocol, participants who completed the task within 2 minutes or less or not within

the use of future-time referencing in the German language. The participants received the same climate change scenario and the same treatment as in the first study. In the PRESENT treatment (n = 228), subjects received a German description of the climate change scenario in the present tense, and in the FUTURE treatment (n = 214), the future tense was used to refer to future events. After reading the climate change scenario, the participants answered a survey that explored the proposed psychological mechanisms.

Table 2.4 presents the descriptive statistics for the four potential mechanisms and their constructs. To compare the treatments, we use two-sided Wilcoxon-Mann-Whitney tests. We identify no statistically significant differences between the two treatments for any of the proposed mechanisms. One reason for the null results might be the low response rate for the second study, as we collected data for only 56.6% of the participants in the first study. Notably, we find meaningful differences going in the proposed direction for the first proposed mechanism based on construal level theory. As anticipated, the temporal distance to climate change is larger, and the RCW measuring the earliest and latest expected years of occurrence of irreversible consequences of climate change is broader in the FUTURE treatment than in the PRESENT treatment. However, neither of these differences is statistically significant. More research is needed to analyze other potential psychological mechanisms.

30 minutes of starting (n = 7), who failed crucial attention checks (n = 0), who did not answer the control question correctly the first time (n = 0), and who gave inconsistent answers to the question regarding the earliest and latest possible points in time of the occurrence of irreversible climate impacts (n = 13) were excluded.

Table 2.4. Descriptive statistics: Psychological mechanisms.

Mechanisms	Constructs	Sample (n = 442)	FUTURE (n = 214)	PRESENT (n = 228)	FUTURE vs. PRESENT p values
Construal level theory	Response category width	1.63 (1.42)	1.72 (1.47)	1.54 (1.35)	0.215
	Temporal distance to climate change (1)	2.52 (1.45)	2.59 (1.43)	2.46 (1.47)	0.177
	Temporal distance to climate change (2)	2.33 (1.20)	2.35 (1.20)	2.32 (1.20)	0.784
Timing precision	Response category width	1.63 (1.42)	1.72 (1.47)	1.54 (1.35)	0.215
	Timing precision: certainty of starting point of response category width scale	4.29 (1.42)	4.21 (1.45)	4.36 (1.38)	0.189
Future orientation	Consideration of Future Consequences (CFC)	5.43 (0.84)	5.42 (0.85)	5.43 (0.84)	0.836
Certainty and hope regarding climate change	Extent of possible climate change mitigation	4.58 (1.09)	4.53 (1.08)	4.62 (1.11)	0.491
	Certainty of irreversible climate consequences	5.90 (1.12)	5.94 (1.08)	5.86 (1.16)	0.513
	Hope regarding climate change	2.21 (1.21)	2.21 (1.16)	2.21 (1.27)	0.528

Note. The table shows the means, standard deviations, and p values obtained from two-sided Wilcoxon-Mann-Whitney tests. Standard deviations are given in parentheses. Except for response category width, participants' answers were measured on a 7-point Likert scale. Response category width was measured on a 10-point scale ranging from 1 ("today") to 10 ("never").

2.6 Discussion and conclusion

This study examines whether there is a causal immediate effect of a language's future-time reference (present vs. future tense) on individual pro-environmental behavior in the form of tree planting. The linguistic-savings hypothesis suggests that languages in which speakers can refer to the future using the present tense lead to more future-oriented behavior than languages that separate the future from the present. Thus far, findings on the impact of future-time referencing in the environmental context are mixed. Although some studies find support for the linguistic-savings hypothesis (Kim & Filimonau, 2017; Liang et al., 2018; Mavisakalyan et al., 2018), others do not (Zhu et al., 2020).

The present study is the first to investigate the causal effect of a language's future-time reference on pro-environmental behavior by experimentally varying the use of the present and future tenses within the same language. Keeping the language constant enables cultural cues to be held constant. This allows us to focus solely on the effect of the grammatical structure on pro-environmental behavior. In this study, participants read a text using the present or future tense for future climate-related events, followed by an incentivized decision task about investing money in planting trees. Based on K. Chen's (2013) linguistic-savings hypothesis, participants in the PRESENT treatment should spend more money on planting trees than participants in the FUTURE treatment. We find the reverse effect: Participants in the FUTURE treatment planted statistically significantly more trees than those in the PRESENT treatment.

The significant positive impact of future tense marking on the number of trees planted can be explained by intensive margin effects. Moreover, we aimed to uncover possible mechanisms behind the association between future-time reference and pro-environmental behavior. In an additional survey experiment, we find meaningful differences going in the proposed direction of construal level theory, however, none of these differences is statistically significant. Taken together, the findings of this study may provide important implications for environmental communication strategies in practice. The results suggest that future tense marking is a potential opportunity to effectively implement behavioral interventions and communication strategies in the environmental context. For example, policy makers and environmental organizations may promote pro-environmental behavior, in particular the intensity of it, by using the future tense to refer to the future impact of climate change.

More research is needed to support the effectiveness of future tense marking in fostering pro-environmental behavior. First, this study investigates the immediate impact of grammatical structure on pro-environmental behavior. Long-term exposure, however, might lead to different patterns of behavior. K. Chen's (2013) linguistic-savings hypothesis does not distinguish between short- and long-term exposure to language. Therefore, an important direction for future research is to examine how long-term exposure to differences in language structure affects pro-environmental behavior and future-oriented behavior in general. Second, more research is warranted to analyze the drivers behind our results. For example, an important direction for follow-up studies is to examine psychological distance, construal levels, and other potential underlying mechanisms more precisely. In addition, the way in which consequences are framed, either as gains or losses, may have an impact on environmental decisions (Ropret Homar & Knežević Cvelbar, 2021). Thus far, experimental studies on future-time referencing have used a gain-framing approach to consequences in intertemporal choice tasks (Angerer et al., 2021; J. I. Chen et al., 2019), whereas we used elements of loss and gain framing. The text on climate change consequences and tree planting emphasizes the future negative consequences of climate change and the positive consequences for the environment that result from participants' decisions to plant trees. Future research would benefit from investigating whether the effects of future-time referencing depend on the framing of future consequences. Another important question is whether the immediate impact of future-time referencing depends on the time horizon and the associated levels of certainty. Previous experimental studies on future-time referencing have focused on financial decisions with outcomes occurring at a specific point in the near future (1 to 12 weeks away; Angerer et al., 2021; Ayres et al., 2023; J. I. Chen et al., 2019). In contrast, in this study, we are concerned with trees' absorption of carbon dioxide, an event that takes place at a distant and uncertain time in the future. Accordingly, the effect of future-time referencing may have different impacts in different domains due to issues related to the time horizon. Addressing the question of time horizon, a recent study by Kiss and Keller (2023) suggests that the usage of future tense increases as the future event gets farther away. This finding could explain why the linguistic-savings hypothesis might not be applicable to events further in the future, especially when both strong and weak FTR language speakers use the future tense for such distant events. Finally, we

cannot rule out the possibility that the results of this study depend on the type of pro-environmental behavior and the language. Future studies could examine whether future marking is similarly effective for other types of pro-environmental behavior, as well as using other weak FTR languages.

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Appendix A: Additional analyses

Table 2.5. Effect of the FUTURE treatment on pro-environmental intentions: OLS regression.

	Main sample			Excl. weak environmental attitudes		
	Intentions	Intentions	Intentions	Intentions	Intentions	Intentions
	(1)	(2)	(3)	(4)	(5)	(6)
FUTURE treatment	–0.029	–0.033	–0.030	–0.032	–0.019	–0.014
	(0.074)	(0.072)	(0.073)	(0.072)	(0.071)	(0.072)
Female		0.392***	0.360***		0.348***	0.317***
		(0.075)	(0.076)		(0.075)	(0.076)
Age in years		0.022***	0.023***		0.021***	0.021***
		(0.004)	(0.006)		(0.004)	(0.005)
Income						
£10,000–£29,000		0.012	0.024		0.008	0.018
		(0.094)	(0.094)		(0.092)	(0.091)
£29,000–£59,000		–0.056	–0.060		–0.126	–0.140
		(0.103)	(0.104)		(0.102)	(0.104)
More than £60,000		–0.075	–0.067		–0.049	–0.047
		(0.120)	(0.120)		(0.117)	(0.118)
Education						
Vocational training		–0.127	–0.118		–0.113	–0.104
		(0.123)	(0.122)		(0.119)	(0.117)
Secondary school/		0.101	0.126		0.060	0.085
high school and less		(0.081)	(0.084)		(0.078)	(0.080)
Conservative ideology		–0.118***	–0.115***		–0.083***	–0.080***
		(0.024)	(0.024)		(0.024)	(0.025)
Non-German culture			0.058			0.130
			(0.143)			(0.151)
German proficiency			0.169**			0.199**
			(0.083)			(0.087)
German frequency			–0.058			–0.072
			(0.049)			(0.053)
Years in country of birth			–0.013			–0.010
			(0.011)			(0.011)
Years in country of			–0.002			–0.001
residence			(0.005)			(0.005)
Constant	4.946***	4.527***	3.663***	5.032***	4.552***	3.467***
	(0.051)	(0.173)	(0.904)	(0.050)	(0.166)	(0.929)
N	781	768	768	725	712	712
R^2	0.001	0.099	0.108	0.000	0.072	0.085

Note. The table presents OLS regression estimates. Robust standard errors are in parentheses. The dependent variable is the mean of all nine behavioral intentions asked, either for the main sample (specifications 1–3) or for the restricted sample that excluded those with weak environmental attitudes (specifications 4–6). Environmental attitudes were measured with six items on a numerical 5-point Likert scale. Weak pro-environmental attitudes are present if the mean is less than 3. The reference group for the FUTURE treatment is the PRESENT treatment. All other variables are as explained in Table 2.2. Thirteen observations are omitted due to missing observations for income (n = 11) and political ideology (n = 2), which were non-required questions. *, **, and *** represent significance at the 10%, 5%, and 1% levels.

Analysis of the different samples

Table 2.6 shows the coefficients of the FUTURE treatment for Specification 1 of Model 1 from the main sample that includes previously excluded participants. First, we run an analysis that includes data for participants who did not believe in climate change and in the positive impact of planting trees. The results show that the significance level and the magnitude of the FUTURE treatment remains basically unchanged. When we restrict the sample to those who have strong environmental attitudes, the magnitude and statistical significance drop, but the effect remains statistically significant at a 10% level. Next, we include data for those who indicated a native language other than German (n = 823). Including these subjects slightly weakens the significance level ($p<0.10$) and the magnitude of the FUTURE coefficient. This result suggests that a large internalized familiarity with the German language might be a prerequisite for the treatment effect. The results of specifications 2 and 3 of Model 1 are also robust except for specification 3, when climate change and tree skeptics are included (the statistical significance level of the FUTURE coefficient drops to $p = 0.103$).

Table 2.6. Analysis of different samples for Specification 1 of Model 1.

	Main sample	Including climate change and tree skeptics	Including non-German native language
Number of trees	0.568**	0.524**	0.467*
	(0.253)	(0.255)	(0.248)
	n = 781	n = 805	n = 823
Number of trees excluding weak environmental attitudes	0.589**	0.478*	0.480**
	(0.247)	(0.250)	(0.243)
	n = 725	n = 736	n = 765

Note. The table displays the coefficients of the FUTURE treatment of Specification 1 of Model 1 for the main sample and the different sub-samples. The baseline group for the FUTURE treatment is the PRESENT group. The dependent variable is the number of trees planted. Robust standard errors are shown in parentheses. In addition, the table displays FUTURE treatment coefficients without participants with weak environmental attitudes. The main sample is the sample used after participants were excluded according to the pre-registered protocol. The sample that included climate change and tree skeptics incorporates participants who did not believe in climate change and/or the positive impact of planting trees as climate change mitigation measure (n = 6). The third sample includes participants who did not speak German as their native language. *, **, and *** represent significance at the 10%, 5%, and 1% levels.

Access to raw data and statistical codes

Raw data and statistical codes for the manuscript "The effect of future-time referencing on pro-environmental behavior" by Andrea Essl, Manuel Suter, and Frauke von Bieberstein can be found under the following link: https://osf.io/49dzu/?view_only=8fa11e500cbd4de68385d7fcb0196260

Appendix B: Experimental material

(Original German instructions were translated to English)

[PRESENT & FUTURE treatment]

Tree Task

In Part 1, you receive an additional payment of **0.86 GBP**. You are asked to make a decision that may affect your final payment for Part 1. This part is about climate change.

[FUTURE Treatment]

The climate crisis will have an increasingly negative impact in the coming decades. The Intergovernmental Panel on Climate Change (IPCC) of the United Nations warns of climate-related risks for natural and human systems. Over the coming decades, due to sea level rise, low-lying areas and coastal zones **will** increasingly **experience** submergence, flooding and erosion. Furthermore, a large fraction of mammals and plants **will face** an increased extinction risk due to climate change during the 21st century. The projected climate change **will** also **affect** human health: The IPCC assumes that there **will be** a greater likelihood of injury and death due to more intense heat waves and fires as well as an increased risk of disease outbreaks. The extent of these effects and the risk of irreversible changes **will depend** on the extent to which humans succeed in lowering and capturing carbon emissions.

Why plant trees to fight climate change?

Carbon dioxide (CO_2) is regarded as a key contributor to climate change, and scientists around the globe agree that in future, climate change **will 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.

Comprehension check

What action is mentioned in the text that can mitigate the extent of the negative impacts of climate change?

- No more oil extraction
- Join environmental organisations
- Reduce and capture carbon emissions [correct answer]

Your task

- You will decide whether you want to keep all of the 0.86 GBP for yourself or whether you want to invest parts or all of it as a contribution to fighting climate change.
- The money that you decide **NOT** to keep **will be used to plant trees** and thus offset carbon dioxide (CO_2). Each tree costs 0.086 GBP to plant. An international forest restoration organisation **will plant** the trees within the next two months.
- The price to plant one tree that will absorb 20 kg of CO2 over its lifetime is 0.086 GBP. This corresponds to an offset of about 80 car kilometers travelled by an average passenger car.
- **Your decision will have an actual and true consequence for the environment**. It is **NOT** a hypothetical decision.

Your choice

The table below shows 11 options and their consequences. You are asked to select **ONE** of the 11 options. For each option, the different investment that you can make to fight climate change are shown. In addition, for each investment option, it is indicated how many trees the forest restoration organisation **will plant** within the next two months and how many kg of CO2 these trees **will absorb** over their lifetime. To help you further understand your contribution, each amount of CO2 absorbed is "translated" into how many kilometres travelled by car can be offset by your choice.

Example

Suppose you select "**Option 6 trees"**:

- Within the next two months, a forest restoration organisation **will plant six trees with your investment of 0.51 GBP**.
- Thus, you keep 0.35 GBP (0.86 GBP - 0.51 GBP) for yourself.
- The **six trees will absorb 120 kg of CO_2** during their lifetimes.
- The lifetime CO2 absorption of the six trees planted **will offset about 480 kilometres travelled by car**.

Option 0 Bäume

Ihre Investition: £0

Diese Option ...

- **wird** 0 Bäume **pflanzen**
- **wird** 0 kg CO_2 **absorbieren**
- **wird** 0 Autokilometer **kompensieren**

Option 1 Baum

Ihre Investition: £0.086

Diese Option ...

- **wird** 1 Baum **pflanzen**
- **wird** 20 kg CO_2 **absorbieren**
- **wird** 80 Autokilometer **kompensieren**

Option 2 Bäume

Ihre Investition: £0.17

Diese Option ...

- **wird** 2 Bäume **pflanzen**
- **wird** 40 kg CO_2 **absorbieren**
- **wird** 160 Autokilometer **kompensieren**

Option 3 Bäume

Ihre Investition: £0.26

Diese Option ...

- **wird** 3 Bäume **pflanzen**
- **wird** 60 kg CO_2 **absorbieren**
- **wird** 240 Autokilometer **kompensieren**

Option 4 Bäume

Ihre Investition: £0.34

Diese Option ...

- **wird** 4 Bäume **pflanzen**
- **wird** 80 kg CO_2 **absorbieren**
- **wird** 320 Autokilometer **kompensieren**

Option 5 Bäume

Ihre Investition: £0.43

Diese Option ...

- **wird** 5 Bäume **pflanzen**
- **wird** 100 kg CO_2 **absorbieren**
- **wird** 400 Autokilometer **kompensieren**

Option 6 Bäume

Ihre Investition: £0.51

Diese Option ...

- **wird** 6 Bäume **pflanzen**
- **wird** 120 kg CO_2 **absorbieren**
- **wird** 480 Autokilometer **kompensieren**

Option 7 Bäume

Ihre Investition: £0.60

Diese Option ...

- **wird** 7 Bäume **pflanzen**
- **wird** 140 kg CO_2 **absorbieren**
- **wird** 560 Autokilometer **kompensieren**

Option 8 Bäume

Ihre Investition: £0.68

Diese Option ...

- **wird** 8 Bäume **pflanzen**
- **wird** 160 kg CO_2 **absorbieren**
- **wird** 640 Autokilometer **kompensieren**

Option 9 Bäume

Ihre Investition: $0.77

Diese Option ...

- **wird** 9 Bäume **pflanzen**
- **wird** 180 kg CO_2 **absorbieren**
- **wird** 720 Autokilometer **kompensieren**

Option 10 Bäume

Ihre Investition: £0.86

Diese Option ...

- **wird** 10 Bäume **pflanzen**
- **wird** 200 kg CO_2 **absorbieren**
- **wird** 800 Autokilometer **kompensieren**

Comprehension check

To ensure that we have explained Part 1 comprehensibly, we ask you to answer the following questions:

Assume, that you select **"Option 2 trees"**:

- What is your **investment** (in GBP) for planting trees?
- How many **trees will** the forest restoration organisation **plant** with your investment within the next two months?
- How many **kg of CO_2 will** these trees **absorb** over their lifetimes?

Assume, that you select **"Option 9 trees"**:

- How many **trees will** the forest restoration organisation **plant** with your investment within the next two months?
- How many **kilometres travelled by car will be compensated** by the lifetime CO_2 absorption of these trees?
- What is your **investment** (in GBP) for planting trees?

Will your decision **have** a real consequence for the environment? (Yes / No)

Your choice

Please select the option that will be implemented.

What is your **investment** (in GBP) for planting trees based on your selected option?

How many **kg of CO_2 will** these trees **absorb** over their lifetimes?

If you would like a confirmation email after the trees for this study have been planted, please email us.

[PRESENT Treatment]

The climate crisis has an increasingly negative impact in the coming decades. The Intergovernmental Panel on Climate Change (IPCC) of the United Nations warns of climate-related risks for natural and human systems. Over the coming decades, due to sea level rise, low-lying areas and coastal zones increasingly **experiences** submergence, flooding and erosion. Furthermore, a large fraction of mammals and plants **face** an increased extinction risk due to climate change during the 21st century. The projected climate change also **affects** human health: The IPCC assumes that there **is** a greater likelihood of injury and death due to more intense heat waves and fires as well as an increased risk of disease outbreaks. The extent of these effects and the risk of irreversible changes **depend** on the extent to which humans succeed in lowering and capturing carbon emissions.

Why plant trees to fight climate change?

Carbon dioxide (CO_2) is regarded as a key contributor to climate change, and scientists around the globe agree that in future, climate change **is 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 **leads** to a great offset of CO_2 emissions and, thus, to a great contribution to the fight against climate change.

Comprehension check

What action is mentioned in the text that can mitigate the extent of the negative impacts of climate change?

- No more oil extraction
- Join environmental organisations
- Reduce and capture carbon emissions [correct answer]

Your task

- You will decide whether you want to keep all of the 0.86 GBP for yourself or whether you want to invest parts or all of it as a contribution to fighting climate change.
- The money that you decide **NOT** to keep **is used to plant trees** and thus offset carbon dioxide (CO_2). Each tree costs 0.086 GBP to plant. An international forest restoration organisation **plants** the trees within the next two months.
- The price to plant one tree that will absorb 20 kg of CO2 over its lifetime is 0.086 GBP. This corresponds to an offset of about 80 car kilometers travelled by an average passenger car.
- **Your decision has an actual and true consequence for the environment**. It is **NOT** a hypothetical decision.

Your choice

The table below shows 11 options and their consequences. You are asked to select **ONE** of the 11 options. For each option, the different investment that you can make to fight climate change are shown. In addition, for each investment option, it is indicated how many trees the forest restoration organisation **plants** within the next two months and how many kg of CO2 these trees **absorbs** over their lifetime. To help you further understand your contribution, each amount of CO2 absorbed is "translated" into how many kilometres travelled by car can be offset by your choice.

Example

Suppose you select "**Option 6 trees"**:

- Within the next two months, a forest restoration organisation **plants six trees with your investment of 0.51 GBP**.
- Thus, you keep 0.35 GBP (0.86 GBP - 0.51 GBP) for yourself.
- The **six trees absorb 120 kg of CO_2** during their lifetimes.
- The lifetime CO2 absorption of the six trees planted **offset about 480 kilometres travelled by car**.

Option 0 Bäume

Ihre Investition: £0

Diese Option ...

- **pflanzt** 0 Bäume
- **absorbiert** 0 kg CO_2
- **kompensiert** 0 Autokilometer

Option 1 Baum

Ihre Investition: £0.086

Diese Option ...

- **pflanzt** 1 Baum
- **absorbiert** 20 kg CO_2
- **kompensiert** 80 Autokilometer

Option 2 Bäume

Ihre Investition: £0.17

Diese Option ...

- **pflanzt** 2 Bäume
- **absorbiert** 40 kg CO_2
- **kompensiert** 160 Autokilometer

Option 3 Bäume

Ihre Investition: £0.26

Diese Option ...

- **pflanzt** 3 Bäume
- **absorbiert** 60 kg CO_2
- **kompensiert** 240 Autokilometer

Option 4 Bäume

Ihre Investition: £0.34

Diese Option ...

- **pflanzt** 4 Bäume
- **absorbiert** 80 kg CO_2
- **kompensiert** 320 Autokilometer

Option 5 Bäume

Ihre Investition: £0.43

Diese Option ...

- **pflanzt** 5 Bäume
- **absorbiert** 100 kg CO_2
- **kompensiert** 400 Autokilometer

Option 6 Bäume

Ihre Investition: £0.51

Diese Option ...

- **pflanzt** 6 Bäume
- **absorbiert** 120 kg CO_2
- **kompensiert** 480 Autokilometer

Option 7 Bäume

Ihre Investition: £0.60

Diese Option ...

- **pflanzt** 7 Bäume
- **absorbiert** 140 kg CO_2
- **kompensiert** 560 Autokilometer

Option 8 Bäume

Ihre Investition: £0.68

Diese Option ...

- **pflanzt** 8 Bäume
- **absorbiert** 160 kg CO_2
- **kompensiert** 640 Autokilometer

Option 9 Bäume

Ihre Investition: $0.77

Diese Option ...

- **pflanzt** 9 Bäume
- **absorbiert** 180 kg CO_2
- **kompensiert** 720 Autokilometer

Option 10 Bäume

Ihre Investition: £0.86

Diese Option ...

- **pflanzt** 10 Bäume
- **absorbiert** 200 kg CO_2
- **kompensiert** 800 Autokilometer

Comprehension check

To ensure that we have explained Part 1 comprehensibly, we ask you to answer the following questions:

Assume, that you select **"Option 2 trees"**:

- What is your **investment** (in GBP) for planting trees?
- How many **trees does** the forest restoration organisation **plant** with your investment within the next two months?
- How many **kg of CO_2 do** these trees **absorb** over their lifetimes?

Assume, that you select **"Option 9 trees"**:

- How many **trees does** the forest restoration organisation **plant** with your investment within the next two months?
- How many **kilometres travelled by car are compensated** by the lifetime CO_2 absorption of these trees?
- What is your **investment** (in GBP) for planting trees?

Does your decision **have** a real consequence for the environment? (Yes / No)

Your choice

Please select the option that will be implemented.

What is your **investment** (in GBP) for planting trees based on your selected option?

How many **kg of CO_2 do** these trees **absorb** over their lifetimes?

If you would like a confirmation email after the trees for this study have been planted, please email us.

[PRESENT & FUTURE treatment]

Questionnaire

Behavioral intentions

How would you rate your willingness to act in a certain way in relation to the following areas? Please indicate your answer on a scale from 1 to 7, where 1 means "extremely unlikely" and 7 means "extremely likely". You can also use the values in between to indicate where you fall on the scale.

[FUTURE Treatment]

- I will try to reduce my carbon footprint in the forthcoming month *(Mancha & Yoder, 2015)*. (α = .78)
- I will turn off the lights as much as possible in the forthcoming month (*adapted from Fujii, 2006)*. (α = .80)

- I will spend less time in the shower in the forthcoming month *(adapted from Fujii, 2006)*. (α = .80)
- I will buy goods with less packaging material in the forthcoming month *(adapted from Fujii, 2006)*. (α = .79)
- I intend to engage in environmentally friendly behavior in the forthcoming month *(Mancha & Yoder, 2015)*. (α = .77)
- I intend to completely switch off appliances that are in stand-by mode in the forthcoming month. (α = .80)
- I intend to use less hot water in the shower in the forthcoming month. (α = .79)
- I intend to avoid single-use bags in the forthcoming month. (α = .80)
- I plan to stop wasting natural resources in the forthcoming month *(Mancha & Yoder, 2015)*. (α = .78)

[PRESENT treatment]

- I try to reduce my carbon footprint in the forthcoming month *(adapted from Mancha & Yoder, 2015)*. (α = .78)
- I turn off the lights as much as possible in the forthcoming month (adapted from *Fujii, 2006)*. (α = .80)
- I spend less time in the shower in the forthcoming month *(adapted from Fujii, 2006)*. (α = .78)
- I buy goods with less packaging material in the forthcoming month *(adapted from Fujii, 2006)*. (α = .80)
- I intend to engage in environmentally friendly behavior in the forthcoming month *(Mancha & Yoder, 2015)*. (α = .76)
- I intend to completely switch off devices that are in stand-by mode in the forthcoming month. (α = .80)
- I intend to use less hot water in the shower in the forthcoming month. (α = .78)
- I intend to avoid using single-use bags in the forthcoming month. (α = .81)
- I plan to stop wasting natural resources in the forthcoming month *(Mancha & Yoder, 2015)*. (α = .78)

[PRESENT & FUTURE treatment]

Climate change beliefs – 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? *(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? *(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.)*

Beliefs in planting trees

Have you ever invested money in planting trees to fight climate change? *(Yes, No)*
How effective do you consider tree planting to be as a climate protection measure? *(4-Point Likert Scale; very effective, effective, not very effective, not effective at all)*

Environmental attitudes – ISSP Research Group, 2012

(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. ($\alpha = .70$)
2. We worry too much about the future of the environment and not enough about prices and jobs. ($\alpha = .68$)
3. There are more important things to do in life than protect the environment. ($\alpha = .69$)
4. There is no point in doing what I can for the environment unless others do the same. ($\alpha = .69$)
5. It is too difficult for someone like me to do much about the environment. ($\alpha = .70$)
6. Modern science will solve our environmental problems with little change to our way of life. ($\alpha = .68$)

Demographic and language-related questions

Please select the gender with which you most identify.

- Male
- Female
- Non-binary or other

What is your year of birth? (exactly 4 numbers, e.g. 1995)

In which country were you born? [DropDown with countries]

How many years did you live in your country of birth between the ages of 0 - 18? (in whole years)

In which country do you reside? [DropDown with countries]

How many years have you lived in your country of residence? (in whole years)

Please rate your knowledge of German on a scale from 1 (not at all extensive) to 10 (very extensive). You can use the values in between to indicate where you lie on the scale.

How often do you use German in your everyday life on a scale from 1 (very rarely) to 10 (very often)? You can use the values in between to indicate where you lie on the scale.

In political matters, people talk about "left/progressive" and "right/conservative". Where would you place your views on a scale from 1 (completely left/progressive) to 10 (completely right/conservative)? You can use the values in between to indicate where you lie on the scale.

What is your highest completed level of education?

- Doctorate
- University
- University of applied sciences
- Advanced vocational education
- Vocational training
- Secondary school / High school
- Less than Secondary school / High school

Which culture do you consider yourself most influenced by?

- British
- German
- Islamic
- Arabic
- American
- Southern European
- Asian
- Other - please specify [field]

What is your annual household income? Please estimate in British pounds. [dropdown]

- 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 - £150,000
- More than £150,000

Appendix C: Follow-up survey – Survey items

Items - Measurement of the construal level of psychological distance

Response category width (RCW) (= value (b) – value (a)):

The Intergovernmental Panel on Climate Change (IPCC) expects irreversible consequences of climate change around the year 2040 if the current rate of warming continues. What do you think ...

a) ... is the earliest possible time when irreversible consequences of climate change will occur if no drastic measures are taken against them? *(10-point scale; today, from 2030, from 2040, from 2050, from 2060, from 2070, from 2080, from 2090, from 2090+, never)*

b) ... is the latest possible time when irreversible consequences of climate change will occur if no drastic measures are taken against them? *(10-point scale; today, from 2030, from 2040, from 2050, from 2060, from 2070, from 2080, from 2090, from 2090+, never)*

Psychological distance to climate change (1): To me, climate change feels very close … very distant (7-point scale; 1=very close, 7=very distant)

Psychological distance to climate change (2): To me, climate change feels like tomorrow … like thousands of years away (7-point scale; 1=tomorrow, 7=thousands of years away)

Items - Measurement of time precision

Response category width (see above)

Timing precision certainty of starting point of category width scale item:

You have indicated that you expect irreversible climate-related impacts to occur at the earliest [answer to RCW question a)]. How certain are you about this date ([answer to RCW question a)])? *(Please indicate your answer on the following scale: 0 means: completely uncertain, 7 means: completely certain. You can use the values in between to indicate where you lie on the scale.)*

Items - Measurement of future orientation

Consideration of Future Consequences (CFC):

To what extent are the following statements characteristic of or true for you? Please read each statement carefully and choose the number that corresponds to your answer. *(7-point likert scale; 1=not at all characteristic for me; 2=uncharacteristic for me; 3=; 4=neither; 5=; 6=characteristic for me; 7=very characteristic for me)*

- I think about what the future might look like and try to influence it with my daily behaviour. (α = .75)
- I act only to satisfy immediate needs and believe that the future will take care of itself. (α = .72)
- I believe that it is mostly unnecessary to do without something at present, as one can take care of future consequences later. (α = .76)
- I act only to satisfy immediate needs and believe that I will take care of any problems that may arise later. (α = .73)
- When I make a decision, I think about how it might affect me in the future. (α = .75)
- My behaviour is generally influenced by future consequences. (α = .76)

Items - Measurement of certainty and hope regarding climate change

Degree of possible climate change mitigation:

How much do you think very severe climate-related impacts can be mitigated in Central Europe? *(Please indicate your answer on the following scale: 0 means: not at all, 7 means: completely. You can use the values in between to indicate where you lie on the scale.)*

Certainty of irreversible climate consequences:

How likely do you think it is that very severe, irreversible climate-related consequences will occur in Central Europe in the next few decades? (*Please indicate your answer on the following scale: 1 means: extremely unlikely, 7 means: extremely likely. You can use the values in between to indicate where you lie on the scale.)*

Emotions with regard to climate change:

When you think about climate change and all the things you associate with it: How strongly does it trigger the following feelings in you? *(Please indicate your answer on the following scale: 0 means: not at all, 7 means: very much. You can use the values in between to indicate where you lie on the scale.)*

Hope, Optimism, Discouragement, Hopelessness, Fear

As the climate scenario text also talks about the benefits of tree planting, items related to construal level theory, time precision, certainty and emotions, and efficacy were also asked in relation to tree planting (e.g., “How much do you think climate-related risks in Central Europe can be mitigated by planting a large number of trees around the world?”). We identify no statistically significant differences between the two treatments for any of the proposed mechanisms.

Essay 3: The benefits of less: The effect of sufficiency gain framing on consumption reduction

Manuel Suter, Simon Rabaa, Andrea Essl*

Abstract

Sufficiency strategies aimed at reduced production and consumption levels have a high potential to help combat environmental issues. There is limited knowledge on how to promote voluntary sufficiency behaviors at the individual level. In an online experiment with participants from the United States (n = 1,317), we examine the effect of providing information about different sufficiency benefits to nature, society, or the individual on sufficiency behavior. Sufficiency behavior was measured by participants' voluntary consumption reduction in an incentivized task. The results show that the individual sufficiency gain framing leads to significantly less consumption compared to a neutral control group. Informing about individual sufficiency benefits, such as more free time and better mental health, may be fruitful in promoting sufficiency behavior.

Keywords: *Sufficiency; Consumption reduction; Pro-environmental behavior; Laboratory experiment, Sufficiency gain framing*

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* Manuel Suter, Institute for Organization and HRM, University of Bern, Bern, Switzerland, email: manuel.suter@unibe.ch; Simon Rabaa, Chair of Environment and Economics, ESCP Business School, Berlin, Germany, email: srabaa@escp.eu; Andrea Essl, Institute for Organization and HRM, University of Bern, Bern, Switzerland, email: andrea.essl@unibe.ch;

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3.1 Introduction

Human activity leads to global warming, the degradation of ecosystems, and the mass extinction of species, thereby risking to destroy the livelihood of present and future generations (IPBES, 2019; IPCC, 2022; O'Neill et al., 2018; Rockström et al., 2009). The consumption of goods and services is one of the main drivers of natural resource use and the associated negative environmental impacts (Ivanova et al., 2016; Wiedmann et al., 2020). Current sustainability endeavors largely rely on efficiency strategies which aim to reduce resource use and emissions per product unit. Due to rebound effects, increased efficiency often does not lead to the expected absolute reductions in resource use and emissions, and thus may be inadequate in adhering to the boundaries set by our planet (Alexander & Rutherford, 2019; Brockway et al., 2021; Haberl et al., 2020). Consequently, significantly reducing environmental impacts requires a change in consumption patterns.

Sustainability strategies that focus on sufficiency may serve as a complementary approach to efficiency. Sufficiency is about a reduction in production and consumption to lessen negative environmental impact and aims to shift human behavior (Princen, 2005). It is discussed as a means to bring human activities within ecological limits and as an end in itself, promising a more satisfying life (Jungell-Michelsson & Heikkurinen, 2022). The idea of sufficiency fundamentally questions the prevailing notion that economic growth, which is strongly related to increasing the production and consumption of goods, leads to more well-being. This makes sufficiency a sensitive topic that may provoke negative reactions, which makes an appropriate communication important (Kurz, 2019; Sandberg, 2021). So far, policy campaigns by governments and non-profit organizations have had little success in changing consumer behavior toward sufficiency (Tröger & Reese, 2021; Zell-Ziegler et al., 2021). Therefore, a better understanding of how to promote a sufficiency lifestyle can help address environmental challenges. In this paper, we experimentally examine whether information about sufficiency benefits affects voluntary reduction in product consumption measured by an incentivized decision task.

Most experimental studies promoting behaviors that lead to direct reductions in resource use have focused on household energy conservation behavior (Andor & Fels, 2018). There are only a few experimental studies on reducing product consumption, which are primarily based on self-reports (e.g., Frick et al., 2021). The two studies most closely related to our research have used self-reports to experimentally examine whether highlighting sufficiency gains affects intentions or willingness to reduce consumption (Balderjahn & Appenfeller, 2023; Herziger et al., 2020). While both of these studies suggest that self-interested motives might have a more powerful behavioral impact than environmental arguments, Tomaselli et al. (2021) find no effect of different messages about the environmental and individual gains of transitioning to a post-growth economy on attitudes toward economic growth. Due to the small number of experimental studies on reducing product consumption, inconclusive results on

sufficiency gain frames, and the lack of studies measuring actual behavior, more research is needed to understand the effectiveness of communicating different sufficiency benefits in encouraging voluntary consumption reduction.

In a between-subject online experiment with participants from the United States (n = 1,317), we examine the effect of communicating different sufficiency benefits to nature, society, and the individual on voluntarily waiving consumption. The experiment consists of three experimental treatments and one control condition. In the NATURE treatment participants received a text that informed about benefits of sufficiency behavior to nature (e.g., ”Forests and moors could be protected, which would save more plant and animal species from extinction.”). The SOCIETY treatment focused on sufficiency benefits to society (e.g., “We could focus more on the well-being of those around us and look out for each other, leading to a more balanced and caring society.”), while the INDIVIDUAL treatment concentrated on sufficiency benefits to the individual (e.g., “You could focus on non-material things such as taking a walk in nature, cultivating social contacts or a sense of purpose, that make you happy in the long run.”). In the CONTROL condition, participants received a neutral text. Our main outcome variable is the individual consumption level, as measured by an incentivized decision task. In particular, participants were offered a 1.50 USD Amazon voucher and had to decide whether to keep it or refrain from all or parts of it by donating to a project fostering reduced consumption. Therefore, this incentivized decision task represents a trade-off between a consumption option and the promotion of a sufficiency lifestyle. In addition, we assessed sufficiency policy support and green behavioral intentions as secondary outcome variables.

The results suggest that communicating sufficiency benefits to the individual leads to significantly less consumption than in the neutral control group. The significant effect of the individual sufficiency gain treatment persists within subgroups characterized by a rather liberal, left-leaning political ideology, an annual income above 60,000 USD, or an education level of a bachelor’s degree or higher, but not in the respective opposite groups. Exploratory analyses, using sampling weights to enhance the representativeness and generalizability of our treatment effects to the US population, show that both the INDIVIDUAL and SOCIETY treatments have a statistically significant impact on consumption reduction compared to the control group. We do not find any significant differences between the control group and the NATURE treatment. Furthermore, none of the treatments shows a significant effect on sufficiency policy support or green behavioral intentions. According to these results, informing about benefits of sufficiency lifestyles for individual well-being such as more free time and better mental health may prove most fruitful in promoting sufficiency behavior, especially among individuals with a rather liberal, left-leaning political ideology, higher income, and higher level of education. These insights are relevant for organizations and policy makers who seek to foster sufficiency behavior.

We argue that the value of our paper is threefold: First, experimental research on sufficiency behaviors aimed at directly reducing resource use has mainly focused on household energy and water

conservation behavior in the field (Andor & Fels, 2018; V. L. Chen et al., 2017; Günther et al., 2020). However, sufficiency requires reductions in all types of consumption. We contribute to the limited experimental literature dealing with reductions in product consumption. Second, little research has focused on the effect of communicating sufficiency gains on voluntary consumption reduction. Our study seems to be the first that distinguishes between information about sufficiency gains for nature, society, and the individual. In particular, we examine whether and which of these pieces of information affect voluntary consumption reduction. Third, studies analyzing consumption reduction of products are mostly qualitative or used self-reports to measure sufficiency behaviors and are thus unable to assess the impact on actual behavior. We make a methodological contribution by introducing a new incentivized task to measure the level of refraining consumption in the laboratory or online. To the best of our knowledge, there are no comparable tasks that measure actual sufficiency behavior with real consequences in an incentivized way. Therefore, this measure is an important complement to self-reported sufficiency measures (e.g., Homar & Cvelbar, 2021; Lades et al., 2021).

3.2 Related literature and hypotheses

Sufficiency is about reducing production and consumption to minimize the environmental impact of human activities and thereby respect planetary boundaries (Figge et al., 2014; Princen, 2005). While much of the literature addresses the need to implement sufficiency to stay within planetary boundaries (e.g., Cordroch et al., 2022; Haberl et al., 2020), several studies also discuss what sufficiency lifestyles look like (e.g., Bocken & Short, 2016; Kropfeld et al., 2018) as well as the barriers to adoption (e.g., Sandberg, 2021; Tröger & Reese, 2021). Accordingly, sufficiency is also related to questions about individual and societal needs and wants, and the conditions for a good life (O'Neill et al., 2018; Schneidewind & Zahrnt, 2014). The debate revolves around possible behavioral change toward reduced individual consumption and questioning the capitalist norm of ever-greater consumption as the path to happiness and life satisfaction (O'Neill et al., 2018). In this context, sufficiency is related to various movements such as anti-consumerism (Whitmarsh et al., 2017), voluntary simplicity (Alexander & Ussher, 2012; Rich et al., 2020), frugality (Kropfeld et al., 2018), or minimalism (Herziger et al., 2020).

Besides mitigating environmental harm (e.g., Ivanova et al., 2016; Wiedmann et al., 2020), sufficiency lifestyles offer potential benefits to individuals and societies, especially in the Global North. Refraining from consumption enables individuals to perceive a stronger sense of authenticity (Zavestoski, 2002), to reduce the risk of falling into debt (Nepomuceno & Laroche, 2015), to be better able to self-express (Black & Cherrier, 2010), to be happier (Alexander & Ussher, 2012; Hüttel et al., 2020), and to have a higher life satisfaction (Boujbel & d'Astous, 2015; Kuanr et al., 2020). On a societal level, sufficiency may enhance societal well-being in consumer nations (Hüttel et al., 2020), ensure social justice (Muller, 2009), improve health (Workman et al., 2019), and indirectly inhibit zoonotic disease outbreaks (Ellwanger et al., 2020). Thus, implementing sufficiency lifestyles in the Global North

offers a pathway to simultaneously reduce ecological impact and enhance individual and societal welfare (Chancellor & Lyubomirsky, 2011).

The prevailing consumerist culture in the Global North stands out as a significant barrier to sufficiency behavior (Sandberg, 2021). Consumers may be hindered to deviate from the prevailing consumption patterns due to internalized norms or feelings of not meeting their own desires or expectations from others (Joyner Armstrong et al., 2016). For example, consumers seek prestige and status through owning the latest goods and gadgets (Bocken & Short, 2016). These barriers may provoke negative reactions toward sufficiency since it contradicts people's deeply internalized "more is better" mindset (Tröger & Reese, 2021). Therefore, how sufficiency is presented is crucial for promoting sufficiency behavior (Gossen et al., 2019).

There are studies that show that framing pro-environmental behaviors as a sacrifice might not be effective to convince people to adopt them. For example, Gifford and Comeau (2011) show that motivational messages (e.g., "We help solve climate change when we take transit, compost, or buy green energy") lead to higher pro-environmental intentions than sacrifice messages (e.g., "I am going to have to get used to driving less, turning off the lights, and turning down the heat"). In a similar vein, Nolan and Tobia (2019) find that polling questions asking about a financially costly climate change policy when the goal of the policy is to create efficient technologies (e.g., "Require that all gasoline be formulated to produce lower emissions even if it adds an additional cost of five cents to the price of gasoline") received more support than when the goal is to curtail behavior (e.g., "Adding an additional cost of five cents to the price of gasoline so people either drive less, or buy cars that use less gas"). Taken together, these studies show that if pro-environmental behavior is presented as sacrifice, pro-environmental intentions and support for environmental policy measures are relatively low.

Fruitful tools for motivating people to refrain from consumption include interventions such as moral appeals (S. Chen et al., 2022), social comparison feedback (Kim & Kaemingk, 2021), and informing about health impacts (V. L. Chen et al., 2017). Few experimental studies have explored how emphasizing sufficiency benefits affects self-reported indicators of reduced product consumption. Balderjahn and Appenfeller (2023) demonstrate that communicating a social norm with regard to personal benefits (i.e., "Increasingly more people say they are happy and satisfied with consuming less.") significantly reduces consumption intentions, while communicating a social norm with an environmental benefit (i.e., "Increasingly more people say they consume less to protect the environment.") does not (Balderjahn & Appenfeller, 2023). Similarly, Herziger et al. (2020) found that showing videos about minimalism increased participants' willingness to reduce consumption more when presented with an egoistic appeal (e.g., reducing stress) than when introduced with a biospheric appeal (e.g., reducing carbon emissions). Tomaselli et al. (2021) found no effect of different messages regarding environmental gains, environmental losses, well-being gains, and well-being losses on attitudes toward moving to a post-growth economy. While the above interventions are promising, they

leave a gap in understanding whether and which sufficiency gain frames influence actual product consumption reduction.

Our study aims to investigate whether text framings emphasizing sufficiency gains for nature, society, and the individual can effectively promote voluntary product consumption reduction. The three selected dimensions nature, society, and individual roughly correspond to the three "disciplinary roots" of the sufficiency concept (Jungell-Michelsson & Heikkurinen, 2022): First, ecological economics with the idea of complementarity of capital and limitations to economic growth. Second, political ecology with the idea of creating a just social metabolism that meets the needs of all humanity. Third, ecological philosophy with considerations of non-material values and self-restraint as a path to greater well-being, as well as altruistic motivations to engage in sufficiency behavior.

As with other pro-environmental behaviors (Homar & Cvelbar, 2021; Jacobson et al., 2019; Segev et al., 2015), information about the benefits to nature may also encourage to refrain from consumption. Although Balderjahn and Appenfeller (2023) and Herziger et al. (2020) found no effect of promoting sufficiency through environmental motivation, communicating specific benefits of reducing consumption to the planet can make people aware of the positive effects of their actions. In addition, explaining sufficiency gains for nature may activate other-regarding preferences, i.e., considering the well-being of plants and animals or nature as a whole (Heinz & Koessler, 2021). A well-established stream of research has found that other-regarding preferences are positively related with pro-environmental behavior (Dietz et al., 2005; Schultz & Zelezny, 1999). Therefore, we hypothesize that informing about sufficiency gains for nature leads participants to refrain from a higher amount of consumption than not informing about sufficiency gains (Hypothesis 1).

Research has also shown that emphasizing societal outcomes, rather than solely focusing on the impact of environmental issues on nature, can be fruitful to motivate pro-environmental behavior (Klein et al., 2022; Sapiains et al., 2016). Similar to highlighting outcomes for nature, highlighting societal issues can activate other-regarding preferences, i.e., giving up own resources to the benefit of others (Fehr & Schmidt, 2006; Heinz & Koessler, 2021). One channel through which other-regarding interventions can work is by enlarging the moral circle. As the number of entities considered to have moral value increases, the willingness to protect these entities even at one's own expense increases (Crimston et al., 2016). Accordingly, we hypothesize, that informing about sufficiency gains for society leads participants to refrain from a higher amount of consumption than not informing about sufficiency gains (Hypothesis 2).

Pro-environmental behavior can also be promoted by focusing on individual gains. Literature has documented that interventions addressing self-regarding preferences, e.g., focusing on individual gains or economic incentives, are an effective way to promote pro-environmental intentions (Czap et al., 2015; Hafner et al., 2019). In contrast to other-regarding preferences, self-regarding preferences aim to

maximize self-interest (Fehr & Schmidt, 2006; Heinz & Koessler, 2021). Communicating that a happy and satisfying life with less consumption is possible has been shown to reduce the intention to purchase (Balderjahn & Appenfeller, 2023; Herziger et al., 2020). Thus, informing about individual benefits of a lifestyle with less focus on consumption may also be a powerful tool to motivate actual sufficiency behavior (Tröger & Reese, 2021). Therefore, we hypothesize, that informing about sufficiency gains for individuals leads participants to refrain from a higher amount of consumption than not informing about sufficiency gains (Hypothesis 3).

3.3 Online experiment

3.3.1 Experimental design and procedure

We conducted a between-subject online experiment to examine the effect of communicating different sufficiency gains on sufficiency behavior conceptualized as waiving consumption in the form of an Amazon voucher.[17] The study was pre-registered on the platform aspredicted.org (#107289)[18] and obtained ethical approval from the Faculty of Business Administration, Economics and Social Sciences of the University of Bern (serial number: 222022).

The experiment involves a control group and three experimental groups called NATURE, SOCIETY, and INDIVIDUAL treatment. The experimental treatments distinguish in terms of the kind of sufficiency gains described in a text: sufficiency gains through reduced consumption for NATURE (e.g., "By solving the problem of waste pollution, the land, the sea, and the air would be cleaner."), for SOCIETY (e.g., "We as society would be safer from resource conflicts because more people could benefit from the available natural resources."), or for the INDIVIDUAL person (e.g., "You could become more independent of material goods and thus experience a higher sense of satisfaction."). For all three experimental treatments, four different benefits were mentioned and the scientific sources for the benefits were given below the texts. The control group received a text about an artwork unrelated to consumption, nature, society, and the individual. The texts of the experimental groups as well as the one of the control group can be found in the supplementary material.

In the first part of the study, participants were asked to read the text about possible gains enabled through reduced consumption (experimental groups) or about artwork (control group). Depending on the experimental treatment, the text mentioned sufficiency gains for nature, society, or the individual. To ensure that the participants read the text carefully, they had to answer a control question that asked them to identify a sufficiency benefit mentioned in the text. Participants who did not answer the control

[17] Experimental instructions and survey questions are available in the online supplementary material.

[18] Pre-registration can be found here: https://aspredicted.org/CJ6_NWJ

question correctly were instructed to read the text and answer the control question again. Participants who did not answer the control question correctly the second time were excluded from the main sample.

In the second part of the study, we used an incentivized decision task to measure participants' sufficiency behavior. Participants were offered a 1.50 USD Amazon voucher and had to decide whether to keep the 1.50 USD for themselves or refrain from all or parts of it by donating to a sufficiency project.[19] The amount of the voucher they refrained from measures sufficiency behavior and serves as the primary outcome of the experiment. For example, choosing 1.30 USD Amazon voucher resulted in a donation of 0.20 USD to a sufficiency project. Participants had to indicate in a text field how much of the 1.50 USD they want to keep for themselves and in a further text field the amount they want to donate. Entries were only accepted in increments of 0.10 USD, giving them 16 options and the total had to add up to 1.50 USD. Participants were informed that their decision would have actual consequences and they were given the opportunity to receive a confirmation email for the donation to the organization. Subsequently, we measured sufficiency policy support and green behavioral intentions as secondary outcome variables. Sufficiency policy support was measured with four items from Harring et al. (2017) and one self-formulated item (Cronbach's alpha = 0.74). Participants could indicate their support for a policy such as "Impose consumption taxes on polluting consumption" on a 5-point Likert scale ranging from 1 (a very bad suggestion) to 5 (a very good suggestion). Green behavioral 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). The reliability of the measure was good (Cronbach's alpha = 0.84).

In the third part of the study, we measured the psychological distance to sufficiency benefits, sufficiency orientation, perceived effectiveness of reduced consumption, and demographic variables. An adapted scale from Brügger et al. (2016) was used to measure the perceived psychological distance to the benefits of reduced consumption. Participants could indicate for five different kinds or formulations of psychological distance how close the benefits of a reduced consumption feel for them (e.g., very close (1) to very distant (7) or very real (1) to very hypothetical (7)) (Cronbach's alpha = 0.92). Next, we measured sufficiency orientation with a 5-point Likert scale from Tröger et al. (2021) (Cronbach's alpha = 0.87). Participants indicated how strongly they agree or disagree with 13 different statements. Subsequently, participants were asked to indicate how effective they consider reduced

[19] The organization is based in Switzerland and called ökozentrum. They promote various projects that aim to increase sufficiency. In one project, they conducted workshops with tourism businesses to show how sufficiency can be implemented in tourism and how this can be promoted to consumers. The reason for this donation was to offer participants a legitimate alternative use for the waived money. This enabled to exclude that participants take the voucher because they fear that our research team might spend the money on consumption. However, in the instructions, the participants were neither given the additional information about the organization nor any specific sufficiency projects to keep the focus on the Amazon voucher.

consumption to increase the well-being of the stakeholder mentioned in their treatment (i.e., nature, society, or individual person). Participants in the control treatment were asked how effective they consider reduced consumption to increase planetary and human well-being (4-point Likert scale ranging from "very effective" to "not effective at all"). Reduced consumption was considered effective or very effective to increase the well-being benefits mentioned by 92% in the NATURE, INDIVIDUAL, and CONTROL group, and by 90% in the SOCIETY treatment. These high rates underline that the participants accept the information presented in the text.[20] Finally, the demographic variables gender, age, education, political ideology, and the household income were collected.

The experiment was conducted online on the crowdsourcing platform Amazon Mechanical Turk (MTurk) from September 21 to September 27, 2022. Experimental sessions lasted on average 6 minutes, with a flat payment of 0.50 USD per participant. The mean additional payment for the decision task was 0.91 USD in form of an Amazon voucher (range: 0 to 1.50 USD, SD = 0.42). Participants gave on average 0.59 USD to the sufficiency project resulting in total donations of 949.60 USD.

3.3.2 Sample characteristics

Given our interest in analyzing sufficiency behavior within a consumerist culture, we chose participants from the United States, where consumerism is widespread. We aimed for a final sample of 1,400 participants, with 350 in each condition. This enables to detect an effect of Cohen's d of 0.2 with an error probability of 0.05 and a power of 0.80 (based on a two-sided Wilcoxon-Mann-Whitney test). Due to the exclusion criteria, we planned to recruit 1,600 completed surveys.

[20] Participants in the INDIVIDUAL treatment rated the effectiveness of consumption reduction as to increase their own well-being significantly higher than participants in the SOCIETY treatment did related to the well-being of society ($p = 0.018$). However, no other significant differences were found between treatments regarding the perceived effectiveness of sufficiency measures.

Table 3.1. Socio-demographic characteristics of the main sample.

Variables	Total sample	CONTROL	NATURE	SOCIETY	INDIVIDUAL	Group comparisons
Gender (% female)	53.00	59.46	53.85	48.96	49.85	$p = 0.027$
Mean age in years	32.09 (9.57)	32.09 (9.25)	32.58 (10.18)	31.96 (9.70)	31.74 (9.17)	$p = 0.729$
Income						$p = 0.471$
% less than 10,000 USD	3.95	4.20	4.49	3.58	3.56	
% 10,000 - 19,999 USD	2.28	1.80	3.53	1.79	2.08	
% 20,000 - 29,999 USD	5.62	5.41	4.17	5.67	7.12	
% 30,000 - 39,999 USD	5.24	6.61	5.45	5.37	3.56	
% 40,000 - 49,999 USD	10.78	9.61	11.86	8.96	12.76	
% 50,000 - 59,999 USD	35.23	32.73	37.82	35.82	34.72	
% 60,000 - 69,999 USD	11.31	10.51	9.62	12.24	12.76	
% 70,000 - 79,999 USD	9.26	7.81	9.62	9.55	10.09	
% 80,000 - 89,999 USD	4.71	7.81	9.62	9.55	10.09	
% 90,000 - 99,999 USD	4.10	6.91	2.56	4.18	2.67	
% 100,000 - 149,999 USD	6.07	8.41	5.13	5.97	4.75	
% More than 150,0000 USD	1.44	1.20	0.96	1.49	2.08	
Education						$p = 0.218$
% Less than high school, high school, or equivalent to high school	13.41	16.57	11.61	13.77	11.61	
% Associate's or bachelor's degree	69.28	69.28	70.32	66.17	71.43	
% Master's degree or higher	17.30	14.16	18.06	20.06	16.96	
Political ideology						$p = 0.981$
% Liberal to somewhat conservative	48.75	49.25	47.44	48.36	49.85	
% Conservative and very conservative	49.20	49.25	50.32	49.25	48.07	
% None	2.05	1.50	2.24	2.39	2.08	
Observations	1,317	333	312	335	337	

Note. The table reports means and standard deviations for continuous variables and percentage frequencies for categorical variables for each group of the experiment. Standard deviations are given in parentheses. Female is a binary variable taking a value of 1 for women and 0 for men, non-binary and other individuals. For categorical variables the results of Chi-squared test comparisons are given and for continuous variables the results of one-way analyses of variance (one-way ANOVA).

We collected 1,611 completed surveys. In accordance with the pre-registered protocol, participants were excluded who did not complete the survey within 30 minutes of starting (n = 2), who completed the survey faster than two standard deviations from the average completion time (n = 0), who failed the attention check (n = 128), and who incorrectly answered the control question more than once (n = 203). The exclusion criteria reduced the main sample to 1,317 subjects (53% female; mean age: 32 years, SD

= 9.57). [21] Out of these subjects, 312 received the NATURE treatment, 335 the SOCIETY treatment, 337 the INDIVIDUAL treatment, and 333 the CONTROL condition. In Table 3.1 we provide an overview of the mean values of the demographic variables for each of the three experimental groups and the CONTROL group. Randomization between the groups was successful for all variables considered, except for gender, which we control for in the analysis.

3.4 Results

3.4.1 Effect of sufficiency gain framing on consumption level

First, we investigate whether information about different sufficiency benefits to nature, society, or the individual leads to more sufficiency behavior conceptualized as waiving consumption in the form of an Amazon voucher. Fig. 3.1 displays the distribution of the voucher waived. Of the 1.50 USD Amazon voucher provided, participants in the CONTROL group waived on average 0.57 USD (SD = 0.42, SE = 0.02). Participants in the NATURE treatment waived on average 0.56 USD (SD = 0.41, SE = 0.02), participants in the SOCIETY treatment waived on average 0.59 USD (SD = 0.44, SE = 0.02), and participants in the INDIVIDUAL treatment waived on average 0.63 USD (SD = 0.42, SE = 0.02). The difference between the CONTROL and the INDIVIDUAL treatment results in an effect size of Cohen's d of 0.15. The difference between the INDIVIDUAL and the CONTROL treatment (H_3) is statistically significant at the 5-percent level (two-sided Mann-Whitney rank sum test: z = -2.21, p = 0.027). Additionally, there is a statistically significant difference at the 10% level between the INDIVIDUAL and NATURE treatments (INDIVIDUAL vs. NATURE: z = -1.878, p = 0.060). However, there are no statistically significant differences between the NATURE and the CONTROL treatment (H_1) (z = -0.23, p = 0.816), between the SOCIETY and the CONTROL treatment (H_2) (z = -0.61, p = 0.541), and between the other experimental treatments (INDIVIDUAL vs. SOCIETY: z = -1.585, p = 0.113; NATURE vs. SOCIETY: z = -0.367, p = 0.713).

[21] There are overlaps regarding participants who did not complete the survey within 30 minutes of starting and who failed the attention check (n = 1), who did not complete the survey within 30 minutes of starting and who incorrectly answered the control question more than once (n = 2), who failed the attention check and who incorrectly answered the control question more than once (n = 37), who did not complete the survey within 30 minutes of starting and failed the attention check (n = 1) and incorrectly answered the control question more than once (n = 1).

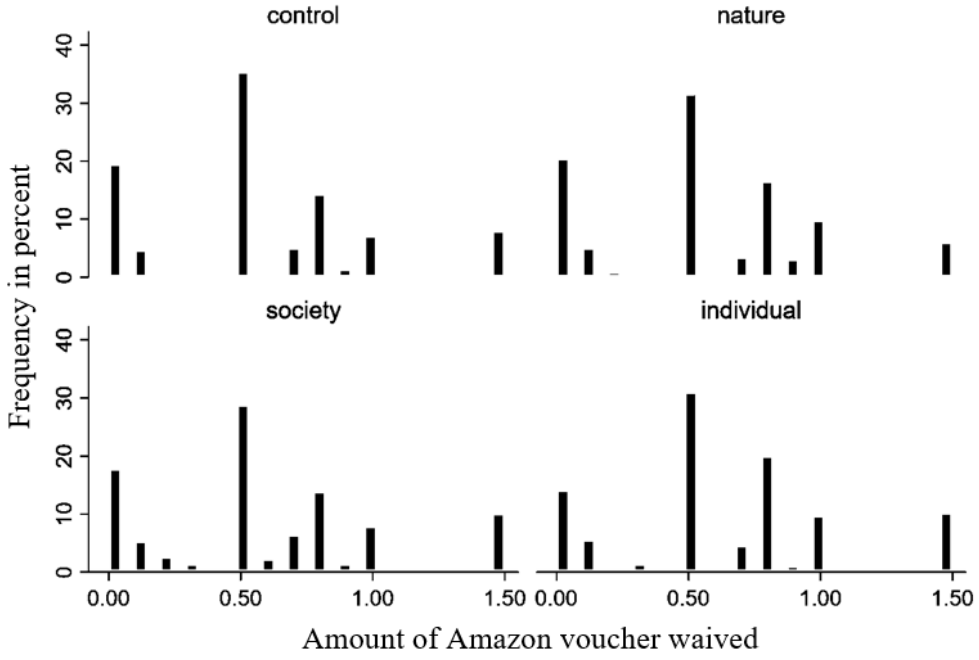

Fig. 3.1. Distribution of the amount of Amazon voucher waived by experimental treatments

OLS regression modeling reveals the stability of the results and shows additional factors influencing the amount of voucher waived (Table 3.2). Compared to the control group, only the INDIVIDUAL treatment has a consistently statistically significant positive influence on the amount of voucher waived. The INDIVIDUAL treatment effect remains on the same significance level and the magnitude of the coefficient slightly increases when controlling for sociodemographic variables (Specification 2). Females and older people show significantly higher levels of sufficiency behavior, whereas education, income, and a conservative ideology are not significantly associated with the amount of voucher waived. The finding that women generally show more sufficiency behavior than other genders combined with the fact that there are significantly more women in the CONTROL than in the INDIVIDUAL group (Pearson $\chi^2(1) = 6.24$, $p = 0.013$; see also Table 3.1), suggests that the treatment effect is larger than estimated in the hypothesis test. Specification 3 additionally includes sufficiency orientation, perceived psychological distance to sufficiency benefits, and perceived effectiveness of reduced consumption. Not surprisingly, sufficiency orientation and the assessment that the sufficiency gains are effective in reducing consumption are both significantly related to a higher amount of voucher waived. The positive correlation between the amount of voucher waived and participant's sufficiency orientation can be seen as an indicator that we have developed a valid incentivized task to measure sufficiency behavior (Pearson correlation coefficient; $r = 0.12$, $p < 0.001$). Psychological distance has no significant effect on the amount of voucher waived.[22] Taking together, the regression results provide considerable indication

[22] Note that the low R-squared is common for behavioral experimental studies in economics (e.g., Buser & Dreber, 2015; Cohn et al., 2017) and text framing experiments in environmental behavioral science (Asensio & Delmas, 2015; Bilandzic et al.,

for a significant positive effect of the INDIVIDUAL treatment on sufficiency behavior compared to the control group (H_3).

2017). This phenomenon is observed in randomized controlled trials in general. The reason is that due to the randomization, covariates are orthogonal to the treatment indicator.

Table 3.2. Effect of sufficiency gain framing on the amount of voucher waived: OLS regression results.

	Amount of voucher waived (1)	Amount of voucher waived (2)	Amount of voucher waived (3)
NATURE	-0.004	0.006	0.008
	(0.033)	(0.033)	(0.033)
SOCIETY	0.019	0.029	0.030
	(0.033)	(0.033)	(0.032)
INDIVIDUAL	0.065**	0.081**	0.082**
	(0.033)	(0.033)	(0.032)
Female		0.063***	0.054**
		(0.024)	(0.024)
Age in years		0.005***	0.005***
		(0.002)	(0.002)
Education			
Associate's or bachelor's degree		-0.056	-0.065
		(0.049)	(0.049)
Master's degree or higher		-0.061	-0.062
		(0.053)	(0.054)
Income			
10,000 - 19,999 USD		-0.043	-0.058
		(0.121)	(0.120)
20,000 - 29,999 USD		-0.051	-0.041
		(0.091)	(0.092)
30,000 - 39,999 USD		-0.072	-0.056
		(0.091)	(0.092)
40,000 - 49,999 USD		-0.067	-0.057
		(0.076)	(0.078)
50,000 - 59,999 USD		0.092	0.102
		(0.074)	(0.075)
60,000 - 69,999 USD		0.120	0.113
		(0.078)	(0.079)
70,000 - 79,999 USD		-0.069	-0.069
		(0.084)	(0.084)
80,000 - 89,999 USD		-0.045	-0.030
		(0.091)	(0.092)
90,000 - 99,999 USD		0.132	0.137
		(0.105)	(0.106)
100,000 - 149,999 USD		0.088	0.122
		(0.093)	(0.093)
More than 150,000 USD		0.062	0.062
		(0.155)	(0.157)
Political ideology			
Conservative and very conservative		-0.012	-0.013
		(0.027)	(0.027)
None		0.079	0.074
		(0.124)	(0.124)
Sufficiency orientation			0.098***
			(0.024)
Psychological distance			-0.009
			(0.007)
Assessment of treatment effectiveness			
Not very effective			0.145
			(0.110)
Effective			0.205**
			(0.094)
Very effective			0.133
			(0.098)
Constant	0.568***	0.393***	-0.110
	(0.023)	(0.087)	(0.146)
Observations	1,317	1,312	1,312
R-squared	0.004	0.048	0.075
F-test *p*-value	0.139	0.016	0.000

Note. The table presents ordinary least squares estimates. Robust standard errors are in parentheses. The dependent variable is the amount of Amazon voucher waived. The reference group for the treatments (NATURE, SOCIETY, INDIVIDUAL) is the CONTROL group. Female is a binary variable taking a value of 1 for women and 0 for men and non-binary and other individuals. The reference group for the education variable are participants with a level of education below that of a bachelor's or associate's degree. The reference category for the income variable is "less than 10,000 USD". The reference category for political ideology is "very liberal to somewhat conservative". Sufficiency orientation is measured on a 5-point scale, with higher numbers indicating a higher sufficiency orientation. Psychological distance is measured on a 7-point scale, with higher numbers indicating a higher psychological distance. The reference category for the perceived effectiveness of reduced consumption to increase the well-being of the stakeholder mentioned in the treatment is "not effective at all". 5 observations are omitted because of missing observations from the non-required responses on education. *, **, and *** document significance at the 10%, 5%, and 1% levels, respectively.

3.4.2 Effect of sufficiency gain framing on pro-environmental intentions and sufficiency policy support

We also measured the effect of the experimental treatments on sufficiency policy support and green behavioral intentions. Fig. 3.2 displays the distribution of sufficiency policy support and green behavioral intentions by experimental treatment. Table 3.4 in the Appendix reports means and standard deviations of these secondary outcome variables for each treatment group. According to Mann Whitney rank sum tests, the experimental treatments do not differ statistically significantly from the control group, neither with regard to sufficiency policy support nor green behavioral intentions (see Table 3.4 in the Appendix). Table 3.3 presents OLS regression estimates, confirming the descriptive findings.[23]

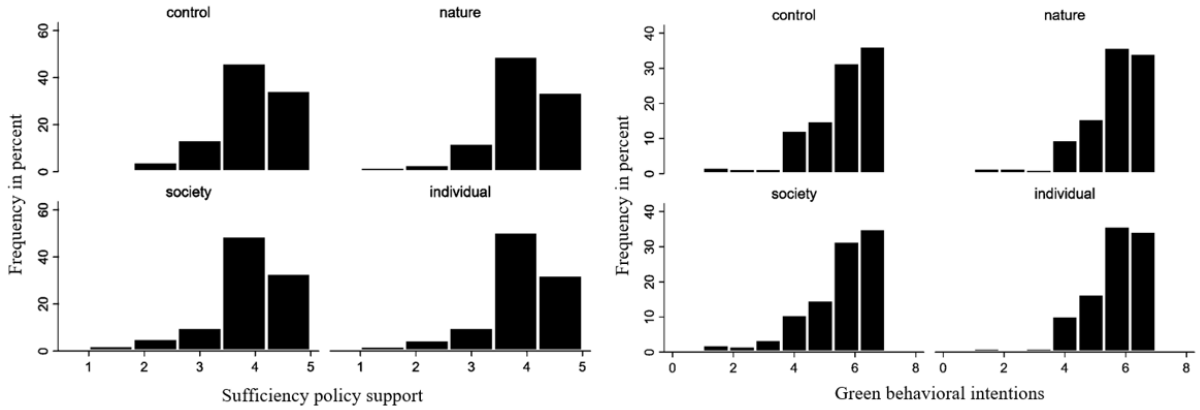

Fig. 3.2. Distribution of sufficiency policy support and green behavioral intentions by experimental treatment

[23] In addition, we ran OLS regressions for each sufficiency policy and green behavioral intention item. We find no significant treatment effects except a marginal significant positive effect of the NATURE treatment on policy support for policy 3 ("Work more actively to ban environmentally hazardous products") and a marginal significant negative effect of the SOCIETY treatment on the green intention item 2 ("I intend to engage in environmentally friendly behaviour in the forthcoming month."). The OLS regression estimates for sufficiency gain framing on sufficiency policy support items can be found in Table 3.5 of the Appendix and those for sufficiency gain framing on green behavioral intentions items in Table 3.6 of the Appendix.

Table 3.3. Effect of sufficiency gain framing on sufficiency policy support and green behavioral intentions: OLS regression results.

	Sufficiency policy support		Green behavioral intentions	
	(1)	(2)	(3)	(4)
NATURE	0.028	0.027	0.027	0.018
	(0.057)	(0.040)	(0.091)	(0.062)
SOCIETY	-0.007	-0.021	-0.068	-0.072
	(0.055)	(0.040)	(0.095)	(0.065)
INDIVIDUAL	0.026	-0.004	0.098	0.040
	(0.055)	(0.040)	(0.086)	(0.062)
Female		0.028		0.036
		(0.029)		(0.046)
Age in years		-0.003		0.003
		(0.002)		(0.003)
Education				
Associate's or bachelor's degree		0.067		0.170*
		(0.062)		(0.101)
Master's degree or higher		0.172**		0.220*
		(0.068)		(0.113)
Income				
10,000 - 19,999 USD		0.017		-0.089
		(0.150)		(0.237)
20,000 - 29,999 USD		-0.111		0.002
		(0.125)		(0.181)
30,000 - 39,999 USD		-0.011		-0.081
		(0.117)		(0.193)
40,000 - 49,999 USD		-0.082		0.037
		(0.109)		(0.167)
50,000 - 59,999 USD		0.057		0.101
		(0.104)		(0.161)
60,000 - 69,999 USD		0.037		0.001
		(0.103)		(0.172)
70,000 - 79,999 USD		0.103		0.089
		(0.109)		(0.169)
80,000 - 89,999 USD		-0.002		-0.027
		(0.116)		(0.181)
90,000 - 99,999 USD		0.049		0.067
		(0.117)		(0.194)
100,000 - 149,999 USD		-0.017		0.042
		(0.126)		(0.198)
More than 150,000 USD		-0.139		-0.028
		(0.205)		(0.346)
Political ideology				
Conservative and very		-0.025		-0.005
conservative		(0.033)		(0.053)
None		-0.506***		0.033
		(0.164)		(0.232)
Sufficiency orientation		0.804***		1.282***
		(0.033)		(0.051)
Psychological distance		0.010		-0.067***
		(0.009)		(0.014)
Assessment of treatment effectiveness				
Not very effective		0.016		0.224
		(0.142)		(0.250)
Effective		0.237**		0.715***
		(0.116)		(0.205)
Very effective		0.333***		0.910***
		(0.120)		(0.211)
Constant	3.849***	0.606***	5.537***	0.063
	(0.0390)	(0.196)	(0.065)	(0.318)
Observations	1,317	1,312	1,317	1,312
R-squared	0.000	0.504	0.003	0.522
F-test *p*-value	0.001	0.000	0.307	0.000

Note. The table presents ordinary least squares estimates. Robust standard errors are in parentheses. The dependent variables are sufficiency policy support (specifications 1 and 2) and green behavioral intentions (specifications 3 and 4). All other variables as explained in Table 3.2. 5 observations are omitted because of missing observations from the non-required responses on education. *, **, and *** document significance at the 10%, 5%, and 1% levels, respectively.

In general, the results indicate high approval rates for sufficiency policies. Across all groups and for all policies, approval was greater than disapproval (overall mean policy support = 3.86; SD = 0.72) (Fig. 3.2 and Table 3.4 in the Appendix). This high approval rate for sufficiency policies is particularly noteworthy for the U.S. sample at hand, in which 49% describe themselves as conservative or very conservative and 63% have household incomes of less than 60,000 USD per year. Also with regard to the green behavioral intentions the participants showed a high willingness to act environmentally friendly in the forthcoming month (overall mean green behavioral intentions = 5.55; SD = 1.16) (Fig. 3.2 and Table 3.4 in the Appendix). In addition, we find weak, positive correlations between the amount of voucher waived and green behavioral intentions ($r = 0.11$, $p < 0.001$) as well as between the amount of voucher waived and sufficiency policy support ($r = 0.06$, $p < 0.05$). Sufficiency policy support and green behavioral intentions highly correlate ($r = 0.65$, $p < 0.001$).

3.4.3 Robustness checks and exploratory analyses

To deepen our understanding of the results, we conducted various robustness checks and exploratory analyses. As pre-registrated, we first tested the robustness of the results with an alternative sample excluding participants who did not consider the benefits of reduced consumption as effective to increase the well-being of the planet, our society, or the individual well-being. The results indicate that excluding these participants does not alter the outcome, with the INIDIVIDUAL treatment remaining significant across all specifications (see Table 3.7 in the Appendix).

The effect of communicating the three kinds of sufficiency benefits may vary between samples with different characteristics. To explore this, we conducted heterogeneity analysis by running split regression models for the variables sufficiency orientation, political ideology, income, and education. Despite limited statistical power due to smaller sample sizes, the INDIVIDUAL treatment has a small yet significant effect on the amount of voucher waived for both individuals with a sufficiency orientation above and below the median (Specifications 1 and 2 of Table 3.8 in the Appendix). This suggests that sufficiency orientation is not required as a prerequisite for individuals to be affected by the treatments. Furthermore, when running a regression analysis exclusively with participants who classified themselves as conservative to very conservative, the significant effect of the INDIVIDUAL treatment disappears (Specification 4 of Table 3.8). However, there is a statistically significant effect of the INDIVIDUAL treatment among participants who classified themselves as very liberal to somewhat conservative (Specification 3 of Table 3.8). When analyzing income-based split regressions, the significant effect of the INDIVIDUAL treatment is only evident for the participant group with incomes above or equal to 60,000 USD (Specification 5 of Table 3.8). In terms of education-based split regressions, the INDIVIDUAL treatment remains statistically significant only for individuals who have at least a bachelor's degree or an associate's degree (Specification 8 of Table 3.8). Interestingly, participants with a level of education below that of a bachelor's or associate's degree show significantly

higher levels of sufficiency behavior in the SOCIETY treatment than those with the same level of education in the CONTROL group (Specification 7 of Table 3.8).

Our MTurk sample displays differences from the US population, including lower average age and income, a higher education level, and a more conservative political ideology. To enhance the representativeness and generalizability of our treatment effects to the US population, we utilize sampling weights, as presented in Table 3.9 in the Appendix. Table 3.10 presents estimates from OLS regressions using these weights. Both the INDIVIDUAL and SOCIETY treatments show statistically significant effects on the voucher amounts waived compared to the control group when weights are applied. A sensitivity analysis shows that excluding the education variable's weights eliminates statistical significance. This aligns with findings from education-based split regression models, suggesting that the significant impact of the SOCIETY treatment depends on the education level.

As further exploratory analyses we used alternative coding for the income, education, and political control variables.[24] Regarding income, we explored three alternative specifications: a dummy variable for very low incomes (1 = less than 30,000 USD, 0 otherwise), a continuous income variable, and an income dummy variable based on the median income category of our sample. Importantly, using alternative coding for income has no major bearing effect on our treatment effects. Both the magnitudes and the statistical significances of our INDIVIDUAL treatment remain basically unchanged. When utilizing the continuous income variable, we identify a statistically significant positive relationship between income and the amount of voucher waived. All other income variable specifications do not yield any statistically significant associations between income and sufficiency behavior. Employing the categorical variable with 12 income categories enhances the explanatory power of the model. In addition, we used a binary variable for education, taking the value 1 for an education level higher than a bachelor’s degree and 0 otherwise. The results remain unchanged showing a significant INDIVIDUAL treatment effect and no significant effect of education on the amount of voucher waived. Furthermore, we tested the robustness of our results in respect to an alternative coding of the political ideology variable, defining it as a binary variable with a value of 1 if the political ideology was classified as “somewhat conservative”, “conservative”, or “very conservative”. The application of this new coding does not significantly alter the treatment effects, nor does it indicate a significant effect of political ideology on the amount of voucher waived.

[24] The regressions including different control variable specifications are available upon request.

3.5 Discussion and conclusion

We examine whether information about the benefits of sufficiency encourages voluntary consumption reduction, as measured by an incentivized task. Thereby, we contribute to the literature by distinguishing three different kinds of sufficiency benefits: benefits to the nature, benefits to the society, and benefits to the individual well-being. Of these three types of benefits, the results consistently suggest that sufficiency behavior in our study is most strongly promoted by information about self-regarding, individual gains. Focusing on sufficiency benefits that emphasize individual well-being leads to significantly less consumption compared to a neutral control condition. One plausible explanation for this finding is that people may perceive a high self-efficacy and likelihood of success of reducing the own consumption level to achieve individual sufficiency gains. Note that the benefits of reduced consumption mentioned in the INDIVIDUAL treatment can be achieved without having to rely on other people to cooperate, i.e., that others also reduce their consumption level. In contrast, to obtain the benefits mentioned in the NATURE and SOCIETY treatment, individuals also rely on others to reduce consumption. Following Heinz and Koessler (2021), we speculate that the perceived cooperation of other people might be critical for effective interventions targeting other-regarding preferences. This assumption is related to research on social dilemmas which has shown that many people cooperate when others also cooperate (Fischbacher et al., 2001). In addition, other experimental studies suggest that interventions targeting other-regarding preferences only work when combined with social norms (Ferraro et al., 2011). Therefore, we think that future work should aim to further examine under which conditions different sufficiency gain frames are effective in changing consumption behavior.

The finding that emphasizing sufficiency benefits for the individual leads to less consumption has direct implications for policy making. It shows practitioners what form of content and arguments they can use to effectively promote sufficiency behavior. In particular, policy makers and other stakeholders may foster sufficiency behavior by communicating individual benefits of reduced consumption, such as more free time, better mental health, or a higher sense of satisfaction. However, emphasizing benefits to the individual can be seen as a contradictory means of moving toward a more sufficiency-oriented society, since such a society is much less about egoism and more about cooperation and community (Brossmann & Islar, 2020). But even if focusing on sufficiency benefits to the individual might distract people from engaging in collective actions, it may be that being convinced of the individual benefits of sufficiency is a prerequisite for being motivated to support and engage in actions targeting systemic changes. With this in mind and the plausible assumption that benefits to the individual, society and nature do not activate conflicting preferences, we suggest to test the combined effect of different sufficiency benefits in future research.

The results point out that socio-demographic variables shape the impact of the INDIVIDUAL and SOCIETY treatments on the consumption level of experiment participants. Split regressions highlight the significant effect of individual sufficiency gain communication on participants with a bachelor's

degree or higher. Participants with a level of education below that of a bachelor's or associate's degree show significantly higher sufficiency behavior in the SOCIETY treatment than those in the CONTROL group. When applying sampling weights representative of the US population, both the INDIVIDUAL and SOCIETY treatment exhibit statistically significant effects on waived voucher amounts compared to the CONTROL group. Excluding education variable weights removes this significance. These findings indicate that the impact of the SOCIETY treatment depends on education level. Future research could explore how education level and other socio-demographic factors interact with communication strategies promoting different sufficiency benefits. Furthermore, the INDIVIDUAL treatment is significant for participants with a more liberal political ideology but not for those with a more conservative one. In terms of income, sufficiency communication focusing on individual benefits appeals particularly to participants with an annual income exceeding 60,000 USD. High-income individuals may find individual sufficiency gains more appealing due to diminishing returns on material consumption for emotional well-being, as supported by research on income and well-being (Diener et al., 2008; Kahneman & Deaton, 2010). Therefore, arguments emphasizing non-material, individual sufficiency gains may be more persuasive for high-income individuals. The results also reveal that females and older people engage in significantly more sufficiency behavior, which is in line with previous research (e.g., Gifford & Nilsson, 2014; Hunter et al., 2004; Zelezny et al., 2000). Literature has often found the level of education (Blankenberg & Alhusen, 2019; Meyer, 2015) and Democratic-Republican partisanship (Coffey & Joseph, 2013; Lee et al., 2015) to be strong drivers of concern and engagement in pro-environmental behavior. However, the main regression analysis shows no direct statistically significant association between political ideology, income, and education and the reduction in consumption. This suggests that sufficiency behavior may be partly driven by different sociodemographic factors than other pro-environmental behaviors. The study only marks a starting point for further research on the role of individual characteristics in promoting sufficiency behavior.

Furthermore, the results show that the experimental treatments are not statistically significantly different from the control group, neither in terms of sufficiency policy support nor green behavioral intentions. One possible explanation for these null results is that the connection between these secondary outcome variables and the texts on sufficiency gains was insufficiently emphasized. The treatment texts on sufficiency gains specifically promote reducing consumption to achieve the mentioned sufficiency benefits, which may have been effectively captured by waiving an Amazon voucher due to its tangible association with immediate real consumption reduction. In contrast, the sufficiency policy support items largely focus on regulating environmentally harmful consumption without a direct link to individual or societal well-being. Since the INDIVIDUAL treatment emphasizes personal benefits through reduced consumption without a clear link to benefits to nature, participants may have perceived the INDIVIDUAL treatment as more closely tied to waiving an Amazon voucher than to agreeing with the sufficiency policies. In addition, individuals may not have seen the connection between sufficiency policies and their individual well-being, but rather a sense of personal loss due to the permanent

regulation of consumption. Similarly, the link between green behavioral intentions and the INDIVIDUAL treatment may be weaker compared to the Amazon voucher, as the intentions do not explicitly mention consumption.[25] Furthermore, all the behavioral outcomes of the green intentions (e.g., reduction of carbon footprint) can also be achieved with means other than reducing product consumption, further weakening the connection with the sufficiency gain treatments compared to the Amazon voucher outcome variable. In summary, making an effective link between the effects of product consumption and the sufficiency policy items or the green behavioral intentions used in our study may require greater cognitive effort to recognize the connection between reduced consumption and personal benefits compared to the more straightforward association with the Amazon voucher outcome variable.

Other limitations of this study raise further interesting questions for future research. While our study has primarily focused on the effect of sufficiency gains on reduced consumption, there remains an opportunity to examine frames related to losses resulting from lifestyles not geared towards sufficiency (Homar & Cvelbar, 2021) and comparing both the effects of loss and gain frames on sufficiency behavior. Furthermore, the focus of our study on measuring the immediate impact of the interventions on subsequent behavior may restrict the results to short-term effects. A long-term study, in which sufficiency gains are communicated repeatedly, could examine behavior change and habit formation. In addition, the reliance on a specific sample of US-based MTurk workers may raise concerns about generalizability. Therefore, we encourage future research to replicate our study in other countries of the Global North where consumerism is a prevalent barrier to sufficiency behavior. Finally, it remains speculative whether comparable effects of sufficiency benefits on voluntary consumption reduction will be observed with higher stakes at hand. While some may argue that a 1.5 USD voucher is not compelling enough, our results show that participants responded to this voucher incentive.[26]

[25] None of the three green behavioral intentions mentions the word consumption but more general terms: carbon footprint, environmentally friendly behaviour, and natural resources.

[26] The significant difference between the CONTROL group and the INDIVIDUAL treatment with regard to the voucher amount waived highlights the response to the voucher incentive. Overall, 91% of participants retained part of the voucher, indicating redemption was not overly burdensome. Additionally, participants waived an average of 0.59 USD, suggesting satisfaction with the payment. Even the CONTROL group waived over one third of the Amazon voucher, possibly due to pre-existing sufficiency orientation, altruistic tendencies (e.g., Grodeck & Schoenegger, 2023; Vesely & Klöckner, 2018), or the generous compensation compared to typical Amazon MTurk studies (Hara et al., 2018).

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Appendix A: Additional analyses

Table 3.4. Descriptive statistics for each sufficiency policy support and green behavioral intention item

		CONTROL	NATURE	SOCIETY	INDIVIDUAL	Group comparisons
Sufficiency policy support						
(1)	Impose consumption taxes on polluting consumption	3.92 (1.03)	3.89 (1.03)	3.85 (1.02)	3.94 (1.00)	$p = 0.696$
(2)	Impose more regulations and prohibitions to prevent people from harming the environment	3.95 (1.00)	3.98 (0.95)	3.93 (0.99)	4.03 (0.95)	$p = 0.578$
(3)	Work more actively to ban environmentally hazardous products	4.07 (0.90)	4.14 (0.89)	4.09 (0.93)	4.07 (0.91)	$p = 0.730$
(4)	Ban sale of appliances that are not energy efficient	3.79 (1.07)	3.79 (0.99)	3.79 (1.02)	3.77 (1.04)	$p = 0.994$
(5)	Introduce a ban on advertising	3.51 (1.18)	3.58 (1.19)	3.55 (1.17)	3.57 (1.21)	$p = 0.886$
Green behavioral intentions						
(1)	I will try to reduce my carbon footprint in the forthcoming month.	5.43 (1.37)	5.47 (1.32)	5.37 (1.46)	5.55 (1.26)	$p = 0.382$
(2)	I intend to engage in environmentally friendly behaviour in the forthcoming month.	5.56 (1.28)	5.51 (1.22)	5.42 (1.43)	5.67 (1.14)	$p = 0.092$
(3)	I plan to stop wasting natural resources in the forthcoming month.	5.62 (1.38)	5.71 (1.34)	5.61 (1.35)	5.69 (1.29)	$p = 0.729$
Observations		333	312	335		337

Note. The table reports means and standard deviations for each sufficiency policy support and green behavioral intentions item for each group of the experiment. Standard deviations are given in parentheses. The *p*-values for the group comparisons are derived from one-way analyses of variance (one-way ANOVA).

Table 3.5. Effect of sufficiency gain framing on sufficiency policy support items: OLS regression results.

	Impose consumption taxes on polluting consumption	Regulations and prohibitions to protect environment	Work to ban environmentally hazardous products	Ban sale of appliances that are not energy efficient	Introduce a ban on advertising
NATURE	-0.024	0.053	0.116*	-0.018	0.008
	(0.067)	(0.064)	(0.063)	(0.070)	(0.079)
SOCIETY	-0.072	-0.005	0.041	-0.034	-0.034
	(0.067)	(0.066)	(0.063)	(0.070)	(0.077)
INDIVIDUAL	-0.016	0.067	0.010	-0.059	-0.020
	(0.067)	(0.065)	(0.063)	(0.070)	(0.079)
Female	0.029	0.063	0.004	0.065	-0.019
	(0.048)	(0.047)	(0.044)	(0.051)	(0.057)
Age in years	-0.004	-0.004	0.002	0.0006	-0.007**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Education					
Associate's or Bachelor's degree	0.130	0.009	-0.113	0.072	0.237**
	(0.100)	(0.096)	(0.086)	(0.101)	(0.111)
Master's degree or higher	0.218**	0.090	-0.137	0.173	0.517***
	(0.110)	(0.106)	(0.095)	(0.110)	(0.122)
Income					
10,000 - 19,999 USD	-0.361	0.046	0.197	-0.015	0.217
	(0.230)	(0.237)	(0.199)	(0.227)	(0.237)
20,000 - 29,999 USD	-0.323*	-0.033	0.020	-0.175	-0.045
	(0.165)	(0.191)	(0.185)	(0.203)	(0.188)
30,000 - 39,999 USD	-0.062	0.146	0.325**	-0.281	-0.184
	(0.173)	(0.183)	(0.166)	(0.190)	(0.174)
40,000 - 49,999 USD	-0.278*	-0.121	0.065	-0.067	-0.009
	(0.150)	(0.169)	(0.152)	(0.190)	(0.171)
50,000 - 59,999 USD	-0.164	-0.019	0.144	0.016	0.307*
	(0.143)	(0.163)	(0.148)	(0.179)	(0.159)
60,000 - 69,999 USD	-0.191	0.018	0.239	-0.075	0.193
	(0.149)	(0.166)	(0.148)	(0.185)	(0.171)
70,000 - 79,999 USD	-0.078	0.162	0.234	-0.011	0.209
	(0.153)	(0.173)	(0.160)	(0.189)	(0.177)
80,000 - 89,999 USD	-0.404**	-0.046	0.379**	-0.036	0.099
	(0.182)	(0.187)	(0.163)	(0.198)	(0.201)
90,000 - 99,999 USD	-0.117	0.247	0.451***	-0.241	-0.098
	(0.188)	(0.186)	(0.160)	(0.216)	(0.224)
100,000 - 149,999 USD	-0.168	-0.051	0.545***	-0.186	-0.225
	(0.173)	(0.201)	(0.165)	(0.211)	(0.204)
More than 150,000 USD	-0.221	0.139	0.416*	-0.079	-0.948***
	(0.343)	(0.307)	(0.226)	(0.294)	(0.338)
Political ideology					
Conservative ideology	-0.095*	-0.161***	-0.193***	0.039	0.283***
	(0.053)	(0.052)	(0.050)	(0.057)	(0.063)
None	-0.600***	-0.545**	-0.320	-0.606***	-0.458*
	(0.222)	(0.235)	(0.219)	(0.218)	(0.254)
Sufficiency orientation	0.854***	0.781***	0.751***	0.854***	0.779***
	(0.051)	(0.051)	(0.049)	(0.056)	(0.062)
Psychological distance	0.010	-0.003	-0.020	0.010	0.055***
	(0.014)	(0.014)	(0.014)	(0.016)	(0.018)
Assessment of treatment effectiveness					
Not very effective	0.199	0.115	0.570***	-0.326	-0.476**
	(0.203)	(0.202)	(0.216)	(0.219)	(0.243)
Effective	0.459***	0.461***	0.413**	-0.051	-0.099
	(0.164)	(0.161)	(0.189)	(0.177)	(0.199)
Very effective	0.631***	0.617***	0.406**	-0.034	0.044
	(0.173)	(0.168)	(0.193)	(0.184)	(0.205)
Constant	0.480*	0.765***	0.897***	0.606*	0.285
	(0.276)	(0.291)	(0.299)	(0.322)	(0.347)
Observations	1,312	1,312	1,312	1,312	1,312
R-squared	0.311	0.295	0.239	0.263	0.316
F-test *p*-value	0.000	0.000	0.000	0.000	0.000

Note. The table presents ordinary least squares estimates. Robust standard errors are in parentheses. The dependent variables are the five sufficiency policy support items. Sufficiency policy support was measured on a 5-point scale, with higher numbers indicating more support for the policies. Female is a binary variable taking a value of 1 for women and 0 for men and non-binary and other individuals. The reference group for the education variable are participants with a level of education below that of a bachelor's or associate's degree. The reference category for the income variable is "less than 10,000 USD". Political ideology takes the value 0 for a "very liberal", "liberal", "somewhat liberal", "moderate", "somewhat conservative", or "conservative, the value 1 if the political ideology is "conservative" or "very conservative, and 2 for other political views . Sufficiency orientation is measured on a 5-point scale, with higher numbers indicating a higher sufficiency orientation. Psychological distance is measured on a 7-point scale, with higher numbers indicating a higher psychological distance. The perceived effectiveness of reduced consumption to increase the well-being of the stakeholder mentioned in the treatment takes the value 1 for the assessment as "not very effective", 2 for "effective", 3 for "very effective", and 0 for "not effective at all". 5 observations are omitted because of missing observations from the non-required responses on education. *, **, and *** document significance at the 10%, 5%, and 1% levels, respectively.

Table 3.6. Effect of sufficiency gain framing on green behavioral intention items: OLS regression results.

	I will try to reduce my carbon footprint in the forthcoming month.	I intend to engage in environmentally friendly behaviour in the forthcoming month.	I plan to stop wasting natural resources in the forthcoming month.
NATURE	0.033	-0.047	0.066
	(0.078)	(0.076)	(0.082)
SOCIETY	-0.062	-0.143*	-0.010
	(0.080)	(0.082)	(0.081)
INDIVIDUAL	0.049	0.064	0.008
	(0.078)	(0.076)	(0.083)
Female	0.020	0.011	0.076
	(0.058)	(0.057)	(0.060)
Age in years	-0.001	0.003	0.006*
	(0.004)	(0.003)	(0.003)
Education			
Associate's or Bachelor's degree	0.053	0.108	0.350***
	(0.116)	(0.108)	(0.126)
Master's degree or higher	0.166	0.190	0.306**
	(0.130)	(0.124)	(0.140)
Income			
10,000 - 19,999 USD	0.121	-0.325	-0.065
	(0.295)	(0.293)	(0.265)
20,000 - 29,999 USD	0.216	-0.014	-0.196
	(0.220)	(0.199)	(0.217)
30,000 - 39,999 USD	0.171	-0.104	-0.308
	(0.243)	(0.207)	(0.230)
40,000 - 49,999 USD	0.358*	-0.045	-0.201
	(0.202)	(0.183)	(0.197)
50,000 - 59,999 USD	0.338*	0.191	-0.225
	(0.199)	(0.173)	(0.183)
60,000 - 69,999 USD	0.374*	-0.120	-0.250
	(0.212)	(0.187)	(0.197)
70,000 - 79,999 USD	0.196	0.116	-0.046
	(0.209)	(0.186)	(0.193)
80,000 - 89,999 USD	0.048	0.096	-0.227
	(0.222)	(0.208)	(0.218)
90,000 - 99,999 USD	0.271	0.120	-0.189
	(0.244)	(0.217)	(0.224)
100,000 - 149,999 USD	0.234	0.214	-0.322
	(0.234)	(0.210)	(0.227)
More than 150,000 USD	0.031	0.148	-0.262
	(0.445)	(0.348)	(0.365)
Political ideology			
Conservative ideology	0.065	-0.163***	0.085
	(0.065)	(0.063)	(0.069)
None	-0.025	0.026	0.096
	(0.249)	(0.232)	(0.238)
Sufficiency orientation	1.384***	1.225***	1.238***
	(0.063)	(0.062)	(0.065)
Psychological distance	-0.073***	-0.082***	-0.045**
	(0.018)	(0.018)	(0.018)
Assessment of treatment effectiveness			
Not very effective	0.523*	0.266	-0.117
	(0.275)	(0.298)	(0.318)
Effective	0.992***	0.689***	0.462*
	(0.226)	(0.252)	(0.268)
Very effective	1.194***	0.831***	0.706**
	(0.237)	(0.261)	(0.274)
Constant	-0.709*	0.492	0.405
	(0.368)	(0.379)	(0.410)
Observations	1,312	1,312	1,312
R-squared	0.451	0.384	0.385
F-test *p*-value	0.000	0.000	0.000

Note. The table presents ordinary least squares estimates. Robust standard errors are in parentheses. The dependent variables are the three green behavioral intentions. Green behavioral intentions were measured on a 7-point scale, with higher numbers indicating higher behavioral intentions. Female is a binary variable taking a value of 1 for women and 0 for men and non-binary and other individuals. The reference group for the education variable are participants with a level of education below that of a bachelor's or associate's degree. The reference category for the income variable is "less than 10,000 USD". Political ideology takes the value 0 for a "very liberal", "liberal", "somewhat liberal", "moderate", "somewhat conservative", or "conservative, the value 1 if the political ideology is "conservative" or "very conservative, and 2 for other political views . Sufficiency orientation is measured on a 5-point scale, with higher numbers indicating a higher sufficiency orientation. Psychological distance is measured on a 7-point scale, with higher numbers indicating a higher psychological distance. The perceived effectiveness of reduced consumption to increase the well-being of the stakeholder mentioned in the treatment takes the value 1 for the assessment as "not very effective", 2 for "effective", 3 for "very effective", and 0 for "not effective at all". 5 observations are omitted because of missing observations from the non-required responses on education. *, **, and *** document significance at the 10%, 5%, and 1% levels, respectively.

Table 3.7. Effect of sufficiency gain framing on amount of voucher waived: Analysis of different samples for Specification 3 of Model 1 of Table 3.2.

Variables	Main sample	Subsample (belief in sufficiency effectiveness)
NATURE	0.008	0.009
	(0.033)	(0.033)
SOCIETY	0.030	0.023
	(0.033)	(0.033)
INDIVIDUAL	0.082**	0.082**
	(0.032)	(0.032)
Additional controls		
Demographic variables	YES	YES
Sufficiency-related variables	YES	YES
Constant	-0.110	0.015
	(0.146)	(0.130)
Observations	1,312	1,279
R-squared	0.075	0.072
F-test *p*-value	0.000	0.000

Note. The table presents ordinary least squares estimates. Robust standard errors are in parentheses. The dependent variable is the amount of Amazon voucher waived, either for the main sample, for the restricted sample excluding those who do not consider the benefits of reduced consumption as effective to increase the well-being of the planet, our society, or the individual well-being. The reference group for the experimental treatments (NATURE, SOCIETY, INDIVIDUAL) is the CONTROL group. Demographic variables include gender, age, education, political ideology, and income. Sufficiency-related variables include sufficiency orientation, psychological distance to benefits of reduced consumption, and assessment of treatment effectiveness. *, **, and *** document significance at the 10%, 5%, and 1% levels.

Table 3.8. Effect of sufficiency gain framing on amount of voucher waived: Heterogeneity analysis utilizing split regression models for sufficiency orientation, political ideology, income, and education for Specification 3 of Table 3.2.

	Sufficiency orientation	Sufficiency orientation	Political ideology	Political ideology	Income	Income	Education	Education
	above median (> 3.7)	below or at median (≤ 3.7)	Very liberal to somewhat conservative	Conservative to very conservative	60,000 USD and more	less than 60,000 USD	Below bachelor's or associate's degree	Bachelor's or associate's degree or above
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NATURE	-0.020	0.024	0.012	-1.33e-05	0.068	-0.029	0.029	0.003
	(0.047)	(0.048)	(0.055)	(0.039)	(0.064)	(0.038)	(0.128)	(0.034)
SOCIETY	0.010	0.041	0.064	-0.027	0.037	0.024	0.234*	-0.007
	(0.047)	(0.047)	(0.053)	(0.038)	(0.058)	(0.039)	(0.125)	(0.033)
INDIVIDUAL	0.081*	0.077*	0.126**	0.023	0.137**	0.042	0.165	0.069**
	(0.046)	(0.046)	(0.053)	(0.037)	(0.061)	(0.037)	(0.128)	(0.033)
Additional controls								
Demographic variables	YES	YES	YES	YES	YES	YES	YES	YES
Sufficiency-related variables	YES	YES	YES	YES	YES	YES	YES	YES
Observations	618	694	640	645	486	826	176	1,136
R-squared	0.083	0.084	0.077	0.112	0.114	0.062	0.244	0.085
F-test *p*-value	0.001	0.001	0.002	0.000	0.000	0.000	0.000	0.000

Note. The table presents ordinary least squares estimates of the treatment dummy variables (NATURE, SOCIETY, and INDIVIDUAL) of Specification 3 of Table 3.2. Robust standard errors are in parentheses. The dependent variable is the amount of Amazon voucher waived. The reference group for the experimental treatments is the CONTROL. Demographic variables include gender, age, education, political ideology, and income. Sufficiency-related variables include sufficiency orientation, psychological distance to benefits of reduced consumption, and assessment of treatment effectiveness. The step-by-step inclusion of control variables shows that these results are robust. Detailed regression results are available upon request. *, **, and *** document significance at the 10%, 5%, and 1% levels, respectively.

Table 3.9. Characteristics of main sample and US population and corresponding base weights

Variables	Total sample	US-population	Weights
Gender (% female)	53.00	50.50	0.95
Age			
% 44 years and younger	88.76	58	0.65
% 45 years and older	10.33	42	3.73
Income			
% < 60.000 USD	63.01	40.89	0.65
% ≥ 60.000 USD	36.99	59.11	1.60
Education			
% Less than high school, high school, or equivalent to high school	13.41	39	2.91
% Associate's or bachelor's degree	69.28	50	0.72
% Master or higher	17.31	11	0.64
Political ideology			
% Liberal to somewhat conservative	48.75	60	1.23
% Conservative	49.20	36	0.73
% None	2.05	3	1.46

Note. The table reports percentage frequencies for categorical variables for the MTurk sample (n = 1,317) and the US population. US population data for social demographic variables are from the US Census Bureau (2021, 2022) and for political ideology distribution from Gallup (2021).

Table 3.10. Effect of sufficiency gain framing on the amount of voucher waived: Weighted OLS regression results

	Amount of voucher waived (1)	Amount of voucher waived (2)	Amount of voucher waived (3)
NATURE	-0.004	0.049	0.066
	(0.081)	(0.080)	(0.079)
SOCIETY	0.277***	0.280***	0.268***
	(0.099)	(0.081)	(0.079)
INDIVIDUAL	0.254**	0.244***	0.219***
	(0.108)	(0.088)	(0.084)
Female		0.145**	0.143**
		(0.062)	(0.059)
Age in years		0.009***	0.009***
		(0.002)	(0.002)
Education			
Associate's or Bachelor's degree		-0.203***	-0.200***
		(0.069)	(0.067)
Master's degree or higher		-0.235***	-0.229**
		(0.086)	(0.090)
Income			
10,000 - 19,999 USD		-0.253	-0.318*
		(0.186)	(0.166)
20,000 - 29,999 USD		-0.003	-0.053
		(0.172)	(0.157)
30,000 - 39,999 USD		0.013	-0.054
		(0.169)	(0.149)
40,000 - 49,999 USD		0.091	0.068
		(0.134)	(0.124)
50,000 - 59,999 USD		0.249*	0.205*
		(0.138)	(0.120)
60,000 - 69,999 USD		0.306**	0.212*
		(0.139)	(0.116)
70,000 - 79,999 USD		0.078	0.041
		(0.158)	(0.138)
80,000 - 89,999 USD		0.166	0.123
		(0.155)	(0.157)
90,000 - 99,999 USD		0.328**	0.231*
		(0.154)	(0.133)
100,000 - 149,999 USD		0.183	0.159
		(0.135)	(0.120)
More than 150,000 USD		0.102	0.032
		(0.188)	(0.183)
Political ideology			
Conservative and very conservative		-0.029	-0.004
		(0.082)	(0.073)
None		0.117	0.153
		(0.142)	(0.149)
Sufficiency orientation			0.200***
			(0.051)
Psychological distance			-0.008
			(0.017)
Assessment of treatment effectiveness			
Not very effective			-0.124
			(0.233)
Effective			-0.132
			(0.213)
Very effective			-0.342
			(0.226)
Constant	0.549***	0.045	-0.411
	(0.049)	(0.133)	(0.281)
Observations	1,312	1,312	1,312
R-squared	0.059	0.198	0.237
F-test *p*-value	0.005	0.000	0.000

Note. The table presents the estimates of a weighted OLS regression model. Robust standard errors are in parentheses. The dependent variable is the amount of Amazon voucher waived. The reference group for the experimental treatments (NATURE, SOCIETY, INDIVIDUAL) is the CONTROL group. All other variables as explained in Table 3.2. 5 observations are omitted because of missing observations from the non-required responses on education. *, **, and *** document significance at the 10%, 5%, and 1% levels, respectively.

Access to raw data and statistical codes:

Raw data and statistical codes for the manuscript "The benefits of less: The effect of sufficiency gain framings on consumption reduction" by Manuel Suter, Simon Rabaa, and Andrea Essl can be found under the following link: https://osf.io/vms6p/?view_only=6bb03ea0d6c04fb8897ca42b53bf8d69.

Appendix B: Study instructions and questionnaire

Content in [ ] indicates information that have not been showed to participants

[Start of study in oTree]

General Instructions

Thank you for participating in this study. In this study, we will ask you to work on three parts including a decision task and several survey questions.

All tasks and questions are for research purposes only. Your decisions and answers will be completely anonymized and will not influence the terms of any future studies offered to you on MTurk. Please do not reload the page while inserting your answers, as your answers would be lost. You would then need to type them in again.

Click “Continue” to begin the study.

[Page break]

[NATURE Treatment]

Part 1

In Part 1, we kindly ask you to read this text about consumption carefully.

Reducing consumption benefits the planet

Today's consumer society encourages the acquisition of goods and services at an ever-increasing scale. This requires ever greater amounts of natural resources and causes emissions of waste and pollutants.

In fact, recent research suggests that consuming less can **improve the well-being of the planet** [1,2,3]:

- By solving the problem of waste pollution, the land, the sea, and the air would be cleaner.
- Forests and moors could be protected, which would save more plant and animal species from extinction.
- Organic and diverse farming would be possible, which could improve the health of the soil through higher fertility and resilience.
- More oil, gas, and coal could remain in the ground, which would mitigate climate change.

By starting to consume less, it is possible to **improve the well-being of the planet**.

[1] Verfuerth, C., Henn, L., & Becker, S. (2019). Is it up to them? Individual leverages for sufficiency. *GAIA-Ecological Perspectives for Science and Society*, *28*(4), 374-380.

[2] Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., ... & Foley, J. A. (2009). A safe operating space for humanity. *nature*, *461*(7263), 472-475.

[3] IPBES, D. S. (2019). Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. *IPBES secretariat*, 56.

[Page break]

[SOCIETY Treatment]

Part 1

In Part 1, we kindly ask you to read this text about consumption carefully.

Reducing consumption benefits our society

Today's consumer society encourages the acquisition of goods and services at an ever-increasing scale. This requires ever greater amounts of natural resources and causes emissions of waste and pollutants.

In fact, recent research suggests that consuming less can **improve the well-being of our society** [1,2,3]:

- We as society would be safer from resource conflicts because more people could benefit from the available natural resources.
- We would be better protected against new animal-borne diseases, as animals and their habitats would be left in peace.
- We could focus more on the well-being of those around us and look out for each other, leading to a more balanced and caring society.
- We would see that the living conditions of more people remain good enough for them to stay in their home countries without being forced to migrate due to climate change.

By starting to consume less, it is possible to **improve the well-being of our society**.

[1] Workman, A., Blashki, G., Bowen, K. J., Karoly, D. J., & Wiseman, J. (2019). Health co-benefits and the development of climate change mitigation policies in the European Union. *Climate Policy*, *19*(5), 585-597.

[2] Gendron, R., & Hoffman, E. (2009). Resource scarcity and the prevention of violent conflicts. *Peace and Conflict Review*, *4*(1), 1-11.

[3] Iyer, R., & Muncy, J. A. (2009). Purpose and object of anti-consumption. *Journal of Business Research*, *62*(2), 160-168.

[Page break]

[INDIVIDUAL Treatment]

Part 1

In Part 1, we kindly ask you to read this text about consumption carefully.

Reducing consumption benefits your individual well-being

Today's consumer society encourages the acquisition of goods and services at an ever-increasing scale. This requires ever greater amounts of natural resources and causes emissions of waste and pollutants.

In fact, recent research suggests that consuming less can **improve your individual well-being** [1,2,3]:

- You could become more independent of material goods and thus experience a higher sense of satisfaction.
- You might increase your mental health if you detach yourself from identification by products or stop comparing yourself to other's and their possessions.
- You could focus on non-material things such as taking a walk in nature, cultivating social contacts or a sense of purpose, that make you happy in the long run.
- You could afford more free time, which would give you more time for yourself, your friends, and your family.

By starting to consume less, it is possible to **improve your well-being**.

[1] Hook, J. N., Hodge, A. S., Zhang, H., Van Tongeren, D. R., & Davis, D. E. (2021). Minimalism, voluntary simplicity, and well-being: A systematic review of the empirical literature. *The Journal of Positive Psychology*, 1-12.

[2] Boujbel, L., & d'Astous, A. (2012). Voluntary simplicity and life satisfaction: Exploring the mediating role of consumption desires. *Journal of Consumer Behaviour*, *11*(6), 487-494.

[3] Bayat, M., & Sezer, A. (2018). Evaluating Individuals' Voluntary Simplicity Lifestyles and Life Satisfaction in Terms of the Tradition Value: The Example of Düzce University. *Is Ahlakı Dergisi*, *11*(1), 83-87.

[Page break]

[CONTROL Treatment]

Part 1

In Part 1, we kindly ask you to read this text about Mona Lisa carefully.

The portrait Mona Lisa

The Mona Lisa, also known as La Gioconda, is a world-famous portrait oil on wood painting by Leonardo da Vinci from the beginning of the 16th century. It is regarded as an archetypal masterpiece of the Italian Renaissance.

In fact, there are a number of reasons that have led to this prominence of **Mona Lisa** [1,2,3]:

- The painting itself has some pioneering painting features, such as the non-symmetrical eyes or the mysterious smile.
- The date of creation and the identity of the painted woman are unknown and are still disputed today.
- In 1911 it was spectacularly stolen from the Louvre Museum and remained missing for two years, which was reported worldwide.
- The French government used the painting as a diplomatic tool, lending it to the United Stated in the 1960s and to Moscow and Tokyo in the 1970s to improve relations.

The **Mona Lisa** is one of the most valuable and recognized paintings in the world.

[1] Sassoon, D. (2001). *Mona Lisa: the history of the world's most famous painting*. HarperCollins.

[2] Scotti, R. A. (2010). *Vanished smile: The mysterious theft of the Mona Lisa*. Vintage.

[3] Kontsevich, L. L., & Tyler, C. W. (2004). What makes Mona Lisa smile?. *Vision research*, *44*(13), 1493-1498.

[Page break]

[Control questions for NATURE, SOCIETY, INDIVIDUAL & CONTROL Treatment]

Questions about the text

Please answer the following questions about the text. If you're unsure, please go back to the previous page and read the text again.

[Control question 1 - NATURE Treatment]

Question 1

Which benefit that could lead to an increase in the well-being of the planet through reduced consumption was mentioned in the text?

- Protection of the sea from overfishing
- Conservation of glaciers
- **Saving more animals from extinction**

[Control question 1 - SOCIETY Treatment]

Question 1

Which benefit that could lead to an increase in the well-being of the society through reduced consumption was mentioned in the text?

- Society could be protected from sea level rise
- Society could be protected from droughts
- **Society could be protected from new animal-borne diseases**

[Control question 1 - INDIVIDUAL Treatment]

Question 1

Which benefit that could lead to an increase in individual well-being through reduced consumption was mentioned in the text?

- You could have more personal security
- Your life would be easier
- **You could increase your mental health**

[Control question 1 - CONTROL Treatment]

Question 1

What reason that contributed to the fame of the Mona Lisa was mentioned in the text?

- It is the most expensive painting ever sold
- **It was stolen and was missing for two years**
- It was severely damaged by fire

[Control question 2 - NATURE, SOCIETY & INDIVIDUAL Treatment] [Correct answer depends on the given condition]

Question 2

Based on the text, who can achieve a higher well-being by reducing consumption?

- The planet
- We as society
- You as an individual

[Page break]

[CONTROL Treatment]

Question 2

Based on the text, where was the Mona Lisa exhibited besides Paris?

- Berlin
- London
- **Moscow**

[Page break]

[Decision Task - NATURE, SOCIETY, INDIVIDUAL & CONTROL Treatment]

Part 2

In Part 2, you will receive **an additional USD 1.5 in form of an Amazon voucher**. You will be asked to make a decision that may affect the final amount of your Amazon voucher. You will receive the Amazon voucher code with the final amount anonymously in a personal message on MTurk.

Your task

- You will decide whether you want to keep all the USD 1.5 in form of an Amazon voucher, or whether you want to invest parts or all of it as a contribution to reduce consumption.
- You **will decide how to distribute the amount of USD 1.5** between you and an organization that fosters projects promoting reduced consumption.
- The money that you decide **NOT** to get in form of an Amazon voucher will be donated to an organization that fosters projects promoting reduced consumption.
- Your decision will have actual and true consequences. It is **NOT** a hypothetical decision.

[Page break]

Your choice

Please indicate how you want to distribute the amount of USD 1.5 between you and an organization that fosters projects that promote reduced consumption. You can do this in increments of 0.1 USD (i.e. 0, 0.1, 0.2, ..., 1.4 or 1.5). Please note that the total amount must equal to USD 1.5.

How much of the USD 1.5 do you want to keep for yourself in form of an Amazon voucher:

USD _____

How much of the USD 1.5 do you want to donate to projects promoting reduced consumption:

USD _____

Sum: USD _____

If you would like a confirmation email for the donation to the organization, please email us at [study email address]

[Page break]

[Questionnaire - NATURE, SOCIETY, INDIVIDUAL & CONTROL Treatment]

Part 3: Questionnaire

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 anonymized and will not influence the terms of any future studies offered to you on MTurk.

At the end, you will receive your completion code for payment. Please make sure to copy the code and enter it on MTurk.

[Page break]

Questionnaire (1/3)

[Environmental Policy Support (four items from Harring et al., 2017 and one item is self-formulated)]

(Answers on 5-point scale ranging from 1 "a very bad suggestion" to 5 "a very good suggestion", with 3 labeled as "a neither good nor bad suggestion")

There are various ways to get ordinary people in the USA to protect the environment. What do you think about the following suggestions?

- Impose consumption taxes on polluting consumption
- Impose more regulations and prohibitions to prevent people from harming the environment
- Work more actively to ban environmentally hazardous products
- Ban sale of appliances that are not energy efficient
- Introduce a ban on advertising

[Green Behavioral Intentions (Mancha & Yoder, 2015)]

(Answers on 7-point Likert scale ranging from 1 "extremely unlikely" to 7 "extremely likely")

How would you rate your willingness to act in a certain way in relation to the following areas? Please indicate your answer on a scale from 1 to 7, where 1 means "extremely unlikely" and 7 means "extremely likely". You can also use the values in between to indicate where you fall on the scale.

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

[Psychological Distance (adapted from Brügger et al., 2016)]

(Answer scale ranging from 1 to 7 without labelling)

To me, the benefits of a reduced consumption feel

- very close ... very distant
- like here ... like at the other end of the world
- like tomorrow ... like thousands of years away
- like affecting me ... like affecting distant strangers
- very real ... very hypothetical

[Page break]

Questionnaire (2/3)

[Sufficiency orientation (Tröger et al., 2021; Verfuerth et al., 2019)]

(Answers on 5-point scale ranging from 1 "strongly disagree" to 5 "strongly agree")

Please indicate how strongly you agree or disagree with each statement on a scale from 1 to 5, where 1 means "strongly disagree" and 5 means "strongly agree". You can also use the values in-between to indicate where you fall on the scale.

[Sufficiency Attitude Scale (Verfuerth et al., 2019)]

- Through my lifestyle I want to use as little resources as possible (e.g. water, energy, wood).
- I find it desirable to possess few things only.
- I find it appealing to grow and produce as much food by myself as possible.
- My comfort is more important than a frugal way of life.
- All the new things that are sold all the time are a big waste of resources to me.
- I think it is unnecessary to have this affluence of different products in our supermarkets.
- Select "Strongly disagree" for this item

[Sufficiency Consumption impact (Tröger et al., 2021)]

- I am a frugal person.
- High consumption leads to unfair distribution of natural resources in the world.
- Abstaining from consumption can significantly reduce the extent of global warming.
- A lifestyle that significantly reduces the consumption of resources prevents progression of climate change.
- High consumption increases environmental pollution.

- To reduce environmental pollution, it is also necessary to reduce consumption.
- Consumption renunciation is usually helpful for environmental and climate protection.

[Nature Treatment]

How effective do you consider reduced consumption to increase the well-being of the planet?

(very effective, effective, not very effective, not effective at all)

[Page break]

[Society Treatment]

How effective do you consider reduced consumption to increase the well-being of our society?

(very effective, effective, not very effective, not effective at all)

[Page break]

[Individual Treatment]

How effective do you consider reduced consumption to increase your individual well-being?

(very effective, effective, not very effective, not effective at all)

[Page break]

[CONTROL Treatment]

How effective do you consider reduced consumption to increase planetary and human well-being?

(very effective, effective, not very effective, not effective at all)

[Page break]

[Nature, Society, Individual & Control Treatment]

Questionnaire (3/3)

Please select the gender you most identify with:

- female
- male
- non-binary or other

What is your year of birth? (exactly 4 numbers, e.g. 1995)

_____

Which of the following best describes your political views?

- very liberal
- liberal
- somewhat liberal
- moderate
- somewhat conservative
- conservative
- very conservative
- none of the above

What is your highest completed level of education?

- Less than high school
- High school or equivalent
- Associates degree or Bachelor's degree
- Master's degree or Professional degree beyond BA
- PhD or higher
- Trade school
- Prefer not to say

What is your household income per year? Please estimate your answer in USD.

- 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–$150,000
- More than $150,000

[Page break]

End of the study

Thank you very much for your participation.

You decided to **keep USD [amount from decision made in task]** in form of an Amazon voucher and you **invest USD [amount from decision made in task]** in an organization that fosters projects promoting reduced consumption.

You will receive your participation-fee for the study within the next week. The Amazon voucher code will be sent to you anonymously in a personal message on MTurk within the next three weeks.

Your completion code is **Consumption-Study2022**

To confirm that you have completed this study, please return to MTurk and enter the completion code.

[End of study]

Essay 4: Framing effects in expert assessments of optimal GDP development

Manuel Suter, Noel Strahm, Till Bundeli, Kaja Kaessner, Viktoria Cologna, Sebastian Berger*

Abstract

Optimal economic development is a central topic across societies, usually giving Gross Domestic Product (GDP) growth rates a central role. This study delves into the psychological implications of different GDP development framings among academic experts. In an online experiment involving academic researchers, the present study uncovers significant variations in desired GDP developments depending on the framing of GDP growth. Prompting experts to state optimal GDP growth *rates* results in substantially larger GDP sizes compared to the desired growth *factors* over a period of 100 years. This phenomenon holds true across non-economists as well as economists. The findings underscore the importance of the psychological framing of economic growth in shaping individuals' perceptions and preferences. In addition, the research reveals disparities in the preferences for economic development, both between different academic disciplines and between the assessment of low-income and high-income countries.

Keywords: *Economic development, Framing, Growth rate, Growth factor*

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* Manuel Suter, Institute for Organization and HRM, University of Bern, Bern, Switzerland, email: manuel.suter@unibe.ch;
Noel Strahm, Institute for Sociology, University of Bern, Bern, Switzerland, email: noel.strahm@unibe.ch;
Till Bundeli, Institute for Sociology, University of Bern, Bern, Switzerland, email: till.bundeli@unibe.ch;
Kaja Kaessner, Institute for Sociology, University of Bern, Bern, Switzerland, email: kaja.kaessner@unibe.ch;
Viktoria Cologna, Department of the History of Science, Harvard University, Cambridge, United States, email: viktoriacologna@fas.harvard.edu;
Sebastian Berger, Institute for Sociology, University of Bern, Bern, Switzerland, email: sebastian.berger@unibe.ch;

4.1 Introduction

Gross Domestic Product (GDP) is the most commonly applied wealth indicator globally and routinely used to measure economic performance. GDP reflects the market value of all final goods and services produced in a specific time period by a country. The development of GDP has huge implications on how societies evolve and interact with nature (Eisenmenger et al., 2020; van den Bergh, 2009). Large institutions often put emphasis on growth rates, such as the projections of the European Central Bank, the OECD Weekly Tracker of Economic Activity, or the Sustainable Development Goal 8 (SDG) of the United Nations. However, the psychological consequences of GDP development framed as an annual growth rate is rarely addressed. In this study we show experimentally that the framing of GDP development affects judgments about the desired GDP growth among academic researchers.

In recent years, the focus on GDP as the primary indicator of prosperity has been increasingly criticized. Critics argue that GDP fails to account for environmental degradation, social inequality, and overall well-being (Kubiszewski et al., 2013). There is a growing interest in alternative metrics that provide a more holistic view of prosperity such as the Genuine Progress Indicator or the Sustainable Development Index (Hickel, 2020; Kalimeris et al., 2020). The limitations of GDP were a central topic at the Beyond Growth Conference 2023 held at the European Parliament (*Beyond Growth Conference*, 2023). The Beyond Growth Conference brought together scholars, policymakers, and further stakeholders to explore alternatives to the GDP-centric model of economic development. Discussions at the conference emphasized the need to shift towards an economic system that prioritizes environmental health and human well-being over relentless GDP growth.

In light of GDP criticism and alternative perspectives, we present a behavioral perspective on the implications of the current mainstream GDP growth framing. Sustained GDP growth can quickly lead to an enormous GDP. SDG 8 of the United Nations aims to sustain per capita economic growth in accordance with national circumstances. For the least developed countries, the annual GDP growth is set to be at least 7 per cent. A sustained annual GDP growth rate of 7 per cent implies a doubling of GDP every 10.3 years. Several developed countries such as Australia, the United States, the United Kingdom, Austria or Norway reached average yearly growth rates higher than 2 per cent from 1972 to 2022 (World Bank, 2023a). Even an annual GDP growth rate of 2 per cent leads to a doubling of the size of the economy every 36 years. The global average GDP growth rate between 1961 and 2022 has been 3.5%, which is reflected in an exponential, sharply rising growth curve (World Bank, 2023a).

That said, economic expansion does not happen in a vacuum, but strongly affects other variables of the planet by creating pressure on the environmental and other Earth systems. For example, globally, we observe a tight correlation of material use and GDP (e.g., Hickel & Kallis, 2020; Wiedmann et al., 2015). Likewise, CO_2 emissions (e.g., Chaabouni & Saidi, 2017; World Bank, 2023b), energy use (e.g., Haberl et al., 2020; Ward et al., 2016), and water use (e.g., Distefano & Kelly, 2017; Duarte et al., 2014)

are strongly linked to GDP. This implies that potentially biased conceptualizations of optimal GDP loom large. It is therefore paramount to understand factors associated with experts' assessment of optimal GDP, which includes psychological factors such as biases and heuristics (Tversky & Kahneman, 1974).

Past research shows that an exponential growth bias, i.e. an underestimation of the outcomes of growth rates, undermines people's ability to predict growth rate outcomes accurately (e.g., Banerjee et al., 2021; Wagenaar & Sagaria, 1975). Factors such as financial expertise, framing as financial investment scenario, a high need for cognition, short time frames, or being male have been shown to reduce the exponential growth bias (Benzion et al., 1992; Christandl & Fetchenhauer, 2009; Keren, 1983). Thus, there are various factors associated with the estimation of growth rate outcomes. The question arises whether the focus on GDP growth rates also influences experts' perception in determining desired future GDP development. Focusing on annual GDP growth rates may distract from long-term implications of exponential growth. In this context, our study investigates the psychological impact of GDP growth framing on desired GDP growth among academic researchers.

Embedded into a larger survey, our online experiment involves 1,802 academic researchers. It examines their ideal economic development perceptions by framing GDP growth as either a growth rate (e.g., economy grows x% per year for the next 100 years) or a growth factor (e.g., economy is x times bigger in 100 years). Academic researchers publishing in the areas of *Economics, Econometrics and Finance* as well as *Environmental Science* were approached via email using the Scopus database of Elsevier. In this paper, we refer to the first group as *economists* and to the second group as *non-economists*. Divided into the two randomized groups RATE and FACTOR, participants were asked to express their ideal economic development by indicating GDP development for the next century either as a rate or a factor. All participants were asked to express the desired economic development for low-income as well as high-income countries.

The results show that prompting experts to state their desired growth rate leads to substantially larger GDP sizes than when prompting to state desired growth factors. This result has been found for both *economists* and *non-economists*. On average, *economists* prefer to have higher GDP growth for low-income countries than *non-economists*. With regard to the desired growth of high-income countries, no difference between *economists* and *non-economists* has been found. Both groups are in favor of higher growth rates for low-income countries than for high-income countries.

Our study contributes to the ongoing discussion on global economic development with regard to the direction of development (grow, shrink, remain) and the desired extent of economic development for low-income and high-income countries (Drews & van den Bergh, 2017). The investigation also contributes to the framing literature by showing how subtle changes in the presentation of an economic issue can influence individuals' perceptions and preferences. Finally our study contributes to decision biases of experts (e.g., Cain & Detsky, 2008; Englich et al., 2006). The fact that GDP growth framing

has a significant impact on desired growth offers opportunities to critically reflect on rates as the status quo of growth framing and to consider taking a broader perspective with regard to economic development.

4.2 Related literature and hypotheses

4.2.1 The misperception of growth rates

There is ample evidence for an exponential growth bias leading to underestimations of the outcomes of growth rates. In an experiment, participants were asked to estimate the outcome of a financial investment of $100 for different interest rates and durations (Benzion et al., 1992). The participants underestimated the impact of growth rates, which led to significantly lower estimated end values compared to the true value. The extent of the miscalculation increased with a longer time span and a higher level of interest rates. In another experiment, participants were asked to extrapolate a hypothetical development of a pollution (Wagenaar & Sagaria, 1975). The majority of the participants made estimations reaching only 10% or less of the true value, leading to an immense underestimation of the true value. The exponential growth bias has also been shown for the estimation of economic growth rate outcomes: In different experiments, people had considerable difficulties to predict the outcome of economic growth rates in the long run (Christandl & Fetchenhauer, 2009).

The COVID-19 pandemic is another example where the exponential growth bias can have real consequences since the early transmission path of the disease is exponential (Zhao et al., 2020). Studies have documented an exponential growth bias for the prediction of the number of future COVID-19 cases (Banerjee et al., 2021; Banerjee & Majumdar, 2023; Lammers et al., 2020). This underestimation of growth rate outcomes exists despite the fact that there is a simple rule of thumb which helps to calculate the outcomes of growth rates. Based on fixed growth rates, the ”rule of 72” offers a simple heuristic to determine how long it takes for a given GDP size to double. Dividing 72 by the annual growth rate results in the number of years it takes until GDP will duplicate itself. To give an example, for an annual growth rate of 6 per cent it takes 12 years until the GDP size is doubled. The exponential growth bias has not only been found for numerical tasks presenting means of tables or graphs but also for non-numerical paradigms (Wagenaar & Timmers, 1979). Generally, previous studies show that people are bad at predicting exponential growth rate outcomes accurately even though there is a simple rule of thumb to predict numerical exponential growth outcomes.

Previous studies show mixed evidence about the influence of people’s expertise to predict exponential growth outcomes more accurately. Participants owning monetary investments did not differ in their ability to estimate the future values of monetary investments from participants without monetary investments (Benzion et al., 2004). But it has been shown that previous experience with high inflation rates leads to more accurate estimations (Keren, 1983). Further, instructing students on the

characteristics of exponential growth and informing them about people's tendency to underestimate exponential effects led to better estimations than the one's of the control group (Wagenaar & Sagaria, 1975). However, also the informed students tended to underestimate the true values in a subsequent extrapolation task (Wagenaar & Sagaria, 1975). Another study showed that advanced students of economics and business administration made better estimations than a student group of various courses of study (the majority were future teachers) (Christandl & Fetchenhauer, 2009). These results suggest that people's level of expertise may influence the accuracy of their exponential growth predictions.

Besides expertise, further factors can be associated with the accuracy of predicted exponential growth rate outcomes. Males and participants scoring high on the *need for cognition* scale made better estimates than women and participants scoring low on the *need for cognition* scale (Christandl & Fetchenhauer, 2009). Further, there is a positive association between the exponential growth bias and more optimistic economic expectations (Banerjee & Majumdar, 2023). The framing of a task as economic growth scenario can lead to less precise estimations than the framing as financial investment scenario (Christandl & Fetchenhauer, 2009). Although exponential growth bias occurs at short time periods of five years (Wagenaar & Sagaria, 1975), the underestimations increase with the duration and with the magnitude of the interest rate (Benzion et al., 1992). Interest in economics and politics as well as financial incentives have not been shown to influence the accuracy of participants' estimations (Christandl & Fetchenhauer, 2009).

Our study aims to show the impact of GDP growth versus factor framing on desired future GDP development among a large international sample of academic researchers. There are three main differences to previous research investigating the exponential growth bias. First, compared to previous studies, our sample only consists of highly educated academic researchers. At least one published article as a corresponding author in one of the top 100 peer-reviewed journals in the field *Economics*, *Econometrics*, *Finance* or *Environmental Science* between 2018 and 2022 was required to be considered for the survey target population. Second, previous studies used different time periods (from $t = 0.083$ to $t = 25$) and different interacting growth rates (from 1% to 100%) to demonstrate exponential growth bias. The present study draws on a longer time period, as the context demands for this. Regarding optimal growth of economies, 100 years is a horizon over which potential negative effects may accumulate (if green growth is not realized) and which will certainly far exceed planetary boundaries. Third, compared to previous studies, participants are not asked to solve an exponential growth task but to indicate a desired growth rate or growth factor (depending on the treatment group) for the next century. Instead of focusing on the accuracy of growth rate outcome estimations, our study investigates the outcomes of two different GDP growth framings. Growth factors capture the compounding effect of growth over time, while growth rates only represent the annual change. Following previous literature, we hypothesize that participants neglect the compounding effects in the

growth rate framing of GDP. More specifically, we hypothesize that when asked about growth rates versus growth factors, people will suggest higher ideal growth when asked about growth rates compared to growth factors (Hypothesis 1, pre-registered).

4.2.2 Economic growth preferences depending on academic discipline

The preferences regarding the magnitude of economic growth may depend on whether academic researchers belong to the group of *economists* or *non-economists*. Several studies found support that economists rather follow the basic neoclassic concept of *homo economicus*. The *homo economicus* concept assumes that human beings are rational, often self-interested, and opportunistic actors. Already a short introduction to general neoclassical economics assumptions has been shown to lead to more self-interested behavior (Ifcher & Zarghamee, 2018). Advanced economics students have been shown to behave in a more self-serving manner than economics beginners (Haucap & Müller, 2014) suggesting an influence of economic education on compliance with neoclassical concepts. In public goods, prisoner's dilemma, ultimatum, and dictator games, students of economics have displayed behavior more strongly in line with the homo economicus assumption than people without an economic background (e.g., Cadsby & Maynes, 1998; Carter & Irons, 1991; Ifcher & Zarghamee, 2018; Marwell & Ames, 1981; but see McCannon, 2014 or Yezer et al., 1996 for conflicting results). Compared to non-economic students, future economists put more emphasis on the market than on the state and indicated a higher perceived legitimacy for antisocial behaviors such as tax avoidance, throwing garbage into the street, and free-riding (Lopes et al., 2015). Taken together, this may imply that economists place more emphasis on growth compared to other social goals, show a tendency to have a stronger trust in the market, and act more according to the basic neoclassical assumptions than non-economists.

Economists have been shown to have different views regarding economic development than academic researchers from other fields. Compared to other social scientists or natural scientists, economists are rather in favor of a green growth approach, i.e., increasing GDP while decoupling it from negative environmental effects such as greenhouse gas emissions, than focusing on other well-being indicators (King et al., 2023). Scientists of environmental social sciences, natural / environmental sciences, and ecological economics indicated significantly lower favored GDP growth rates for the next decade than scientists of environmental & resource economics as well as scientists from other economic fields (excluding the areas economic growth, environment and energy) (Drews & van den Bergh, 2017). The nearest end of economic growth in rich countries is expected by ecological economists (median = 25-50 years) and environmental scientists (median = 50-100 years) whereas growth economists, environmental and resource economists, and other economists (excluding growth, environment, and energy economists) are the most convinced that eternal GDP growth is possible (Drews & van den Bergh, 2017). Even though ecological economists seem to have lower preferred

growth rates than other economists, this group represents only a small proportion of economists. Thus, we hypothesize, that *economists* will suggest higher ideal growth compared to *non-economists*, in both high- and low-income countries. Further, we expect that this pattern will be present in both experimental conditions (Hypothesis 2, pre-registered).

4.2.3 Perceived ideal growth rate of low-income versus high-income countries

GDP growth is often seen as a solution to poverty. Based on empirical research, it has been argued that growth in low-income countries is a necessity to alleviate poverty (e.g., Garza-Rodriguez, 2018; Škare & Družeta, 2016). However, the conventional view that relentless growth is a panacea for societal ills has been challenged by Max-Neef's (1995) threshold hypothesis. This hypothesis states that although the initial phase of economic growth can be accompanied by an improvement in the quality of life, there is a critical threshold beyond which further growth can lead to a decline in life quality. In line with this hypothesis, it has been proposed that developed countries should stop solely focusing on GDP growth or even downsize their economies in order to provide development space for poorer countries (Alexander, 2012; Kubiszewski et al., 2013). In a global survey with 789 climate policy researchers, 53% at least somewhat agreed with the statement that ”In view of limited natural resources, rich countries may have to give up their economic growth to assure that all poor people in the world can reach a fair standard of living” (King et al., 2023). Thus, academic researchers may desire a higher growth rate for low-income than for high-income countries. We hypothesize that participants’ perceived ideal growth rate is higher for low-income countries than high-income countries. Further, we expect this to be the case within both experimental conditions (Hypothesis 3, pre-registered).

4.3 Online experiment

4.3.1 Open science and ethical statement

The present work followed the following open science standards. First, the study’s hypotheses were pre-registered on the platform Open Science Framework (OSF).[27] All study materials, data, and statistical code to computationally reproduce the presented results are available via the OSF.[28] Ethical approval was granted by the Faculty of Business Administration, Economics and Social Sciences of the University of Bern, with the protocol number 342022.

[27] Hypotheses 3-5 are for this paper, the others for another paper: https://osf.io/3p2dt

[28] https://osf.io/ru26y/?view_only=1b81caa719b7445e897d8c7d6a87b62e

4.3.2 Experimental design and procedure

Our study investigates the optimally perceived GDP development for high-income and low-income countries among academic researchers. We conducted an online experiment to examine whether the perceived ideal economic development differs depending on the GDP growth framing as a rate or as a factor. The experiment was part of a global survey investigating the perception of academic researchers towards the possibility of green growth.[29]

The experiment consists of two treatment groups called RATE and FACTOR. The treatments differ with regard to the given GDP development framing. The RATE group was asked to indicate the perceived ideal economic development as a rate, e.g., "Over the next 100 years, the economy should grow by __ % each year". In contrast, the GROWTH FACTOR group was asked to indicate a factor, i.e., “In 100 years, the economy should be __ times bigger than it is today”. The study participants could in principle also indicate a negative rate (factor) or that the economy should keep the current size.

The survey consists of consent to participation, socio-demographic questions, the experiment and a final questionnaire with further questions about beliefs and attitudes. Among other things, in the first part of the survey participants were asked about their gender, age, and primary scientific field. Participants could self-assign their primary scientific field from a list.[30] Participants that have chosen the fields *Business, Management and Accounting* or *Economics, Econometrics and Finance* are considered as *economists* and all other participants as *non-economists*. In the next part of the survey, participants were asked about their ideal perceived economic development. Participants had to decide what they believe to be the best development of GDP, i.e. whether it should grow, shrink, or remain the same. Depending on the treatment, participants were asked to indicate the perceived ideal (de)growth rate or factor for the next century, for the two categories of high-income and low-income countries. At the end of the survey, political ideology was measured on a 7-point scale ranging from 1 (“completely left/liberal”) to 7 (“completely right/conservative”). As a further control variable, the h-Index[31] of the academic researchers was retrieved from Scopus.

[29] See study instructions and questionnaire in supplementary document.

[30] We made a crosscheck among the participants’ preferences and our initial Scopus pool showing that 36% of participants publishing in the subject area Economics, Econometrics and Finance self-assign themselves to another field than economics whereas only 1.9% of authors publishing in Environmental Science assign themselves to the field economics (see Table 4.6 in Appendix).

[31] The h-index is a metric to calculate the scientific output of a researcher (Hirsch, 2005). The metric is calculated based on citations of the scientist's publications.

4.3.3 Sample characteristics

Academic researchers in the subject areas *Economics, Econometrics and Finance* as well as *Environmental Science* were targeted using the Scopus database of Elsevier. A minimum of one published article as a corresponding author in one of the top 100 peer-reviewed journals of the participants' field between 2018 and 2022 was required to be considered for the target group of the survey.[32] A personalized invitation was sent to 49,838 academic authors via email, followed by two reminders.[33] The emails were distributed in batches from February 21 to March 23, 2023.[34] The data of 2,255 researchers was eligible for data analysis, since these researchers answered all experimental questions (response rate: 4.52%). Similar response rates have been reported in studies with comparable methodology (see e.g., Dablander et al., 2023). We excluded researchers from the data analysis who did not indicate their primary research field (n = 24), who provided no numerical growth rates or factors (n = 100), negative growth rates for a growing economy (n = 1), growth factors of 0 (n = 4), and who indicated surreal high growth factors or rates (growth factor >= 1,000,000 or annual growth rate >= 14.81%, respectively) (n = 65) leading to a sample of 2,061 participants.[35][36][37] This sample is used for the analysis with regard to the academic researchers' preferred future direction of economic development (see section 4.4). In this sample, 853 participants have an economic background and 1,208 participants have a background in other scientific fields, mostly in multidisciplinary, agricultural and biological, or environmental science (see Fig. 4.4 in Appendix). Compared to all invited academic authors, the study participants showed a reasonable similarity in all characteristics. However, an analysis of the continents to which they currently belong revealed that scientists from Europe were overrepresented in our survey, while scientists from Asia were underrepresented (see Fig. 4.5 and Table 4.4 in Appendix).

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[32] Journals were ranked using the CiteScore metric. This metric reflects the annual average number of citations to recent articles published for different academic journals. An overview of all journals can be seen in the the supplementary material. 24,838 economic experts and 112,646 environmental science experts fulfilled these requirements. Due to the imbalance between subject areas, only the top 25,000 Environmental Science experts, determined by the citation count of their articles, were selected to participate in the study.

[33] The first reminder was sent one week and the second two weeks after the initial invitation.

[34] The study responses were collected with the software Qualtrics. Participation in the survey was possible until April 4, 2023.

[35] With the exception of the exclusion criterion with the surreally high growth factors/rates, all criteria meet the necessary requirements for the hypothesis tests to be carried out. The exclusion of participants with surreally high growth factor or rates excludes only 65 participants from the analyses.

[36] For this sample, we winsorized the data: Economy sizes exceeding three standard deviations from the mean were considered as outliers. We substituted outliers with the highest value that was not an outlier.

[37] The answers of respondents who preferred either a growing or shrinking economy, but provided an ideal growth rate of 0 or factor of 1 were manually changed to "remain", as both a growth rate of 0 and factor of 1 lead to unchanged economy sizes after 100 years (n =41).

Since the hypotheses of the study focus on differences between participants who indicated positive growth rates / factors, we provide the sample characteristics of the 1,802 subjects who indicated a numeric, positive growth rate/factor for low-income countries and/or high-income countries.[38] Table 4.1 provides descriptive statistics for sociodemographic variables, academic-related variables, and political ideology of the two treatment groups. The randomization between the two treatment groups was successful for all variables, meaning that no significant differences between the control variables were found.

Table 4.1. Sample characteristics and randomization check between experimental conditions.

Variables	RATE	FACTOR	Group comparisons
Demographics			
Gender (% male)	75	75	p = 1
Age in years	49	49	p = .47
	(11)	(12)	
Academic-related			
Scientific field (% economists)	44	41	p = .29
h-Index	20.38	21.42	p = .34
	(18.75)	(19.36)	
Political ideology			
Conservative ideology	3.12	3.12	p = .92
	(1.36)	(1.37)	
Observations	924	878	1,802

Note. The table reports means and standard deviations for continuous variables and %age frequencies for categorical variables for both groups of the experiment. Standard deviations are given in parentheses. Female is a binary variable taking a value of 1 for individuals who identify themselves as men and 0 for women, individuals who self-describe them or prefer to not state a gender they identify with. Conservative ideology refers to a political ideology and was measured on a 7-point scale ranging from 1 ("completely left/liberal") to 7 ("completely right/conservative"). For categorical variables the results of Chi-squared test comparisons are given and for continuous variables the results of Wilcoxon-Mann-Whitney tests.

4.4 Results

4.4.1 Effect of GDP growth framing on ideally perceived GDP

We first investigate whether GDP development framed as a rate leads to higher desired growth than when framed as a factor. Here, we solely focus on participants who have indicated positive growth numbers. Looking at high-income countries, participants in the RATE treatment indicated a median annual growth rate of 2% (mean = 2.64; SD = 1.85; n = 585) for the next 100 years resulting in an

[38] In other words, this means that we excluded participants who indicated that the economy should shrink or that the economy should neither grow nor shrink for both high- and low-income countries.

economy that is 7.24 times larger than today (mean = 339.06; SD = 1739.30).[39] In the FACTOR condition, the median response resulted in an economy that is 5 times larger in 100 years (mean = 98.27; SD = 895.10; n = 514). Participants in the RATE condition suggested significantly higher ideal perceived growth for high-income countries than participants in the FACTOR condition ($p < 0.01$).[40] For low-income countries, the median growth rate indicated in the RATE treatment is 4% per year (mean = 4.08; SD = 2.41; n = 910) which leads to a median economy size that is 51 times bigger in 100 years (mean = 1,098.37; SD = 3,461.54). In the FACTOR condition the outcome is a median of a 6 times bigger economy size in 100 years (mean = 109.67; SD = 959.77; n = 857). Also for low-income countries participants suggested significantly higher ideal growth when asked about growth rates than when asked about growth factors ($p < 0.01$). The significant difference between FACTOR and RATE framing is also present in a sample including the surreal high growth factors / rates (n = 2126), for both high-income ($p < 0.01$; n = 1,140) and low-income countries ($p < 0.01$; n = 1,825). Our data thereby supports the hypothesis that participants in the RATE condition indicate higher GDP outcomes than participants in the FACTOR condition (Hypothesis 1).

Fig. 4.1 shows the distribution of the resulting economy sizes depending on the condition and income level of the country. The dispersion of the resulting economy sizes is much greater in the RATE condition than in the FACTOR condition. This is due to the fact that growth rates are exponential and therefore even small differences in annual growth rates lead to significantly different economy sizes after 100 years. This dispersion of economy sizes becomes bigger, the higher the growth rates get. This explains the great dispersion of values for low-income countries in the RATE group.

[39] Despite the exclusion of surreally high growth numbers with growth factors equal or higher than 1,000,000 or annual growth rates equal or higher than 14.8%, respectively, there are still some large values leading to a right-skewed distribution with a high mean value. The median is therefore more representative and significantly smaller than the mean.

[40] For between-subject comparisons, one-sided Wilcoxon-Mann Whitney tests were conducted.

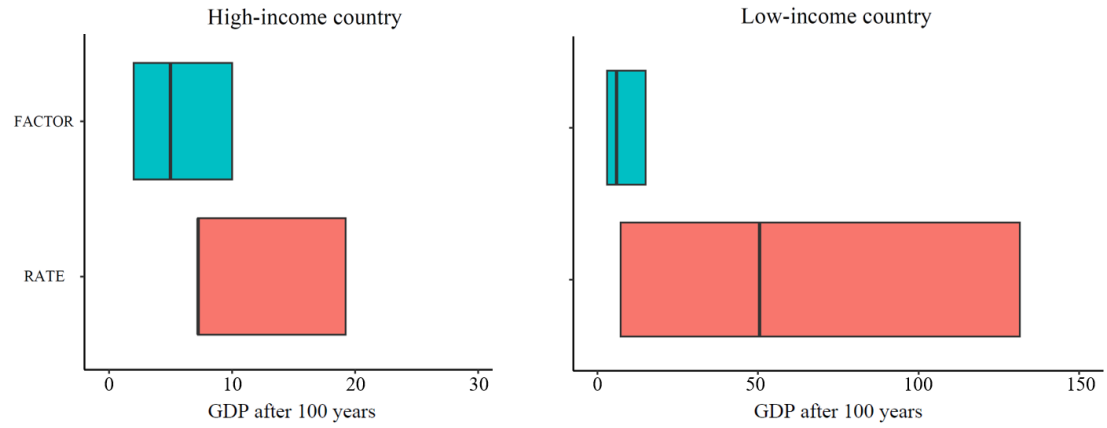

Fig. 4.1. Boxplots showing the distribution of the resulting relative GDP sizes based on the indicated growth factors and rates by condition (RATE or FACTOR) and income of country (high- or low-income). The baseline for the GDP size is 1. The line inside the box represents the median, while the bottom and top edges of the box represent the first and third quartiles, respectively.

OLS regression models confirm the results of the hypothesis tests. There is a significant impact of the rate framing on the resulting economy sizes of high-income countries (see Table 4.2).[41] Specifications 2 and 3 control for further factors potentially influencing the ideal perceived economic growth. While gender, age and participants' h-index do not have a significant influence on the outcome of desired GDP growth, the academic field has. Having an academic background in economics leads to significant smaller ideal perceived economic growth. The mean economy size resulting of the growth indicated by *non-economists* (mean = 302.10) is much higher than that of *economists* (mean = 160.71). In terms of the median, however, both scientific groups have a median of 7.24. Since *non-economists* may have less knowledge about the exponential effect of growth rates, they may have underestimated growth more. For a high mean, it only takes a few people to underestimate exponential growth.[42] The interaction plot visualizes that the experimental condition had stronger effects on non-economists' growth rates than on economists (see Fig. 4.2).[43]

[41] We refrain from showing regression robustness checks including participants who indicated surreally high growth rates or factors. The reason for this is that these participants' growth numbers result in enormously high economic sizes, which completely distort the results of the regression. For high-income countries there are 21 data points with economy sizes that are greater than 1e+10 in 100 years and for low-income countries 32. Due to the exclusion of surreally high growth numbers (growth factor >= 1,000,000 or annual growth rate >= 14.8%, respectively) only 65 participants are excluded and our treatment effect with the restricted sample is highly significant for all specifications ($p<0.01$). Thus we assume that the results are robust.

[42] After winsorizing, the highest value for the economy size of high-income nations is a 10,640 higher economy size in 100 years. Of the 25 participants indicated growth values leading to this size, only 7 stem from *economists*.

[43] See regression tables including the interaction effects in Table 4.4 in the Appendix.

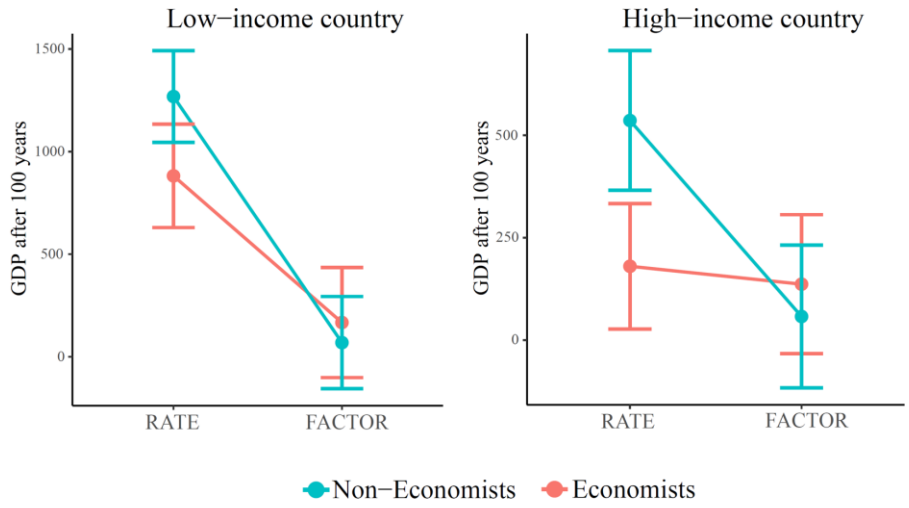

Fig. 4.2. Interaction effects of condition (RATE or FACTOR) and academic field (non-economists or economists) for the resulting mean economy sizes after 100 years (calculated based on the researchers' factors or rates indicated) of both high-income and low-income countries. Error bars are indicated.

Table 4.2. Effect of GDP growth framing on economy size of high-income country: OLS regression results.

	Economy size of high-income country (1)	Economy size of high-income country (2)	Economy size of high-income country (3)
(Intercept)	98.27 *	128.03	226.88 *
	(39.52)	(94.24)	(114.22)
RATE condition	240.79 **	245.43 **	247.51 **
	(82.11)	(87.30)	(88.01)
Male		-36.06	-0.62
		(114.66)	(114.72)
Age		29.80	52.05
		(53.64)	(65.08)
Field Economics			-240.11 *
			(104.01)
h-index			-96.93
			(50.23)
Observations	1,099	1,073	1,073
R2	0.01	0.01	0.01

Note. The table presents ordinary least squares estimates. The dependent variable is the resulting economy size of a high-income country in 100 years. Male is a binary variable taking a value of 1 for men and 0 for women and non-binary and other individuals. Field Economics is a binary variable taking the value of 1 if the academic field is Economics, Econometrics, Finance, Business, Management, or Accounting. *, **, and *** represent significance at the 5%, 1%, and 0.1% levels, respectively.

In comparison to the regression model focusing on factors influencing the economy size of high-income countries, the specifications for low-income countries show two main differences (see Table 4.3). First, the effect of the RATE condition on the economy size is by far stronger for low-income countries. Second, there is no significant influence of an academic background in economics on the desired growth of low-income countries. The interaction plot depicts that *economists*' and *non-economists*' growth numbers are more aligned with regard to low-income countries (see Fig. 4.2).

Table 4.3. Effect of GDP growth framing on economy size of low-income country: OLS regression results.

	Economy size of low-income country (1)	Economy size of low-income country (2)	Economy size of low-income country (3)
(Intercept)	109.66 *** (32.80)	327.56 ** (124.13)	389.80 ** (132.61)
RATE condition	988.72 *** (119.41)	978.83 *** (120.92)	985.25 *** (122.12)
Male		-285.71 (164.86)	-278.50 (166.81)
Age		-10.80 (60.62)	-47.41 (84.36)
Field economics			-166.98 (156.96)
h-index			38.39 (108.31)
Observations	1,767	1,722	1,722
R2	0.04	0.04	0.04

Note. The table presents ordinary least squares estimates. The dependent variable is the resulting economy size of a low-income country in 100 years. Male is a binary variable taking a value of 1 for men and 0 for women and non-binary and other individuals. Field Economics is a binary variable taking the value of 1 if the academic field is Economics, Econometrics, Finance, Business, Management, or Accounting. *, **, and *** represent significance at the 5%, 1%, and 0.1% levels, respectively.

As explorative analyses, sub-groups with the same academic background were analyzed to see whether both *economists* and *non-economists* are influenced by GDP growth framing. Since *economists* might have more knowledge regarding GDP development than other academic researchers, *economists* may be less likely to be influenced by the framing of GDP development. For high-income countries, the

desired extent of economic growth by *economists* leads to a significantly larger economy in 100 years in the RATE condition (median = 7.24; mean = 180.33; SD = 1,193.45; n = 324) than in the FACTOR condition (median = 5; mean = 136.64; SD = 1,085.23; n = 264) ($p > 0.01$). For low-income countries *economists*' optimal perceived growth rates (median = 50.50; mean = 881.80; SD = 3,003.20; n = 400) also lead to a significantly larger economy in 100 years than the indicated growth factors (median = 10; mean = 167.20, SD = 1,280.05; n = 353) ($p < 0.01$). Less surprisingly, also *non-economists*' growth rates lead to a significant larger economy than their indicated growth factors, for both low-income ($p < 0.01$) and high-income ($p < 0.01$) countries.[44][45]

4.4.2 Partially different perceived ideal GDP growth by economists and non-economists

This section focuses on potential differences between *economists* and *non-economists* regarding their ideal perceived GDP growth. The analyses focus only on survey participants who have indicated positive growth numbers. Independent of the condition, the median economy size of high-income countries resulting from the indicated growth rates and factors is 7.24 among *economists* (mean = 160.71; SD = 1,145.38; n = 588) as well as among *non-economists* (mean = 302.09; SD = 1,667.48; n = 511).[46] Thus, across treatments *economists* did not suggest significantly higher ideal growth compared to *non-economists* for high-income countries ($p = 0.78$). For low-income countries, the growth rates and factors indicated by *economists* result in a median economy size that is 19 times larger (mean = 546.8; SD = 2,383.22; n = 753) and the growth rates indicated by *non-economists* result in a median economy size that is 10 times larger (mean = 672.34; SD = 2,780.89; n = 1,014).[47] Across treatments, *economists* suggested significantly higher ideal growth for low-income countries compared to *non-economists* ($p < 0.01$). Fig. 4.3 shows the resulting median economy sizes of high- and low-income countries, broken down by academic fields.

[44] The median economy size of low-income countries in the FACTOR condition among *non-economists* is 5 (mean = 69.36; SD = 645.78; n = 504) and in the RATE condition 20.62 (mean = 1,268.24; SD = 3,776.61; n = 510). For high-income countries, the indicated factors among *non-economists* leads to a median economy size of 5 (mean = 57.76; SD = 635.25; n = 250) and the growth rates to a median economy size of 7.24 (mean = 536.11; SD = 2,226.02; n = 261).

[45] Within the group of *economists* as well as *non-economists*, the significant difference between FACTOR and RATE framing is also present in a sample including the surreal high growth factors / rates, for both high-income and low-income countries (p-values of all four pairwise tests < 0.01).

[46] A 7.24 times bigger economy in 100 years corresponds to an annual growth rate of 2%.

[47] A 19 times bigger economy corresponds to an annual growth rate of 4% and a 10 times bigger economy to an annual growth rate of 3% over the next 100 years.

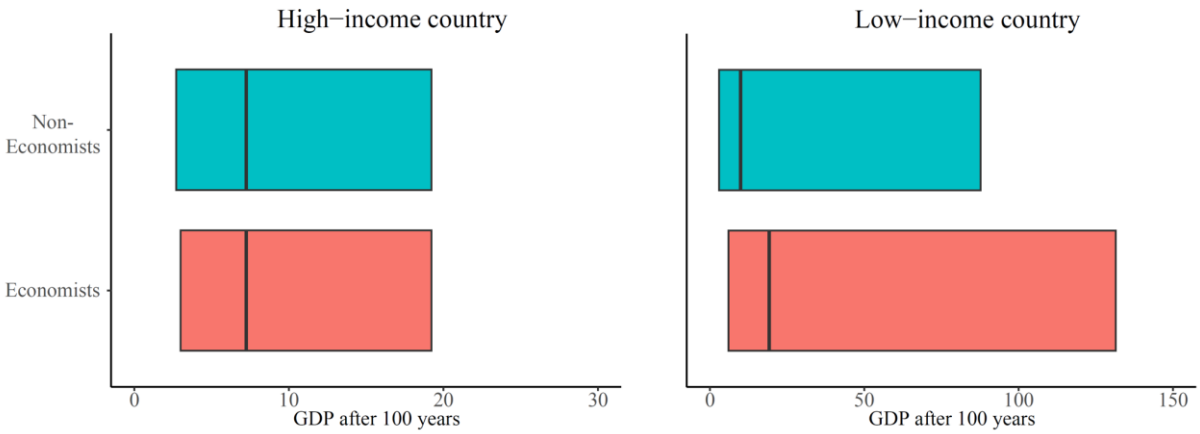

Fig. 4.3. Boxplots showing the distribution of the resulting relative GDP sizes of high- and low-income countries across experimental conditions, broken down by the responses of the two academic fields. The relative GDP sizes are calculated based on the indicated growth factors and rates. The baseline GDP size is 1. The line inside the box represents the median, while the bottom and top edges of the box represent the first and third quartiles, respectively.

Further analyses compare the resulting economy sizes based on the answers of *economists* and *non-economists* sub-divided into the two treatment groups. For high-income countries in the RATE condition, *economists* (median economy size = 7.24; mean = 180.33; SD = 1,193.45; n = 324)[48] did not suggest significantly higher ideal growth compared to *non-economists* (median economy size = 7.24; mean = 536.11; SD = 2,226.02; n = 261)[49] (p = 0.990). Also in the FACTOR condition, *economists* (median = 5; mean = 136.64; SD = 1,085.23; n = 264) did not suggest significantly higher ideal growth for high-income countries compared to *non-economists* (median = 5; mean = 57.76; SD = 635.25; n = 250) (p = 0.183). With regard to low-income countries in the RATE condition, *economists* suggested growth rates leading to a significantly higher median economy size (median = 50.50; mean = 881.80; SD = 3,003.20; n = 400)[50] compared to *non-economists* (median = 20.62; mean = 1,268.24; SD = 3,776.61; n = 510)[51] (p < 0.01). For low-income countries in the FACTOR condition, the growth factors indicated by *economists* also led to a significantly higher economy size (median = 10; mean = 167.20; SD = 1,280.05; n = 353)[52] than the growth factors indicated by *non-economists* (median = 5; mean = 69.36; SD = 645.78; n = 504)[53] (p < 0.01). The hypothesis (2) that *economists* suggest higher ideal

[48] Corresponds to a median growth rate of 2% per year (mean = 2.42; SD = 1.55).

[49] Corresponds to a median growth rate of 2% per year (mean = 2.92; SD = 2.12).

[50] Corresponds to a median growth rate of 4% per year (mean = 4.27; SD = 2.19).

[51] Corresponds to a median growth rate of 3% per year (mean = 3.93; SD = 2.56).

[52] Converted into a growth rate, the median economy size after 100 years corresponds to a median growth rate of 2.34% per year.

[53] Converted into a growth rate, the median economy size after 100 years corresponds to a median growth rate of 1.62% per year.

growth compared to *non-economists* can only be confirmed for the desired growth for low-income countries, but not for high-income countries.[54]

4.4.3 Different perceived ideal GDP growth for high-income and low-income countries

In this section, the focus is on potential differences between the optimal perceived economic growth of low-income versus high-income countries. For this within-subject analysis, only participants who indicated a positive growth rate or factor for both low- and high-income countries are considered (n = 1,064). Across both treatments, the optimal perceived economy size of high-income countries is three times (= median) bigger in 100 years (mean = 152.56; SD = 1,162.88). For low-income countries, the ideal perceived economic growth is a ten times (=median) larger economy size in 100 years (mean = 607.03; SD = 2,594.64). Across all participants who indicated a positive growth rate or factor for low-income and high-income countries, the perceived ideal GDP growth is significantly higher for low-income countries than for high-income countries ($p < 0.01$)[55]. Also when looking at the RATE ($p < 0.01$) and FACTOR ($p < 0.01$) condition groups separately, within both groups the resulting economy size is higher for low-income than for high-income countries. Thus, hypothesis 3 can be confirmed.[56]

4.4.4 Preferences about the direction of economic development

Besides the extent of economic growth, we also measured preferences about the direction of development, i.e. whether the economy size should shrink, remain the same, or increase over the next 100 years. For high-income countries, 16.7% of participants indicated that the size of the economy should ideally decrease, 53.3% that it should increase, and 30% that it should remain in a steady state. For low-income countries, 3.2% of participants indicated that the size of the economy should ideally decrease, 85.7% that it should increase, and 11.1% that it should remain in a steady state. Taken together, 85.7% of participants are in favor of an increasing economy over the next 100 years for low-income countries and 53.3% for high-income countries.

We find significant differences when comparing the ideal perceived direction of economic development between *economists* and *non-economists*. For high-income countries, 10.4% of *economists* are in favor of a decreasing, 68.9% of an increasing, and 20.6% of a steady state economy. 21.2% of *non-economists* prefer a decreasing, 42.3% an increasing, and 36.5% a steady state economy for high-income countries. There is a significant difference between *economists*' and *non-economists*' perception

[54] The p-values obtained from significance tests including the participants who indicated surreal high growth factors / rates confirm this conclusion.

[55] For all within-subject comparisons Wilcoxon signed rank tests were performed.

[56] The p-values obtained from significance tests including the participants who indicated surreal high growth factors / rates confirm this conclusion.

of ideal direction of economic development for high-income countries ($p < 0.01$; Pearson's Chi-squared test) that has also been confirmed for all pairwise tests.[57] With regard to low-income countries, 2.6% of *economists* prefer a decreasing, 88.3% an increasing, and 9.1% a steady economy. Similarly, also a majority of *non-economists* are in favor of an increasing economy size (83.9%) and only a few prefer a decreasing (3.6%) or steady (12.5%) economy size of low-income countries. There is an overall significant difference between the two fields' perceptions of optimal direction of economic development of low-income countries ($p < 0.05$; Pearson's Chi-squared test), and also the pairwise tests for the fractions for an increasing and stable economic size yield a significant difference based on the adjusted p-value.

4.5 Discussion and conclusion

We investigate the ideal perceived GDP development among *economists* and *non-economists* by framing GDP development either as an annual rate (i.e., x% annual growth over the next 100 years) or as a factor (i.e., x times bigger GDP in 100 years). The results of the experiment show that a rate framing leads to a significantly larger economy than GDP factor framing. Both economic and non-economic academic researchers indicated growth rates that lead to significantly larger economy sizes than when suggesting growth factors.

Underestimating exponential growth as well as an anchoring bias are potential reasons why GDP development framed as rate leads to higher desired growth than GDP development framed as factor. An annual growth rate of 2% may sound like a small rate but leads to a 7.24 times larger economy in 100 years. Therefore, the exponential effect of annual growth rates may be underestimated even among academic researchers (see e.g., Christandl & Fetchenhauer, 2009; Wagenaar & Sagaria, 1975). This notion is supported by the finding that the effect of the rate framing on the economy size is stronger for low-income countries where significantly higher desired growth has been indicated than for high-income countries. When asked about annual rates, individuals may also anchor their estimates to historical or target growth rates of countries that they are familiar with (Campbell & Sharpe, 2009; Tversky & Kahneman, 1974). Individuals may use historical or target growth rates as reference points for their growth rate suggestions. In contrast, when asked about growth factors, the absence of specific reference points may reduce the influence of anchoring, leading to more tempered or cautious ideal growth suggestions.

Preferences for continued economic growth seem to be higher in our study than in previous research. For high-income countries, 16.7% of our participants perceive a decreasing economy as

[57] The p-value has been adjusted due to multiple testing. Since the pairwise Chi-square tests are performed for the three directions of economic development for high and low-income countries, the p-value is divided by 6. Thus, the adjusted p-value is 0.00833 (0.05/6).

ideal, 53.3% an increasing size, and 30% a steady state. Similar research investigating GDP development opinions among academic researchers categorized only 27% of participants holding a general green growth position (King et al., 2023) and 22.3% supporting a green growth approach of high-income countries for the current decade (Koskimäki, 2023). In contrast to our study, both of these studies have samples solely consisting of researchers actively publishing on sustainable development. These experts might be more aware of the trade-offs between mitigating environmental pressures and increasing GDP than our study sample. Further, by indicating the level of agreement with different growth-versus-environment statements (e.g., "Economic growth is necessary to finance environmental protection"), the academic researchers in the study of King et al. (2023) were forced to think about environmental aspects in relation to the economic development. Similarly, Koskimäki (2023) asked participants to choose one of four different future pathways, all of which included different developments of GDP, societal well-being, and environmental impact. The different samples and measurements might explain, why in our study participants are more in favor of an increasing GDP.

A limitation of the study is that we do not distinguish between different fields within *economics* and the group of *non-economists* in our analyses. It has been shown that within the broad field of economics different opinions with regard to economic growth exist (Drews & van den Bergh, 2017). For example, environmental & resource economists have been shown to be more in favor of GDP growth than ecological economists. Since ecological economists are a minority among economists, we assume that our study results mainly represent the opinion of mainstream neoclassical economists. The focus of our study is to provide a behavioral perspective on ecological economics that may have significant practical implications on economic development goals and in consequence on the ecological sustainability of the economy. Nevertheless, future studies could investigate whether similar GDP growth framing effects also exist within different sub-groups of economics, such as in the fields of ecological economics or growth theory.

In our study, participants were asked to indicate the optimal direction and extent of economic development over the next 100 years. It can be criticized that 100 years is too long of a period to make an accurate assessment of economic development. However, previous studies already widely demonstrated biases for shorter time periods (from $t = 0.083$ to $t = 25$). Also, we argue that exactly this lack and disability of long-term considerations with regard to GDP development is a major issue. Focusing only on growth rates for the next year or decade may undermine the ability to reflect about the major impact of long-term economic growth. Our study clearly shows that among academic researchers a focus on annual rates leads to significantly higher desired economic growth compared to a focus on factors. This result suggests an underestimation of GDP growth rate outcomes among academic researchers.

Since there is a relationship between exceeding planetary boundaries and economic growth, a critical reflection about the direction and extent of economic development is necessary. Annual target

GDP growth rates may be internalized by different institutions without being questioned with regard to their concrete purpose or potential long-term implications. Our research suggests that preferences with regard to annual growth rates are rather based on heuristics than on a thorough analysis of optimal economic development.

Being aware that even small annual growth rates have a large long-term impact on the size of an economy might raise awareness to consider alternative post-growth perspectives in the discourse on sustainable economic development strategies. Increasing understanding of exponential growth among academic researchers and policy makers dealing with economic growth issues may be a fruitful way forward. Being aware of the exponential development of GDP growth and its framing implications may foster discussions about more nuanced approaches to economic development that are less based on heuristics. Alongside considerations of planetary boundaries and human well-being, economists and policymakers are urged to factor in the framing used to discuss economic growth or degrowth pathways. Ultimately, this holistic perspective may advocate for sustainable economic development goals centered on indicators beyond mere GDP growth.

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Appendix A: Additional analyses

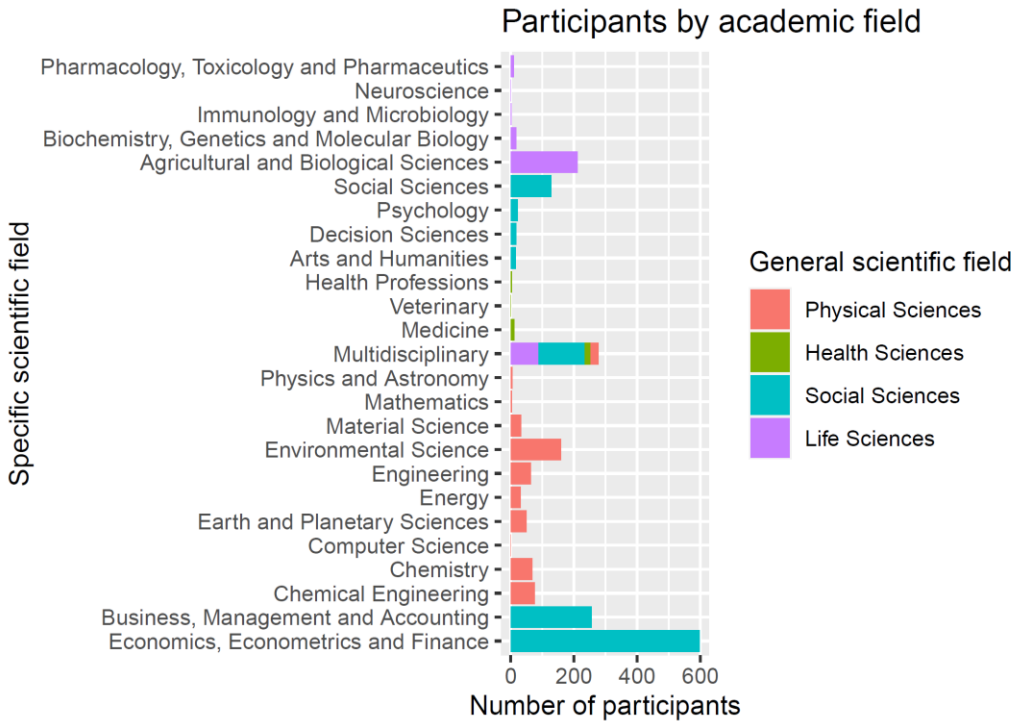


Fig. 4.4. Number of participants by academic field (n=2,061)

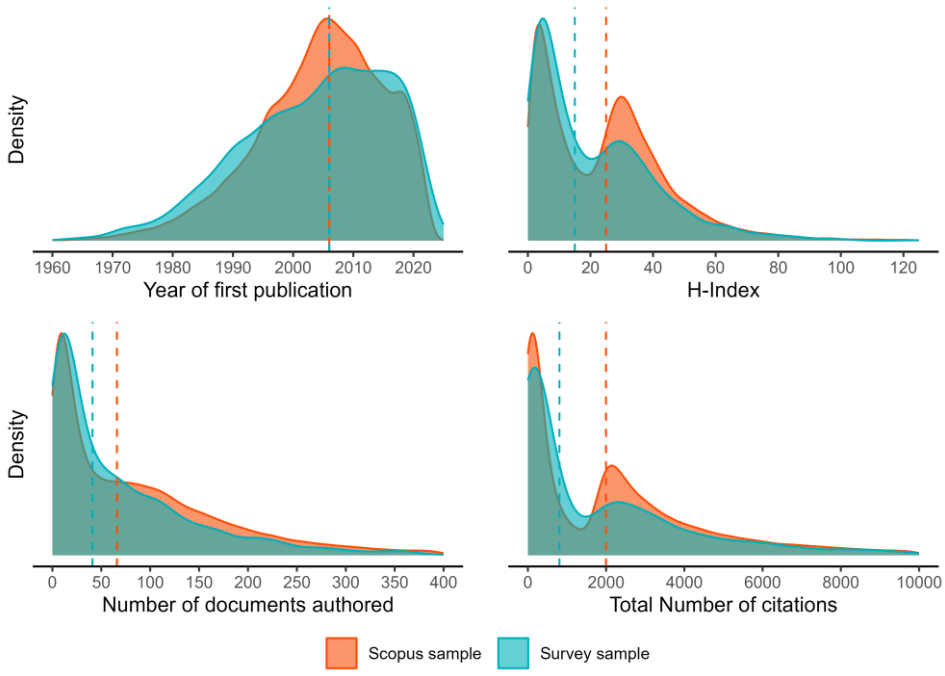


Fig. 4.5. Comparison of survey participants (survey sample, n = 2,061) with the Scopus survey population invited (Scopus sample, n = 49,838). The dashed lines indicate the median values of the respective distributions.

Table 4.4. Comparison of survey participants (survey sample, n = 2,061) with the Scopus survey population invited (Scopus sample, n = 49,838). Gender was self-reported in the survey sample and estimated in the Scopus sample based on the author's first name using the Gender API algorithm (see Santamaría & Mihaljević, 2018). The other variables were obtained from Scopus.

Characteristic	**Total Sample**, N = 49,838[1]	**Survey**, N = 2,061[1]
H-Index	25 (20.15)	15 (19.10)
Number of articles	66 (124.84)	41 (95.31)
Total number of citations	1,997 (4,851.10)	806 (4,271.58)
Year of first publication	2,006 (10.61)	2,006 (12.01)
Affiliation's Continent		
Asia	19,017 (38%)	195 (9.5%)
Europe	15,825 (32%)	1,127 (55%)
North America	11,090 (22%)	493 (24%)
Oceania	2,167 (4.4%)	113 (5.5%)
South America	957 (1.9%)	88 (4.3%)
Africa	588 (1.2%)	34 (1.7%)
Gender		
Female	13,018 (28%)	505 (25%)
Male	33,811 (72%)	1,496 (74%)
Other	21 (<0.1%)	18 (0.9%)

[1] Median (SD); n (%)

Table 4.5. Effect of GDP growth framing and interaction on economy sizes: OLS regression results.

	Economy size of high-income country	**Economy size of low-income country**
(Intercept)	57.76	69.36
RATE condition	478.35***	1,198.88***
Field economics	78.88	97.84
RATE condition × Field economics	-434.66**	-484.29
Observations	1,099	1,767
R^2 / R^2 adjusted	0.016 / 0.013	0.039 / 0.038

Note. The table presents ordinary least squares estimates. The dependent variable are the resulting economy sizes of a low- and high-income country in 100 years. Field Economics is a binary variable taking the value of 1 if the academic field is Economics, Econometrics, Finance, Business, Management, or Accounting. *, **, and *** represent significance at the 5%, 1%, and 0.1% levels, respectively.

Table 4.6. Crosscheck among participants' preferences for their primary scientific field and the initial Scopus pool

	Publishing Author in:		
	Economics, Econometrics and Finance	Environmental Science	**Total**
Self-assigned as:			
Economist	839 (64%)	14 (1.9%)	853 (41%)
Non-Economist	472 (36%)	736 (98%)	1,208 (59%)
Total	1,311 (100%)	750 (100%)	2,061 (100%)

Appendix B: Study instructions and questionnaire

0. Introduction

Thank you

Thank you for your interest in participating in this survey. This study is run by an international team of researchers based at the University of Bern (Switzerland) and Harvard University (USA). Before the survey starts, we would like to inform you about the purpose and procedure of our research. Please read the following information carefully.

Purpose of this research

The purpose of this research is to gain insights into the attitudes and opinions regarding sustainability and economic development of the academics specializing in various fields. You received an invitation to the study because your research was recently published in a relevant scientific journal.

What to expect from this study

You will be asked to answer a series of questions on your attitudes and opinions about various economic and environmental concepts. We will also ask you some open-ended questions that will give you the possibility to elaborate on your answers. Guidance on how to answer questions will be provided.

Anonymity

Data will be handled according to a data management plan that has been derived following the guidelines of the Swiss National Science Foundation, securing the anonymity of responses.

About this study

- Participation will take about 10 minutes.
- Your participation is voluntary.
- You can abort the study at any point in time.

The study received ethical approval from the University of Bern (approval number: 342022). If you have questions, concerns, or complaints, please contact the PI of the project:

Dr. Sebastian Berger
University of Bern
sebastian.berger@unibe.ch

By selecting „I consent to participate“, you consent to the terms and conditions described above

1. Demographics

At the beginning of this survey, we would like to ask you for some information about yourself…

a.) What gender do you identify with?
   i. Female
   ii. Male
   iii. Prefer to self-describe: _____
   iv. Prefer not to say

b.) How old are you?
   i. _____

c.) Please indicate your career stage:
   i. PhD candidate or earlier
   ii. 0-5 years after PhD
   iii. 6+ years after PhD

d.) Please self-assign to a **primary** scientific field
   i. Physical Sciences
      i. Chemical Engineering
      ii. Chemistry
      iii. Computer Science
      iv. Earth and Planetary Sciences
      v. Energy
      vi. Engineering
      vii. Environmental Science
      viii. Material Science
      ix. Mathematics
      x. Physics and Astronomy
      xi. Multidisciplinary
   ii. Health Sciences
      i. Medicine
      ii. Nursing
      iii. Veterinary
      iv. Dentistry
      v. Health Professions
      vi. Multidisciplinary

iii. Social Sciences
    i. Arts and Humanities
    ii. Business, Management and Accounting
    iii. Decision Sciences
    iv. Economics, Econometrics and Finance
    v. Psychology
    vi. Social Sciences
    vii. Multidisciplinary
iv. Life Sciences
    i. Agricultural and Biological Sciences
    ii. Biochemistry, Genetics and Molecular Biology
    iii. Immunology and Microbiology
    iv. Neuroscience
    v. Pharmacology, Toxicology and Pharmaceutics
    vi. Multidisciplinary

e.) **Optional:** Please self-assign to a **secondary** scientific field: Leave blank if you do not have a secondary scientific field. (Same as above)

2. Economic beliefs / Green growth

a. Are you familiar with the concept of Green Growth?
    i. Yes
    ii. No

b. In this study, Green Growth is defined as the idea that continued economic growth can be environmentally sustainable, as technological change and substitution will allow us to increase GDP while keeping resource use and carbon emissions constant or reducing them.

GDP refers to the Gross Domestic Product - The monetary value of all finished goods and services produced by an economy in a specific time period.

This survey is designed to assess expert opinion with respect to the possibility of indefinite economic growth – Green Growth.

All things considered, would you say that Green Growth is possible on a **global** level?
    i. Yes
    ii. No

c. How certain are you of your answer?
   i. 0-100 (Slide Controller) |----------|

d. Please provide the main reasoning for your answer in your own words. Please write as much as you want: You may answer using bullet points.
   i. Open answer

e. What do you consider the strongest arguments **for** the possibility of Green Growth? List up to three arguments. Please try to use as few words as possible for each argument.

   In this study, Green Growth is defined as the idea that continued economic growth can be environmentally sustainable, as technological change and substitution will allow us to increase GDP while keeping resource use and carbon emissions constant or reducing them.
   [Three different answer boxes]
   i. Open answer

f. What do you consider the strongest arguments **against** the possibility of Green Growth? List up to three arguments. Please try to use as few words as possible for each argument.
   In this study, Green Growth is defined as the idea that continued economic growth can be environmentally sustainable, as technological change and substitution will allow us to increase GDP while keeping resource use and carbon emissions constant or reducing them
   [Three different answer boxes]
   i. Open answer

3a. Experimental condition: Growth rate

a. What do you consider an ideal economic growth rate for a **high-income country** for the next 100 years? Only one option can be selected.
   i. Over the next 100 years, the economy should **grow** by __ % each year.
   ii. Over the next 100 years, the economy should **shrink** by __ % each year.
   iii. Over the next 100 years, the economy should **neither grow nor shrink**.

b. What do you consider an ideal economic growth rate for a **low-income country** for the next 100 years? Only one option can be selected.
   i. Over the next 100 years, the economy should **grow** by __ % each year.
   ii. Over the next 100 years, the economy should **shrink** by __ % each year.
   iii. Over the next 100 years, the economy should **neither grow nor shrink**.

3b. Experimental condition: Factor

a. What do you consider an ideal growth factor for an economy in a **high-income country** in a 100 years' time? Only one option can be selected.
   i. In 100 years, the economy should be _ times **bigger** than it is today.
   ii. In 100 years, the economy should be _ times **smaller** than it is today.
   iii. In 100 years, the economy should **remain the same size** that it is today.

b. What do you consider an ideal growth factor for an economy in a low-**income country** in a 100 years' time? Only one option can be selected.
   i. In 100 years, the economy should be _ times **bigger** than it is today.
   ii. In 100 years, the economy should be _ times **smaller** than it is today.
   iii. In 100 years, the economy should **remain the same size** that it is today.

4. Resume normal survey flow

a. Rate the potential of these factors to help mitigate environmental issues:
   (1– No potential at all; 7-Very strong potential)
   i. Technological advances
   ii. Degrowth of the global economy
   iii. Environmental regulations
   iv. Voluntary consumption reduction of end-users
   v. Social innovation
   vi. Non-violent civil disobedience
   vii. Market based solutions
   viii. Other: _____

b. How strongly do you agree with the following statements?
   [1:Strongly disagree – 7: Strongly agree]
   i. GDP growth can be absolutely decoupled from **material and energy use** on a **global** level.
   ii. GDP growth can be absolutely decoupled from **carbon emissions** fast enough to limit global warming to well below 2°C compared to pre-industrial levels.
   iii. Continued economic growth is essential for improving people's well-being.

c. What would it take you to change your mind about Green Growth? Remember, your answer to the question whether you believe that Green Growth is possible was "[YES/NO]". Please write as much as you want:
   i. Open answer

5. Environmental beliefs

a. In your view, what are some environmental issues that we face today? You may list up to **nine** environmental issues that come to your mind and that you find most relevant. List as many as you want. Please try to use as few words as possible for each environmental issue.
    i. 9 separate answer boxes.
b. How strongly do you agree or disagree with the following statements? [1- Strongly Disagree 11- Strongly Agree]
    i. Climate change will bring major negative consequences to people in my local community
    ii. Biodiversity loss will bring major negative consequences to people in my local community

6. Green Growth vs. Degrowth

Can our planet sustain indefinite economic growth?

This topic has sparked an ongoing debate in economic, scientific, as well as political circles around the world. Opinions are often divided into two major concepts:

Green Growth describes the idea that continued economic growth can be environmentally sustainable,
as technological change and substitution will allow us to increase GDP while keeping resource use and carbon emissions constant or reducing them.

Degrowth emphasizes the need to reduce global consumption and production and advocates that economic and social progress can be independent from economic growth. The main argument of degrowth is that an infinite expansion of the economy is fundamentally contradictory to finite planetary boundaries.

We would like to know where **you** and **your scientific field** stand on the debate:
[Spectrum: 0- **Degrowth**: Environmental issues can best be mitigated in a non-growing global economy.; 100- **Green Growth**: Environmental issues can best be mitigated in a growing global economy]

a. Please position **yourself** on the spectrum.
    i. [0- **Degrowth:** Environmental issues can best be mitigated in a non-growing global economy.; 100- **Green Growth**: Environmental issues can best be mitigated in a growing global economy]

b. Please guess the average position of **your scientific field**.
    i. [0- **Degrowth:** Environmental issues can only be mitigated if the global economy shrinks.; 100- **Green Growth**: Environmental issues can only be mitigated if the global economy grows]

7. Demographics II

a. In which country do you currently reside?
    i. Dropdown list of all countries.

b. Which of the following best describes the area you live in?
    i. Rural
    ii. Urban

c. In political matters, people talk of "the left/progressive" and "the right/conservative". Please place your views on the following scale: (1 = completely left/progressive to 7 = completely right/conservative.) [-99 = Prefer not to respond]

d. Please indicate to what extent you consider yourself religious. (1 = not religious at all, 7 = very strongly religious) [-99 = Prefer not to respond]

Appendix C: List of top 100 peer-reviewed journals Economics, Econometrics, and Finance

Source title	Cite score	Publisher
Quarterly Journal of Economics	23,7	Oxford University Press
Journal of Management	21	SAGE
Resources, Conservation and Recycling	17,9	Elsevier
Journal of Innovation and Knowledge	17	Elsevier
Journal of Economic Literature	15,4	American Economic Association
Journal of the Academy of Marketing Science	15,2	Springer Nature
Journal of International Business Studies	15,1	Springer Nature
American Economic Review	15	American Economic Association
Resources, Conservation and Recycling: X	14,5	Elsevier
Long Range Planning	14,4	Elsevier
International Journal of Production Economics	14,3	Elsevier
Journal of Economic Perspectives	13,9	American Economic Association
Entrepreneurship Theory and Practice	13,7	Wiley-Blackwell
Strategic Entrepreneurship Journal	13,6	Wiley-Blackwell
Journal of Political Economy	13,1	University of Chicago Press
American Economic Journal: Applied Economics	12,2	American Economic Association
Journal of Consumer Research	12,2	Oxford University Press
Journal of World Business	12,1	Elsevier
Cambridge Journal of Regions, Economy and Society	11,6	Oxford University Press
Family Business Review	11,4	SAGE
Energy Economics	11,3	Elsevier

Review of Environmental Economics and Policy	11,2	University of Chicago Press
Journal of Finance	11	Wiley-Blackwell
Ecological Economics	10,9	Elsevier
Foundations and Trends in Econometrics	10,8	Now Publishers Inc.
Journal of Business Ethics	10,8	Springer Nature
Small Business Economics	10,7	Springer Nature
Review of Economic Studies	10,5	Oxford University Press
Economic Geography	10,2	Taylor & Francis
Journal of Supply Chain Management	10,2	Wiley-Blackwell
MIS Quarterly Executive	10,2	Indiana University Press
Internet Research	10,1	Emerald
Annual Review of Resource Economics	9,9	Annual Reviews Inc.
International Business Review	9,9	Elsevier
Oxford Review of Economic Policy	9,9	Oxford University Press
American Economic Journal: Macroeconomics	9,8	American Economic Association
Review of Financial Studies	9,8	Oxford University Press
Journal of Financial Economics	9,7	Elsevier
Oeconomia Copernicana	9,4	Instytut Badań Gospodarczych/Institute of Economic Research (Poland)
World Development	9,4	Elsevier
American Economic Journal: Economic Policy	9,3	American Economic Association
European Research on Management and Business Economics	9,3	European Academy of Management and Business Economics
Finance Research Letters	9,3	Elsevier
Review of International Organizations	9,3	Springer Nature
Review of Economics and Statistics	9,1	MIT Press
Econometrica	8,9	Wiley-Blackwell

Electronic Markets	8,9	Springer Nature
Intelligent Systems in Accounting, Finance and Management	8,8	Wiley-Blackwell
International Journal of Accounting Information Systems	8,8	Elsevier
Journal of Finance and Data Science	8,7	KeAi Communications Co.
Canadian Journal of Agricultural Economics	8,6	Wiley-Blackwell
Food Policy	8,5	Elsevier
Journal of Environmental Economics and Management	8,5	Elsevier
Journal of Accounting and Economics	8,3	Elsevier
Foundations and Trends in Entrepreneurship	8,2	Now Publishers Inc.
Palgrave Communications	8,2	Springer Nature
City, Culture and Society	8,1	Elsevier
Journal of Economic Geography	8,1	Oxford University Press
Journal of Marketing Research	8,1	American Marketing Association
Entrepreneurship and Regional Development	8	Taylor & Francis
Journal of Family Business Strategy	8	Elsevier
Technological and Economic Development of Economy	8	Vilnius Gediminas Technical University
Journal of Business and Economic Statistics	7,9	Taylor & Francis
Journal of Economic Surveys	7,9	Wiley-Blackwell
Journal of Financial Intermediation	7,9	Elsevier
Review of Asset Pricing Studies	7,9	Oxford University Press
Journal of the Association of Environmental and Resource Economists	7,8	University of Chicago Press
Review of Corporate Finance Studies	7,8	Oxford University Press

Brookings Papers on Economic Activity	7,6	Brookings Institution Press
Economic Journal	7,6	Wiley-Blackwell
Resources Policy	7,6	Elsevier
Annual Review of Economics	7,5	Annual Reviews Inc.
Structural Equation Modeling	7,5	Taylor & Francis
World Bank Research Observer	7,5	Oxford University Press
Economic Policy	7,4	Oxford University Press
International Journal of Electronic Commerce	7,2	Taylor & Francis
International Review of Financial Analysis	7,2	Elsevier
Journal of Public Economics	7,1	Elsevier
Applied Economic Perspectives and Policy	7	Wiley-Blackwell
International Journal of Consumer Studies	7	Wiley-Blackwell
Journal of International Management	7	Elsevier
Research in International Business and Finance	6,9	Elsevier
Accounting, Auditing and Accountability Journal	6,8	Emerald
Forest Policy and Economics	6,8	Elsevier
Journal of Accounting Research	6,8	Wiley-Blackwell
Marine Policy	6,8	Elsevier
Work, Employment and Society	6,8	SAGE
American Journal of Agricultural Economics	6,7	Wiley-Blackwell
Australasian Marketing Journal	6,7	SAGE
Financial Innovation	6,7	Springer Nature
Socio-Economic Planning Sciences	6,7	Elsevier
Accounting Review	6,6	American Accounting Association

Equilibrium. Quarterly Journal of Economics and Economic Policy	6,6	Instytut Badan Gospodarczych/Institute of Economic Research (Poland)
Asia Pacific Journal of Management	6,5	Springer Nature
China Economic Review	6,5	Elsevier
Critical Perspectives on Accounting	6,5	Elsevier
Emerging Markets Review	6,5	Elsevier
Journal of Population Economics	6,5	Springer Nature
BRQ Business Research Quarterly	6,4	Elsevier
Business Ethics, Environment and Responsibility	6,4	Wiley-Blackwell

Appendix D: List of top 100 peer-reviewed journals Environmental Science

Source title	Cite score	Publisher
Energy and Environmental Science	54	Royal Society of Chemistry
MMWR Surveillance Summaries	43,9	Centers for Disease Control and Prevention (CDC)
Morbidity and Mortality Weekly Report	36,1	US Department of Health and Human Services
Fungal Diversity	35,3	Springer Nature
Applied Catalysis B: Environmental	34	Elsevier
Nature Climate Change	32,4	Springer Nature
Nature Sustainability	30,7	Springer Nature
Chem	29,6	Elsevier
Nature Ecology and Evolution	24,4	Springer Nature
Current Climate Change Reports	21,6	Springer Nature
Applied Energy	20,4	Elsevier
Chemical Engineering Journal	19,4	Elsevier
Conservation Letters	18,7	Wiley-Blackwell
Critical Reviews in Environmental Science and Technology	18,2	Taylor & Francis
Water Research	18	Elsevier
Global Change Biology	17,9	Wiley-Blackwell
Resources, Conservation and Recycling	17,9	Elsevier
Bioresource Technology	17,4	Elsevier
Environment international	17,1	Elsevier
Energy and Environmental Materials	16,4	Wiley-Blackwell
Desalination	16,3	Elsevier
Reviews in Aquaculture	16	Wiley-Blackwell
Reviews in Environmental Science and Biotechnology	16	Springer Nature
Journal of Cleaner Production	15,8	Elsevier

Environmental Chemistry Letters	15,7	Springer Nature
Global Environmental Change	15,7	Elsevier
Frontiers in Ecology and the Environment	15,6	Wiley-Blackwell
Current Opinion in Environmental Science and Health	15,3	Elsevier
Green Chemistry	15,1	Royal Society of Chemistry
Current Environmental Health Reports	14,8	Springer Nature
Environmental Science & Technology	14,8	American Chemical Society
Journal of Hazardous Materials	14,7	Elsevier
MMWR Recommendations and Reports	14,7	Centers for Disease Control and Prevention (CDC)
ACS Sustainable Chemistry and Engineering	14,5	American Chemical Society
Engineering	14,5	Elsevier
Resources, Conservation and Recycling: X	14,5	Elsevier
Wiley Interdisciplinary Reviews: Climate Change	14,5	Wiley-Blackwell
Environmental Science and Technology Letters	14,2	American Chemical Society
ChemSusChem	14,1	Wiley-Blackwell
Science of the Total Environment	14,1	Elsevier
Ultrasonics Sonochemistry	14,1	Elsevier
Environmental Health Perspectives	13,8	US Department of Health and Human Services
npj Clean Water	13,7	Springer Nature
npj Climate and Atmospheric Science	13,7	Springer Nature
Reviews in Fisheries Science and Aquaculture	13,7	Taylor & Francis
Methods in Ecology and Evolution	13,6	Wiley-Blackwell

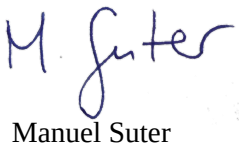
Waste Management	13,5	Elsevier
Energy	13,4	Elsevier
Particle and Fibre Toxicology	13,3	Springer Nature
Biofuel Research Journal	13	Green Wave Publishing of Canada
Environmental Science: Nano	13	Royal Society of Chemistry
Environmental Pollution	12,7	Elsevier
Fish and Fisheries	12,7	Wiley-Blackwell
Landscape and Urban Planning	12,7	Elsevier
Environment and Behavior	12,5	SAGE
Energy Policy	12,4	Elsevier
Journal of Toxicology and Environmental Health - Part B: Critical Reviews	12,4	Taylor & Francis
Green Chemistry Letters and Reviews	12,3	Taylor & Francis
Exposure and Health	12,2	Springer Nature
Journal of Industrial Ecology	12	Wiley-Blackwell
Business Strategy and the Environment	11,9	Wiley-Blackwell
Current Opinion in Environmental Sustainability	11,9	Elsevier
Global Food Security	11,9	Elsevier
Nature Reviews Earth and Environment	11,8	Springer Nature
Chemosphere	11,7	Elsevier
Ecosystem Services	11,7	Elsevier
Earth's Future	11,6	Wiley-Blackwell
Environmental Innovation and Societal Transitions	11,6	Elsevier
Biotechnology for Biofuels	11,5	Springer Nature
Corporate Social Responsibility and Environmental Management	11,5	Wiley-Blackwell

Journal of Environmental Management	11,4	Elsevier
Journal of CO2 Utilization	11,3	Elsevier
Current Forestry Reports	11,2	Springer Nature
Global Sustainability	11,2	Cambridge University Press
Review of Environmental Economics and Policy	11,2	University of Chicago Press
Agronomy for Sustainable Development	11,1	Springer Nature
Current Opinion in Green and Sustainable Chemistry	11,1	Elsevier
Journal of Environmental Sciences	11,1	IOS Press
Global Ecology and Biogeography	11	Wiley-Blackwell
Journal of Advances in Modeling Earth Systems	11	Wiley-Blackwell
Sustainability Science	11	Springer Nature
Ecological Economics	10,9	Elsevier
Trends in Environmental Analytical Chemistry	10,9	Elsevier
Building and Environment	10,7	Elsevier
Computers, Environment and Urban Systems	10,7	Elsevier
Journal of Applied Ecology	10,7	Wiley-Blackwell
Agricultural and Forest Meteorology	10,6	Elsevier
Analytica Chimica Acta	10,5	Elsevier
Conservation Biology	10,5	Wiley-Blackwell
International Journal of Applied Earth Observation and Geoinformation	10,5	Elsevier
Transportation Research, Part D: Transport and Environment	10,5	Elsevier
Agriculture, Ecosystems and Environment	10,3	Elsevier

Ambio	10,3	Springer Nature
Sustainable Environment Research	10,2	Chinese Institute of Environmental Engineering (CIEnvE)
Ecotoxicology and Environmental Safety	10,1	Elsevier
International Soil and Water Conservation Research	10,1	International Research and Training Center on Erosion and Sedimentation and China Water and Power Press
Journal of Pest Science	10,1	Springer Nature
Science China Life Sciences	10,1	Science Press
Wiley Interdisciplinary Reviews: Energy and Environment	10,1	Wiley-Blackwell
Environmental Science and Policy	10	Elsevier

Declaration of authorship

„Ich erkläre hiermit, dass ich diese Arbeit selbständig 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.“



Bern, 03.05.2024 Manuel Suter