Real-time decision support promotes pro-environmental behavior

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Summary: In this controlled online experiment, I show how a transparent decision support environment promotes people's pro-environmental behavior. Participants complete a validated experimental protocol (i.e., the Carbon Emission Task), where they are asked to trade off financial gains and environmental externalities. In a treatment where participants receive decision support via colored feedback, they engage in more pro-environmental behavior than in a neutral control treatment. Furthermore, pro-environmental values positively correlate with corresponding behavior in both treatments. The data does not support the hypothesis that decision support moderates the relationship between pro-environmental values and pro-environmental behavior, or that the correlation between environmental motivation and behavior is moderated to a lesser extent by self-control under the decision support treatment.

Keywords: pro-environmental behaviour, decision support, carbon emission task, behavioral economics, self-control, biospheric values

Entscheidungshilfe in Echtzeit fördert umweltfreundliches Verhalten

Zusammenfassung: In einem kontrollierten Online-Experiment fördert eine Entscheidungsunterstützung umweltfreundliches Verhalten. Die Teilnehmenden absolvieren eine validierte Versuchsanordnung (den Carbon Emission Task), bei dem sie finanzielle Gewinne und externe Umweltauswirkungen gegeneinander abwägen. In der Treatmentbedingung mit Entscheidungshilfen in Form von farbigem Feedback entscheiden sie umweltfreundlicher als in der Kontrollbedingung. Die umweltfreundlichen Werte der Teilnehmenden korrelieren positiv mit dem entsprechenden Verhalten. Hingegen konnte nicht bestätigt werden, dass die Entscheidungshilfe die Beziehung zwischen umweltfreundlichen Werten und umweltfreundlichem Verhalten moderiert oder dass die Korrelation zwischen umweltfreundlichen Werten und Verhalten in der Treatmentbedingung mit Entscheidungshilfen in geringerem Masse durch Selbstkontrolle moderiert wird.

Stichwörter: umweltfreundliches Verhalten, Entscheidungshilfe, Carbon Emission Task, Verhaltensökonomie, Selbstkontrolle, biosphärische Werte

1 Introduction

Limiting global warming to 1.5 instead of 2 degrees Celsius would have clear benefits for natural ecosystems as well as humans according to the Intergovernmental Panel on Climate Change (IPCC, 2018). Without immediate and substantial climate action, the world is facing considerable and irreversible consequences within a few decades. The

reduction of emissions resulting from CO_2 and other greenhouse gases is paramount, and mitigation efforts will involve both the supply as well as the demand side (Creutzig et al., 2022). Mitigating the damage caused by our current behavior will require drastic lifestyle changes on many fronts.

Although many people worldwide believe that humans cause climate change and that it lies in our ability to limit its negative impacts (Carlsson et al., 2021), a discrepancy between people's values and actions has been observed across various domains (Sheeran & Webb, 2016). Research has repeatedly shown that pro-environmental beliefs and values are not always and entirely translated into corresponding behaviors (e.g., Farjam et al., 2019; Wyss et al., 2022). Even though protecting the environment makes people feel good about themselves (Taufik et al., 2015), the context in which people decide can lead them to behave in ways that go against the biospheric values they hold (Steg, 2016). This can explain that although people's environmental values and beliefs have continuously increased since the 1970s, corresponding behavior has often lagged behind (Kennedy et al., 2009). Intriguingly, even people with a relatively high environmental awareness have been shown to behave contrary to their own standards (Juvan & Dolnicar, 2014). This frequently observed attitude-behavior gap has sparked research interest in narrowing or even closing it.

Despite abundant research about the attitude-behavior gap, mitigation efforts have not taken advantage of all available tools for intervention, e.g., by fully integrating the social and behavioral sciences into demand-side solutions (Nielsen et al., 2020). The demand side encompasses the decisions of households and individuals, which account for a considerable share of total emissions. In Switzerland, for example, Rohrer (2021) estimates that about 20 % of the emissions reduction necessary for a sustainable future can be realized by individual behavior change.

In demand-side mitigation, behavioral interventions refer to a class of initiatives that apply a more thorough understanding of the social, cognitive, and contextual factors in decision-making. Behavioral interventions are increasingly part of the policy toolbox (Benartzi et al., 2017). They typically alter the decision environments in an effort also referred to as "choice architecture" to achieve a higher probability of specific options being selected (Weber, 2017).

In the present research, I test the efficacy of a behavioral intervention in a laboratory setting. Using recently established experimental protocols that allow studying personal and environmental tradeoffs, I test the causal impact of real-time decision support, mainly how pro-environmental behavior depends on feedback given at the decision point. I find that real-time decision support promotes pro-environmental behavior on average.

2 Decision support to promote pro-environmental behavior

People's daily consumption decisions offer a considerable chance to alter the trajectory of climate change because of their environmental consequences (IPCC, 2018). A substantial portion of individuals' decisions is shaped by interaction with companies. Oftentimes, companies aim to support their consumers in making pro-environmental or otherwise sustainable choices. For example, consumer labels created by companies assist consumption (Camilleri et al., 2019; Taufique et al., 2022), novel products help people sustain scarce resources such as water (Tiefenbeck et al., 2019), and many customers are offered so-called climate-neutral products via offsetting (Berger et al., 2022). Businesses need to be

careful how they communicate well-intended interventions to their clients. For example, people have been shown to take a company's carbon offset program as a moral license to increase consumption (Günther et al., 2020). There is even evidence that recommendations for voluntary behavioral changes can decrease people's willingness to take action to reduce emissions (Palm et al., 2020). Adverse effects can be difficult to predict, but behavioral research offers different methods to deepen our understanding of what factors influence people's decision process.

One of these methods to deepen our understanding is laboratory research, which can serve as a "wind-channel" to test prospective interventions (Bolton & Ockenfels, 2012; Berger & Wyss, 2021). This way of behavioral economic engineering tests prospective interventions in the lab while analyzing certain psychological mechanisms, and then translates findings into field research by studying real-world behavior. Recent work in environmental psychology has shifted the theoretical thinking away from rational choice approaches (e.g., the theory of planned behavior (Ajzen, 1991)) to self-regulation (Nielsen, 2017). This suggests that not only the intention to act pro-environmentally matters, but equally the self-regulation capacity to align intentions and behaviors. Self-regulation has been identified as an important leverage point in pro-environmental behavior (Nielsen, 2017). Neurological evidence exists that activation in brain regions associated with self-regulation and inhibitory control is linked to pro-environmental behavior (Baumgartner et al., 2019). The concept of self-regulation encompasses people's choice of goals, how they intend to achieve these goals, putting one's plans into action, as well as self-control (Fujita, 2011). Self-control is necessary when we are presented with two mutually exclusive options where one delivers instant gratification and the other supposedly helps us to achieve a (primary) long-term goal (Duckworth et al., 2016). Central concepts of self-control are the ability to override or modify our internal reactions and to refrain from acting according to undesired impulses (Tangney et al., 2004). Self-control has different paths through which it can affect how people act in specific situations. People with higher self-control are more likely to exhibit the behavior that enables them to achieve their goal, but they are also more likely to select themselves into environments that support them in the behavior necessary to achieve their goal (Nielsen & Bauer, 2018).

Understanding self-control only as effortful inhibition would be inadequate, however. Effortful inhibition is a critical component of self-control, but there are other ways how people can advance their distal motivations (Fujita, 2011). In fact, effortful inhibition of impulses should be deemed a last resort for people to reach their environmental goals since prospective strategies can prevent us from even being put in a situation with no other option than to try and resist temptation (Nielsen, 2017). Nevertheless, once confronted with a tempting situation, effortful inhibition can help to shield overriding goals from being compromised by short-term temptations (Nielsen, 2017). It has been suggested that policymakers try to support people by constructing choice settings where the required amount of cognitive control necessary to choose the more sustainable option is kept to a minimum (Langenbach et al., 2019).

The intervention used here is designed in this spirit to facilitate decision-making. The decision support treatment directs participants' focus to their long-term goals. However, this process is not intended to work through deliberation but to offer additional information via intuitively understandable colors. The color red is more likely to be interpreted negatively than green (Krzywinski, 2016). Such a categorization is useful to facilitate

choosing even in a context where people are not aware of their exact preferences and determining them in monetary terms is difficult.

3 The present study

Different approaches have been taken to tackle the problem of overcoming the attitude-behavior gap by targeting newly gained insights into when psychological factors dovetail with behavior. One type of a relatively simple to implement intervention is a label that informs people about the carbon emissions of their choices. People appear to choose more environmentally friendly when presented with information regarding the greenhouse gas emissions associated with specific food options (Camilleri et al., 2019). Another way to help people become more environmentally friendly is to give them real-time feedback on how much energy they are using at the moment (Tiefenbeck et al., 2019).

In the present study, people make a series of trade-offs between pro-environmental choices and environmentally harmful alternatives including a financial bonus. To test the causal impact of decision support, they are randomly assigned to either a decision support condition with color-coded carbon labels or a neutral control condition without any decision support. The color scheme helps participants immediately recognize the trade-off they have to make between a personal financial gain and a pro-environmental choice.

The central hypothesis of this study is that the presence of decision support increases participants' pro-environmental behavior. The second hypothesis is that biospheric values are positively correlated with participants' pro-environmental behavior.

4 Materials and methods

4.1 Open science and ethical statement

The hypotheses were pre-registered. Data, code of statistical analyses, and pre-registration are available via the Open Science Framework (https://osf.io/grxv5/). The experiment was conducted on Prolific, realized using the software oTree (Chen et al., 2016), and analyzed using R (R Core Team, 2020). Only data that matched a pre-registered inclusion protocol were analyzed. As the experiment was a standardized behavioral study involving simple decisions with minimal risk to healthy adult participants, ethical approval was granted via an expedited protocol of the German Society for Experimental Economics. I report all measures, conditions, data exclusions, and sample size decisions.

4.2 Participants and sampling decision

Per budgetary constraint (Lakens, 2022), I recruited a total of 300 participants via Prolific, in exchange for a flat payment of 1.5 GBP and an additional, choice-dependent bonus. Participants were pre-selected to have at least a 90 % approval rating and fluency in English. They needed on average 15 minutes to complete the study and were timed out after a maximal time of 49 minutes. They were told to receive their choice-dependent bonus via Prolific, typically within 2–5 business days. The pre-registered inclusion protocol was the following: I included all participants who correctly answered the comprehension check, the bot check, and the attention check. Additionally, I included all participants who made at least 75 % (i.e., 30) of the trade-off decisions that marked the central dependent variable. Moreover, people with a red-green vision deficiency were removed from the

final dataset since they were not able to draw meaningful information from the decision support treatment. This yielded a final sample of 275 participants from 30 countries (39 % females; mean age: 26.3 years).

4.3 Dependent variable: pro-environmental behavior

I assessed actual pro-environmental behavior through responses in a series of discrete choices, trading off immediate hedonic goals and long-term environmental goals. In the Carbon Emission Task (Berger & Wyss, 2021), a validated experimental protocol to assess pro-environmental behavior, participants face repeated dichotomous trade-offs between a financially rewarding, but environmentally harmful Option A and a financially non-rewarding, but carbon-neutral Option B. This emission is realized through purchases and the retirement of emission certificates from the EU-Emission Trading Scheme, a frequently used method by environmental social scientists to attach actual climate consequences to laboratory behavior (Löschel et al., 2013; Ockenfels et al., 2020; Wyss et al., 2022).

Participants made 40 consecutive choices between the two options. Option A included the emission of 0.23, 1.02, 4.46, or 19.85 lbs. of CO_2 combined with a bonus payment of 1, 2, 3, 4, or 5 GBP. To facilitate the understanding of the amount of CO_2, participants were also shown the approximate distance an average car can drive until said amount is emitted. Option B consisted of no CO_2 emissions and no possible bonus payment. All combinations were displayed twice. One round was chosen at random to determine the actual bonus payment.

4.4 Experimental manipulation

Participants were randomly assigned to one of two conditions, modulating whether or not real-time decision support was given. Participants in the decision support condition were informed that the boxes containing Options A and B would be color-coded. Namely, the color of the box containing Option A indicated how much a specific decision would pollute for a given bonus. Combinations of the lowest possible bonus and the highest possible CO_2 emission featured a red background, whereas the highest bonus combined with the lowest CO_2 value was grey (see Figure 1). Combinations between these two extremes were colored on a linear scale depending on the ratio of each Option A. The box of Option B was always colored green in this condition. Additionally, participants were informed that the accumulated amount of chosen emissions would be displayed by a smoke cloud. A smoke cloud would grow with every choice of Option A. Figure 2 depicts an example of the decision support treatment where the participant has repeatedly chosen the unsustainable Option A, which led to the increase of the cloud. Both options were colored grey in the control condition, and no smoke cloud was shown.

Figure 1: Information provided to participants about the color range from red to grey of Option A in the treatment condition

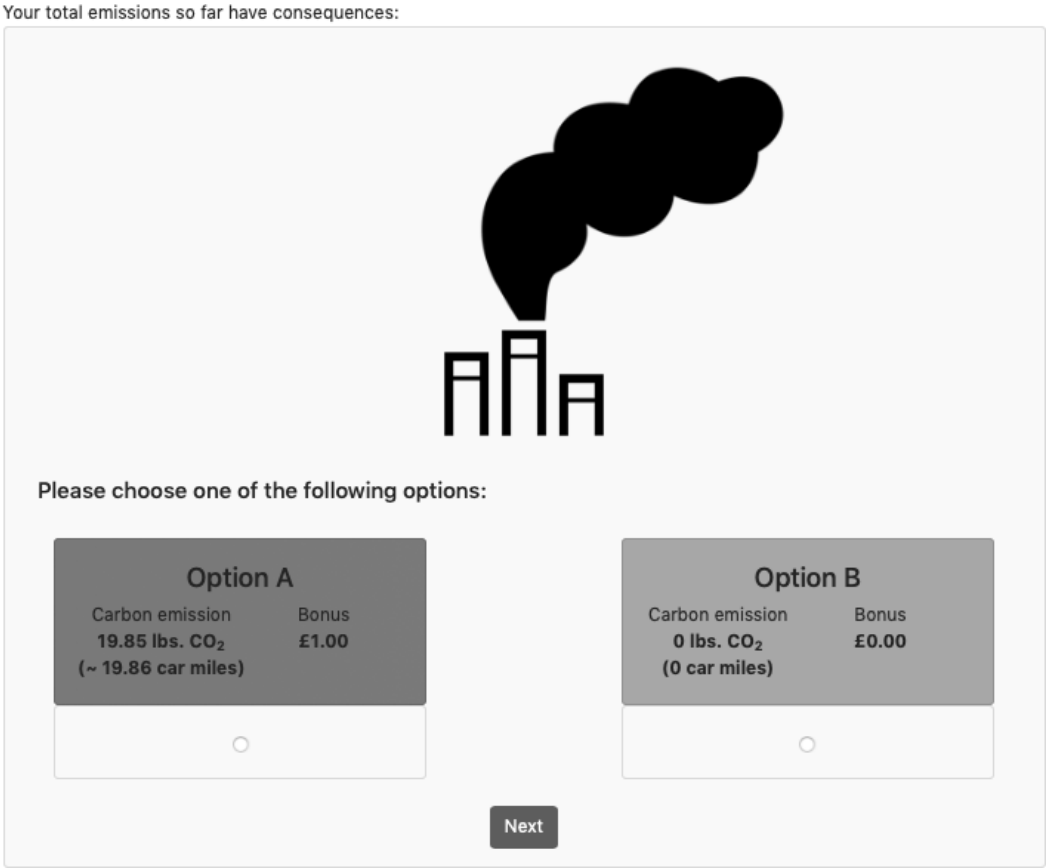

Figure 2: Example of decision support condition with smoke cloud (after choosing Option A repeatedly)

4.5 Post-experimental questionnaire

After the assessment of pro-environmental behavior, participants completed the Social Value Scale (Steg et al., 2012), which includes items reflecting egoistic, hedonic, altruistic, and biospheric values. Biospheric values, which are the relevant dimension for the purpose of this study, were measured with four items: respecting earth, unity with nature, protecting the environment, and preventing pollution. Participants rated the items as "guiding principle in their lives" on a 9-point scale ranging from "opposed to my values" to "of supreme importance". The biospheric values subscale showed a very good internal consistency (Cronbach's alpha =.87). Finally, participants completed a series of demographic

questions, reporting their gender, age, level of highest education, employment, household income, as well as their political orientation.[1]

5 Results

In line with the central hypothesis, average pro-environmental behavior was more pronounced in the decision support treatment than in the control treatment. I found that decision support had an increasing effect on the number of participants' pro-environmental decisions. On average, the percentage of pro-environmental decisions in the treatment condition was about 8 percentage points higher than in the control condition (54.2 % compared to 45.9 %), and the effect was statistically significant, $t(269.57) = -2.3325$, $p = 0.0204$ (see Figure 3). Table 1 includes a more extensive model controlling for demographic variables, where the effect remains statistically significant. Subsequently, I also checked the effect for single decisions in a mixed-effects logistic regression for its robustness, where it persisted (see Supplementary Material Table 3).

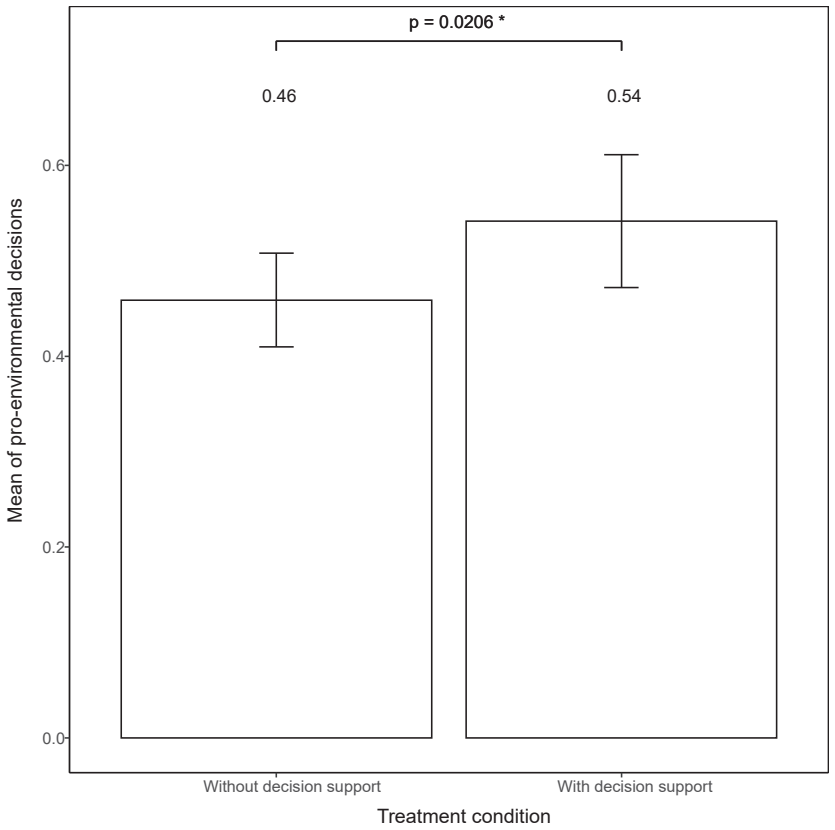

Figure 3: Mean of pro-environmental decisions of participants in the control condition compared to the decision support condition (whiskers indicate 95 % confidence intervals for the simple regression)

1 A scale to measure self-control was also assessed: The Brief Self-Control Scale (Tangney et al., 2004) was administered (Cronbach's alpha = 0.84).

Predictors	Model 1			Model 2		
	Estimates	*CI*	*p*	*Estimates*	*CI*	*p*
(Intercept)	0.46	0.41–0.51	**<0.001**	0.46	0.02–0.89	**0.039**
Decision support (1 if yes)	0.08	0.01–0.15	**0.021**	0.10	0.03–0.17	**0.005**
Age	*NO*			0.00	-0.00–0.01	0.702
Gender (1 if female)	*NO*			*0.09*	0.02–0.16	**0.011**
Education control	*NO*			*YES*		
Income control	*NO*			*YES*		
Political views control	*NO*			*YES*		
Employment control	*NO*			*YES*		
Observations	275			275		
R^2 / R^2 adjusted	0.019 / 0.016			0.255 / 0.153		

Note. CI = 95 % confidence interval. Estimates represent unstandardized beta coefficients.

Table 1: Simple regression of mean of pro-environmental decisions on treatment condition (Model 1) and multiple regression with added control variables (Model 2)

In the analysis of the single decisions, which included the bonus level and the CO_2 to be emitted as independent variables, the effect of the bonus level on participants' decisions becomes apparent. Figure 4 illustrates the respective means of pro-environmental decisions by bonus level and CO_2 emission for all participants. The x-axis combines bonus and CO_2-levels to a single ratio for easier interpretation. Clearly, people seem to decide (economically) consistently within a subset of decisions of the same CO_2-level such that options with a higher bonus level lead to a less pro-environmental choice. However, the ratio of how high the bonus is compared to the CO_2 is not generally decisive. Especially for a bonus level of at least 3 GBP, people on average act less environmentally friendly for a specific carbon level than would be expected if they based their decisions on specific ratios. This was the case in both the treatment and the control condition (see Figure 5).

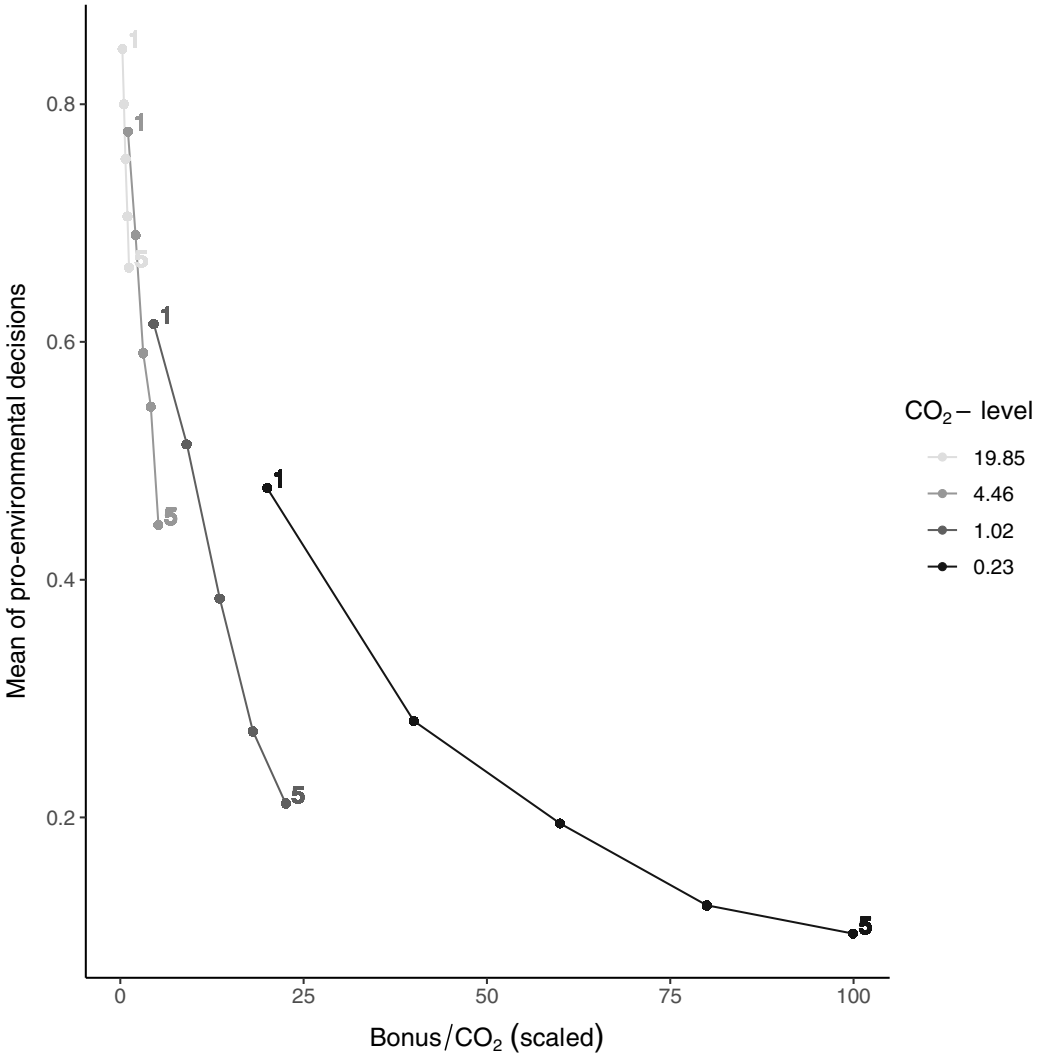

Figure 4: Mean of pro-environmental decisions by bonus in GBP (values 2, 3, and 4 omitted for better readability) and CO_2-level

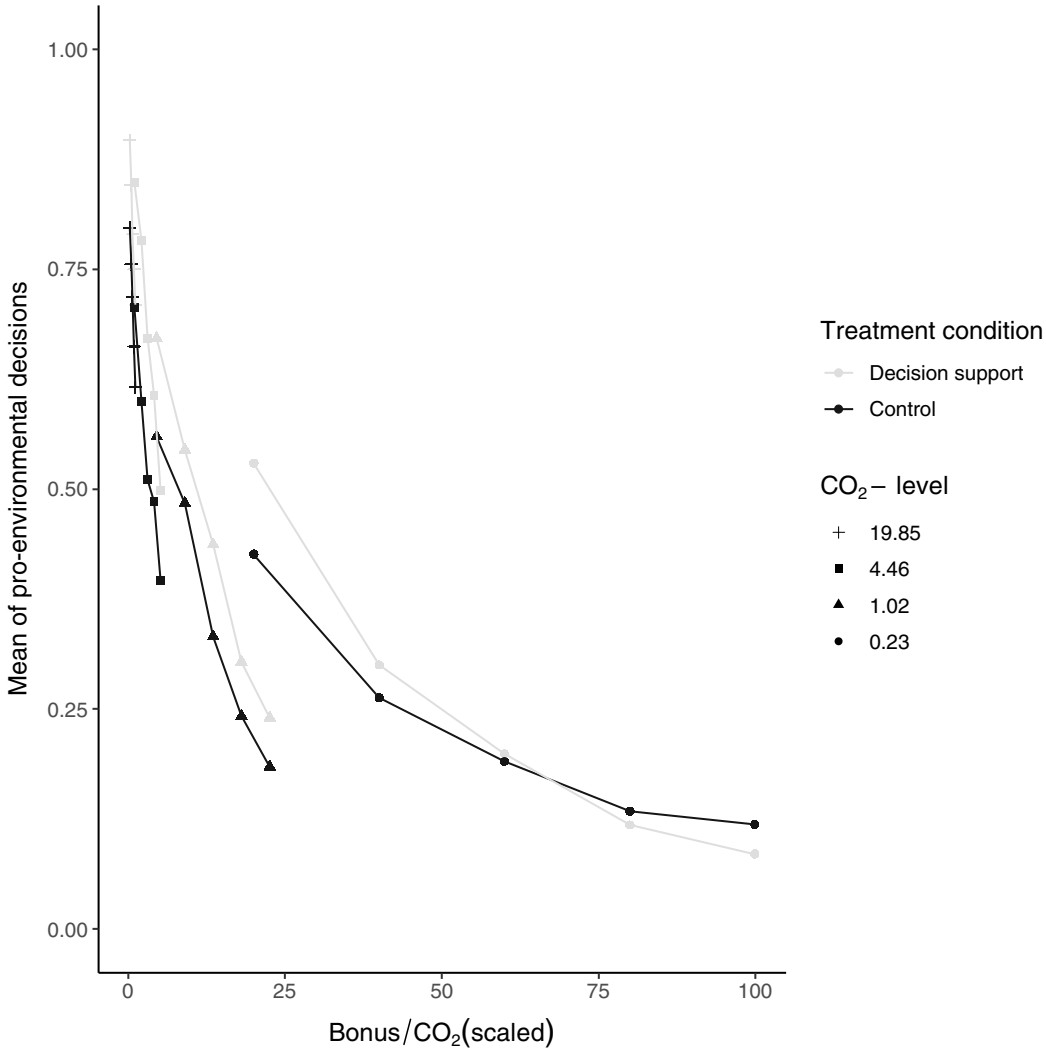

Figure 5: Mean of pro-environmental decisions by bonus (1 GBP to 5 GBP from left to right for each line), CO_2-level, and treatment

As a second hypothesis, I investigated the link of environmental motivation (measured by the biospheric values) with pro-environmental behavior. I find highly significant values for both the simple regression model as well as when controlling for demographic variables (see Table 2). For the respective models, the regression estimates show an increase of 8.4 percentage points (see Figure 6) and a 6.4 percentage point increase in the mean of pro-environmental decisions for an increase in biospheric values of 1. Again, I conducted single decision analyses via mixed-effects logistic regression with participant random effects and bonus and CO_2 fixed effects, adding the controls as above in an additional model (see Supplementary Material Table 4). The effect remains statistically significant.

Predictors	Model 1			Model 2		
	Estimates	*CI*	*p*	*Estimates*	*CI*	*p*
(Intercept)	0.50	0.47–0.53	**<0.001**	0.46	0.07–0.85	**0.022**
Biospheric values (centered)	0.08	0.06–0.11	**<0.001**	0.06	0.04–0.09	**<0.001**
Age control	*NO*			-0.00	-0.01–0.00	0.685
Gender control	*NO*			*YES*		
Education control	*NO*			*YES*		
Income control	*NO*			*YES*		
Political views control	*NO*			*YES*		
Employment control	*NO*			*YES*		
Observations	275			275		
R^2 / R^2 adjusted	0.115 / 0.112			0.288 / 0.190		

Note. CI = 95 % confidence interval. Estimates represent unstandardized beta coefficients.

Table 2: Simple regression of mean of pro-environmental decisions on biospheric values (Model 1) and multiple regression with added control variables (Model 2)

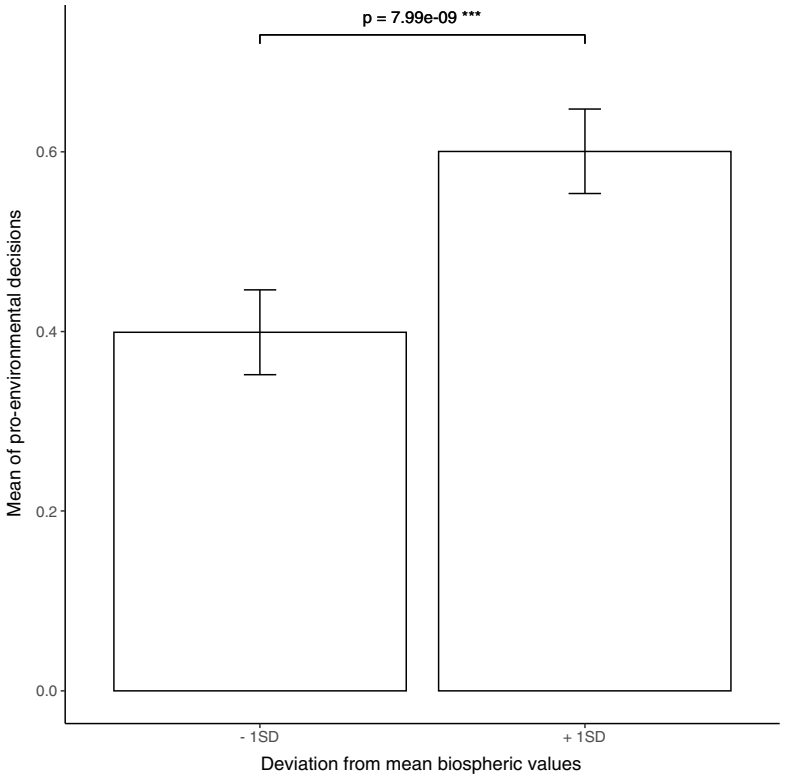

Figure 6: Link of biospheric values and the mean of pro-environmental choices calculated for the simple regression model with one standard deviation below and above the mean of biospheric values, respectively (whiskers indicate 95 % confidence intervals)

Additionally, I pre-registered two more hypotheses, namely that the link of environmental motivation and behavior would be moderated (i.e., higher) in the decision support condition, and that the link of environmental motivation and behavior would be moderated to a lesser extent by self-control under decision support than in the control condition. I do not find evidence for the hypothesized effects (see Supplementary Material Table 5 and Table 6). I will discuss possible implications of these results in the following section.

6 Discussion

While many people show increasing concern about the consequences of climate change, their behavior is often not up to par. Helping people align their actions with their values could prove a promising course for mitigating climate change. Crucially, the psychological mechanisms underlying our decision-making in the environmental context are far from being completely understood. Self-regulation and, more specifically, self-control are considered main targets to improve people's sustainability. One possible avenue to tackle the issue is to design choice environments that support long-term goals rather than short-term satisfaction without taking away people's agency.

In this study, I present a simple intervention that helps participants increase pro-environmental behavior. The numerical information remains the same for both the treatment and the control condition. The main difference is that participants in the decision support treatment are alerted to the ratio of the possible bonus compared to the amount of CO_2 emitted by an easily interpretable color scheme. This simple intervention increases the average amount of pro-environmental decisions by about 8 percentage points. As expected, there is a significant association of biospheric values with pro-environmental behavior in the CET. On average, increased biospheric values are linked to more pro-environmental behavior (about 6.4 percentage points when controlling for demographic variables).

Furthermore, the results of the logistic regressions including the specific CO_2 and bonus values indicate that especially the high financial incentives to behave environmentally harmful (i.e., at least 3 GBP) dominate all other facets of a certain combination of decision variables. Participants appear to no longer consider the exact ratio of bonus to CO_2 emissions with which they are confronted. The bonus values can be considered rather high in this study, since the maximum amount of 5 GBP equals more than triple the amount of the participation fee. This is certainly one aspect to consider when analyzing the link between environmental values and pro-environmental behavior observed in this study. While the overall association is expressed by the results mentioned above, the decision support treatment did not lead to a stronger alignment of biospheric values and the amount of pro-environmental decisions than in the control condition. One possible reason is the comparatively high level of biospheric values in this sample. Overall, the people in the present study showed relatively high pro-environmental values (M = 5.11, SD = 1.2). For example, two out of three samples in the articles by Van der Werff et al. (2013a) (M = 4.79, SD = 1.26, n = 232; M = 5.11, SD = 1.28, n = 50; M = 4.18, SD = 1.46, n = 150), Van der Werff et al. (2013b) (M = 4.73, SD = 1.32, n = 468; M = 5.14, SD = 1.39, n = 138; M = 4.23, SD = 1.28, n = 99) as well as the sample in Nguyen et al. (2016) (M = 2.63, SD = 1.21, n = 682) have significantly lower means (and also larger standard deviations) of biospheric values than the present sample. Thus, while this is by no means conclusive evidence, taken together with the shape of the distribution of biospheric values in my sample (see Figure 7), it appears reasonable to assume that these

participants report their biospheric values to be above average compared to the general population. And even though biospheric values are clearly linked with participant's behavior in the CET, the following closer look at a subset does raise some questions: Out of the 17 people who scored the maximum (7) on the items about biospheric values, only two participants always chose the pro-environmental Option B, whereas four people even chose the unsustainable Option A in each round.

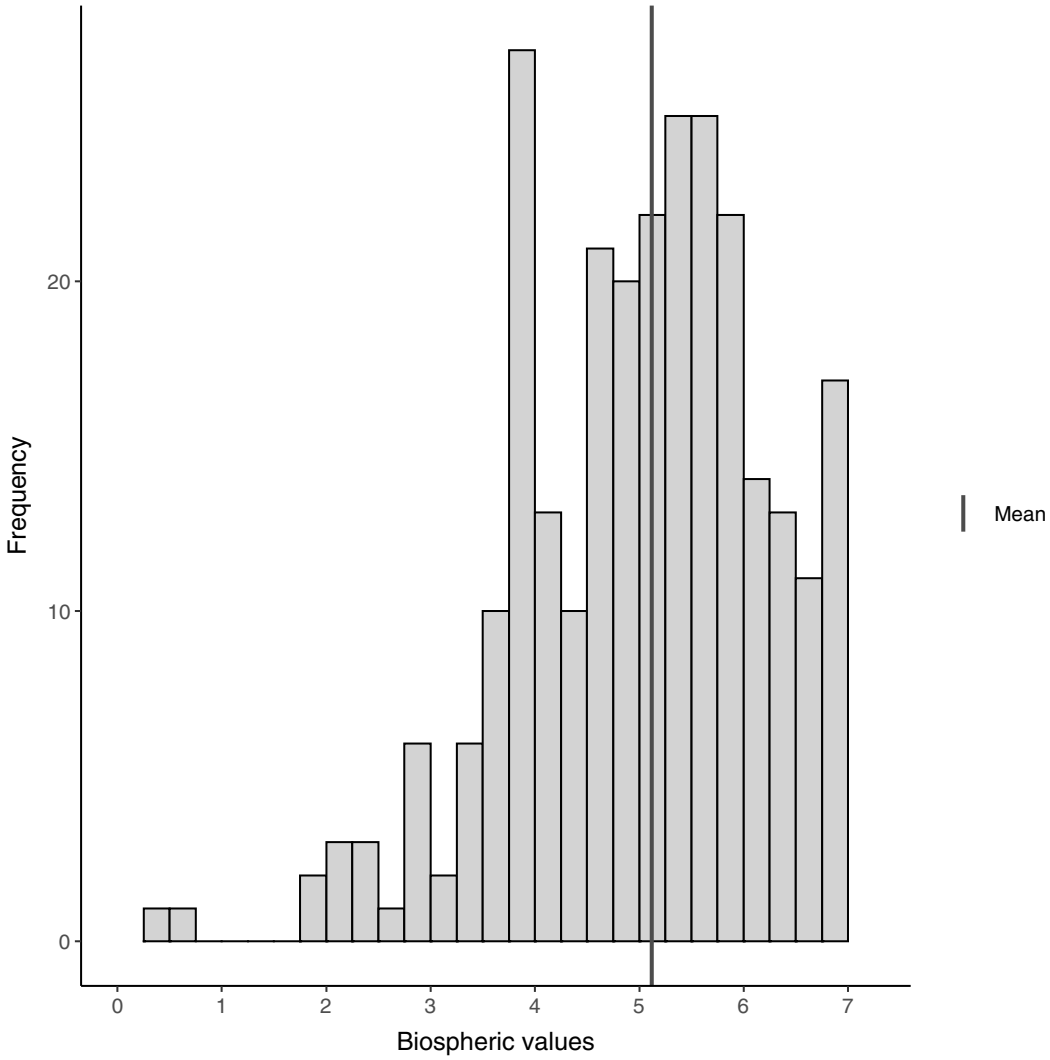

Figure 7: Histogram of biospheric values in the sample

There is no evidence for an effect of self-control on behavior, be it as a main effect or in an interaction. On a purely descriptive level, it can be mentioned that participants with a self-control score above the sample average chose the pro-environmental Option B in about 52.4 % of cases compared to 47.5 % for participants below the sample average. Still, none

of the inferential models identify self-control as a statistically significant factor overall. I reckon the possibly small influence of self-control in this setting was overshadowed by the strong financial incentives discussed above.

The theoretical framework on which I based this study suggests that self-control helps people prioritize long-term goals over short-term gratification (Duckworth et al., 2016). There are different ways how this can be achieved. One possibility is the effortful inhibition of impulses when facing a tempting option. However, effortful inhibition has not been recommended as the optimal solution to this issue. It was rather seen as a measure of last resort when all other self-control strategies have failed (Nielsen, 2017). Crucially, in the choice setting of this study there were no other mechanisms through which self-control could function apart from "simply" resisting temptation. Apparently, even people with a high score on the self-control scale found it challenging to always engage in behavior that was in line with their stated values.

Firms interested in supporting their customers in their decision-making can use the tool presented in this study to make pro-environmental options more salient. The decision support treatment presented works in a context where people have to make quick decisions about CO_2 emissions, a measure that is generally not well known. The benefit of implementing it in the CET is the explicitly measurable financial utility. There are undoubtedly other factors contributing to the utility of specific actions, but they can be difficult or even impossible to quantify. While color-coding is common in our daily lives to steer desirable behavior (e.g., at traffic lights), I have shown that even in a more abstract setting participants react to a simple treatment. There were no hidden mechanisms applied. Participants were informed about the meaning of the stimuli. This is crucial for firms to emphasize a high degree of transparency.

6.1 Limitations

Berger and Wyss (2021) already mention limitations of the CET such as reference-dependence and costs of pro-environmental behavior in practice sometimes consisting of money, but also time, effort, or convenience rather than money. They are also aware that pro-environmental behavior can be financially beneficial in some circumstances.

This study shows that financial incentives still have a very strong effect on people's decisions even in an experimental setting. It is difficult to assess the external validity, although this experiment included real-world consequences. In a real-world setting, personal taste and context-specific norms will most likely have just as strong an impact on consumer decisions as the decision support treatment presented here. Additionally, the sample recruited in this study cannot be assumed to represent the general public. As mentioned above, the environmental values of the participants seem high relative to other studies.

7 Conclusion

The conducted study shows how even when confronted with a rather unknown quantity such as CO_2 emissions people can be supported in their pro-environmental behavior by increasing the salience of available options. The statistically significant increase of about 8 percentage points more pro-environmental decisions in the treatment group compared to the control condition is respectable considering the anonymous experimental setting. I find

no evidence that self-control affected the decisions made by the recruited participants. The literature suggests that effortful inhibition is only one aspect of self-control and may not be strong enough to help people refrain from yielding to temptation. I believe my findings support this view. If businesses want to support their clients in more pro-environmental behavior without limiting their choices, there are other options than only increasing the salience of environmental consequences. One example is giving people the opportunity to limit the choice set voluntarily before deciding.

7.1 Acknowledgements

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7.2 Data and supplementary material

https://osf.io/grxv5

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