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## Climate change denial is associated with diminished sensitivity in internalizing environmental externalities

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E-mail: [sebastian.berger@iop.unibe.ch](mailto:sebastian.berger@iop.unibe.ch)**Keywords:** belief in climate change, pro-environmental behaviour, behavioural tasks, actual behaviour, behavioural economics, climate change mitigationSupplementary material for this article is available [online](#)**Abstract**

Despite a strong scientific consensus about the existence of anthropogenic climate change, widespread scepticism in the general population continues to exist. Past research has largely relied on self-reported behaviours or behavioural intentions when investigating downstream ‘behavioural’ consequences of climate change denial. As a consequence, there remains a large gap in the literature about how belief in climate change interacts with the pursuit of self-interested, environmentally harmful behaviours. To fill that gap, the present research uses a novel, experimental economic paradigm that allows to attach true environmental consequences to laboratory decisions. Based on ~56 000 pollution decisions from 2273 participants in more than 30 countries, we find that belief in climate change meaningfully affects decision-making. Our results show that climate change scepticism predicts self-interested choices and showcases that sceptics have an insensitive acceptance of emissions, reaping benefits no matter how large the climate cost are or how small the personal benefits become. Therefore, our results critically augment meta-analytic evidence arguing that downstream behavioural consequences are small to medium in their effect size. We discuss the use of experimental economic paradigms as a crucial innovation tool for psychological research addressing people’s willingness to engage in climate action.

**1. Introduction**

Anthropogenic climate change has large, irreversible, and detrimental effects on humanity as well as on global ecosystems, making environmental sustainability our most pressing social, cultural, and policy challenge. Experts have established an overwhelming consensus about the rapid need to transform nearly all aspects of our economy, including the energy sector, the transportation sector, or the global food systems, in an effort to achieve a fundamental reduction of greenhouse gases (Hough-Guldberg *et al* 2018). Individual consumption significantly contributes to the total emissions (Ivanova *et al* 2016) and, as a result, experts call for an increased focus on individuals and their decision-making (Ethics Commission for a Safe Energy Supply 2011, Acatech *et al* 2017). Although successful climate change mitigation

will involve political regulation in order to secure global cooperation (e.g. price or quantity regulation of emissions), how people respond to these incentives requires an accurate understanding of human beliefs and behaviours that alleviate or exacerbate emission levels (Creutzig *et al* 2016, Kaiser *et al* 2020). This results in an important role of psychological research in our mitigation efforts (Clayton *et al* 2015, Lange *et al* 2018).

Although intentions and behaviours are not always and fully in line with each other, many people in principle agree that climate change is real, dangerous, and that we have a moral obligation to combat the adverse effects thereof. Yet, a significant share of the population remains doubtful about the existence and anthropogenic origin of climate change. This share remains rather large and ranges between 35% and 46%

depending on the study (Anderegg *et al* 2010, Hall *et al* 2018).

It is therefore not surprising that the environmental social sciences and closely related disciplines have developed a distinct research interest in the causes and consequences of belief (and disbelief) in climate change. Hornsey *et al* (2016) conducted a large meta-analysis synthesizing the existing body of work. The most important results address antecedents of climate change belief, finding that traditional societal fault lines, among them gender, age, race, or income, seem only loosely connected to belief in climate change. In a similar vein, meta-analytical results suggest only a modest association of variables such as education, knowledge, or experience with (extreme) weather events and climate change beliefs. Antecedents with more predictive power are typically rooted in values, ideologies, or preferences for system justification (Hornsey *et al* 2016).

Next to the causes of climate change scepticism, the downstream consequences have similarly been addressed in previous research, also summarized in the extensive meta-study by Hornsey *et al* (2016). The body of research on downstream consequences is largely motivated by the fact that climate scepticism is regarded a prime inhibitor of pro-environmental behaviour and other collective climate action, therefore threatening successful mitigation efforts (Gifford 2011). As our mitigation efforts are urgent and require large-scale consensus about our joint need to act, an exact understanding of the behavioural consequences of climate scepticism is a paramount research task.

Surprisingly, the consequences of climate change scepticism in terms of actual decision-making remain largely unknown. This results from the fact that the research efforts on the downstream consequences of climate scepticism have almost exclusively relied on self-reports of behaviour or on intentions to engage in pro-environmental behaviours<sup>3</sup>. This seems partly driven by a lack of consequential behavioural tasks (Lange and Dewitte 2019). To illustrate, out of 196 studies investigated in the meta-analysis (Hornsey *et al* 2016), merely one investigated actual behaviour and none focused on controlled behaviour under varying incentives. This opens the door for potential measurement bias (e.g. social desirability, recall inaccuracy; Lange *et al* 2018, Lange and Dewitte 2019) and largely ignores the well-documented phenomenon that attitudes do not fully and accurately translate into behaviour, referred to as the environmental attitude-behaviour gap (Kollmuss and Agyeman 2002).

<sup>3</sup> We acknowledge that research on pro-environmental behaviour has to a certain extent relied on actual behaviours (see Lange and Dewitte 2019 for a review). However, to our knowledge, this has not been the case with regard to downstream consequences of belief in climate change.

Thus, a large open spot in the research landscape persists, namely the investigation in how far deniers of versus believers in climate change are actually willing to internalize carbon-related externalities. The present research taps into that blank-spot and employs a novel behavioural task with actual environmental consequences coined the carbon emission task (CET, Berger and Wyss 2021). Because the task uses a within-participants experimental manipulation of the personal and environmental consequences, we can observe to what degree people high versus low in belief in climate change are willing to internalize the associated climate costs of reaping personal benefits. We test if people who deny climate change are largely insensitive to the environmental harm caused by their action, meaning that people who believe in climate change take into account higher carbon cost and lower personal gains and respond with a higher propensity to engage in pro-environmental behaviour. In addition, we expect belief in climate change to correlate positively with average pro-environmental behaviour.

## 2. Methods

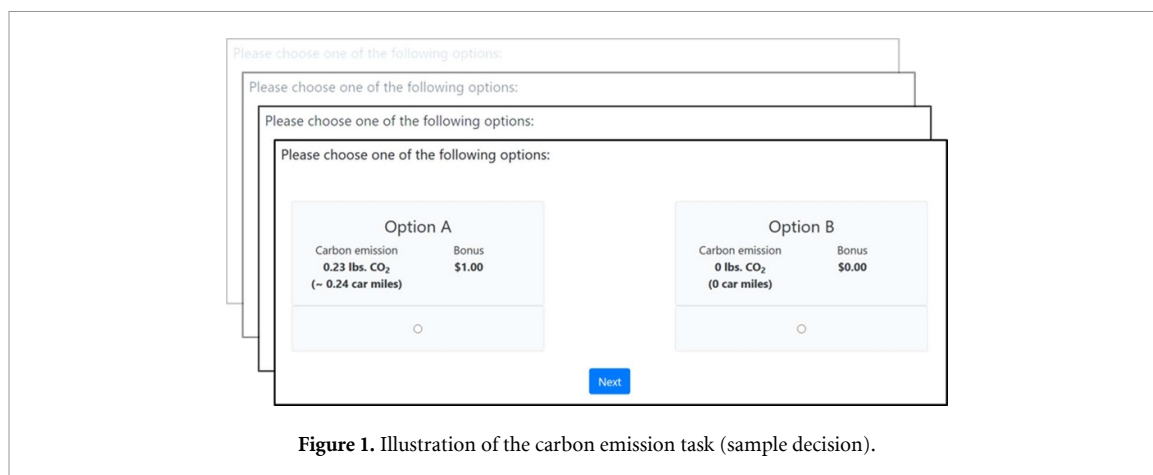
### 2.1. Open science practices

All materials, data, and code to replicate the statistical analyses are available on the Open Science Framework (osf.io/h2r5e). We confirm that we report all experimental conditions (i.e. these are uniquely within participants variations). All data exclusions follow the pre-registered protocol established in Berger and Wyss (2021).

We disclose below how we determined our sample size, including a power sensitivity analysis showing that the smallest detectable effect is smaller than the reported average effect in the meta-study by Hornsey *et al* (2016). For the present research, we collapsed all data we possess as of October 2020 that included the CET with identical payoffs, without an experimental manipulation preceding the assessment of behaviour, and for which we have a measurement of individual differences in belief in climate change. The final sample resulted in eight single experimental sessions involving a total of  $n = 2273$  participants. The descriptive statistics for each session can be found in the supplementary material (available online at [stacks.iop.org/ERL/16/074018/mmedia](https://stacks.iop.org/ERL/16/074018/mmedia)). Study instructions were identical for each session. All participants were recruited through Amazon Mechanical Turk or Prolific.ac. To account for between-session heterogeneity, the respective session was included as a fixed effect in all statistical models.

### 2.2. Sample size determination and participants

Our study is grounded on a high-powered sample with data from 2273 participants (42% female,  $M_{\text{age}} = 35$  years, ranging from 18 to 79 years),



**Figure 1.** Illustration of the carbon emission task (sample decision).

involving roughly 56 000 decisions. The sampling decision followed budgetary constraints (Lakens 2021). As the meta-study published by Hornsey *et al* (2016) offers a good estimate of expected effect sizes—although these are grounded in self-reported behaviours rather than actual behaviour—we can compare our minimum detectable effect to the published average effect size of the correlation of climate change beliefs and self-reported behaviour. As our sample yields a minimum detectable effect of  $\rho = 0.07$  based on an alpha error of 5% and high power of 95%, our study is sufficiently powered to detect a substantially smaller effect than in the meta-study. The 95% CI for the effect of climate change belief on private pro-environmental behaviour is around 0.28–0.35 per visual inspection (see figure 3 in Hornsey *et al* 2016). For each analysis, we used the maximum possible number of participants (i.e. implying that sample sizes vary between distinctive analyses). Throughout the data reported here, participants received a flat compensation plus the varying amount depending on their decisions in the CET. Our study received ethical approval and was conducted in line with the Declaration of Helsinki. All participants gave written informed consent prior to the study.

### 2.3. The carbon emission task

The CET is a validated behavioural experimental paradigm to measure consequential environmental behaviours, which has shown good internal consistency and construct validity (Berger and Wyss 2021). It taps into the individual trade-off between personal short-term gains and long-term environmental goals, therefore directly pitching financial rewards against people's motive to avoid carbon emissions. In the task, people are confronted with a series of decisions about choosing a financially rewarding Option A and a financially non-rewarding, but carbon-neutral Option B (see figure 1).

Potential bonus levels and carbon consequences are fully crossed and randomly presented to decision-makers. The level of rewards were 0.20, 0.40, 0.60,

0.80, or 1.00 USD (Amazon Mechanical Turk) or GBP (Prolific.ac), the level of carbon emissions were 0, 0.23, 1.02, 4.46, or 19.85 lbs CO<sub>2</sub>. Participants received a lump sum payment for participation and the opportunity of an additional bonus, depending on their decisions. One trial is randomly selected for payoff, a method referred to as the 'pay one' method in experimental economics (Charness *et al* 2016). Crucially, the environmental externality attached to choices of Option A is realized through the purchase and retirement of emission certificates through the European Emission Trading System (see Berger and Wyss 2021, for details). Experimental economists increasingly use this method to attach actual environmental consequences to laboratory behaviour (e.g. Tavoni *et al* 2011).

### 2.4. Self-report measures

In addition to the CET, participants completed self-report measures in the same fixed order. As the key interest of this paper, we had participants complete a three-item scale assessing 'Belief in Climate Change' (adapted from Heath and Gifford 2006, Cronbach's alpha >.73 for each individual session, see supplementary material). Particularly, we used three items tapping into the occurrence, causes, and consequences of global climate change. The items were 'Global warming is occurring now', 'The main cause of global warming are human activities', and 'Global warming will bring about some serious negative consequences'. Furthermore, we assessed a self-report measure of pro-environmental attitudes through the New-Environmental-Paradigm Scale-Revised (Dunlap *et al* 2000, Cronbach's alpha >.76 for each individual session, see supplementary material).

Participants answered items on both of these constructs using five-point scales ranging from 'strongly disagree' to 'strongly agree'. We formed composite measures for these two scales, as the underlying constructs are unidimensional. In addition, we collected various demographic variables, among them age, gender, education, income, religiousness, and political orientation on the liberal/conservative spectrum.

**Table 1.** Results from mixed-effects logistic regressions with session fixed effects used to estimate marginal effects plotted in figure 2 (panel A) and control models.

Predictors	Model 1			Model 2			Model 3		
	OR	CI	<i>p</i>	OR	CI	<i>p</i>	OR	CI	<i>p</i>
(Intercept)	0.08	0.05–0.11	<.001	0.05	0.03–0.08	<.001	0.05	0.03–0.10	<.001
Belief in climate change	1.56	1.36–1.78	<.001	1.56	1.36–1.78	<.001	1.38	1.16–1.64	<.001
Carbon emission	1.12	1.11–1.12	<.001	1.12	1.11–1.12	<.001	1.12	1.11–1.12	<.001
Belief in climate change × carbon emission	1.03	1.03–1.03	<.001	1.03	1.03–1.03	<.001	1.03	1.03–1.04	<.001
Gender (1 if female)	—	—	—	1.43	1.15–1.77	.001	1.32	1.05–1.65	.018
Political ideology	—	—	—	—	—	—	0.97	0.91–1.04	.392
Environmental attitudes	—	—	—	—	—	—	1.18	0.95–1.47	.134
Income FE	—	No	—	—	Yes	—	—	Yes	—
Session FE	—	Yes	—	—	Yes	—	—	Yes	—
Random effects									
$\sigma^2$	3.29			3.29			3.29		
$\tau_{00}$	5.92 participant			5.82 participant			5.85 participant		
ICC	0.64			0.64			0.64		
<i>N</i>	2266 participants			2263 participants			2133 participants		
Observations	56 246			56 171			52 937		
Marg. $R^2$ /Cond. $R^2$	0.177/0.706			0.184/0.706			0.180/0.705		

Note: differences in sample size occur due to missing values.

Finally, additional self-reported scales that were not part of the present research question were gathered in some of the sessions. The entire materials are presented in the supplementary material.

## 2.5. Procedure

After giving informed consent, participants first completed the 25 trials of the CET in randomized order. Each participant provided his or her answer within a time limit of 15 s. The time limit was introduced in order to assure a similar duration for each participant in the task. That said, this timing constraint did not restrict any participants. After completion of the CET, participants provided answers to the self-report scales as well as the demographic questions. Finally, participants were thanked and received the notification that their payment would be processed through the platforms (Amazon Mechanical Turk or Prolific.ac).

## 3. Results

### 3.1. Diminished sensitivity of climate change deniers

The results show strong behavioural differences in line with the hypothesis. The more sceptic people are, the less they take into account the environmental externality associated with their choices, and the less sensitive they are to the prospective bonus payments. In contrast, people who believe in climate change are highly reactive to incentives and forego the opportunity to gain financially when the environmental cost are high or when the bonus is low. Thus, the results show that deniers of anthropogenic climate change seize to reap the financial bonus, no matter

how small the personal benefits are or how large the environmental consequences become. Tables 1 and 2 present regressions showing the interaction of belief in climate change and the external incentives (table 1: environmental consequences; table 2: bonus level). Figure 2 plots the interaction.

### 3.2. Belief in climate change correlates with consequential pro-environmental behaviour

Consequently, this diminished sensitivity to personal and environmental incentives affects the sceptics' overall pro-environmental behaviour. Collapsing over all decisions, people's mean emission behaviour is significantly correlated with their belief in climate change, both in terms of the number of unsustainable decisions ( $r_s = .24$ , 95% CI [.20, .28],  $p < .001$ ), as well as with respect to accumulated carbon saved in the 25 choices ( $r_s = .30$ , 95% CI [.27, .34],  $p < .001$ ). Table 3 shows that this result is robust to various statistical controls, among them date and source of data collection (Model 1), gender, education, income (Model 2), as well as political ideology and pro-environmental attitudes (Model 3).

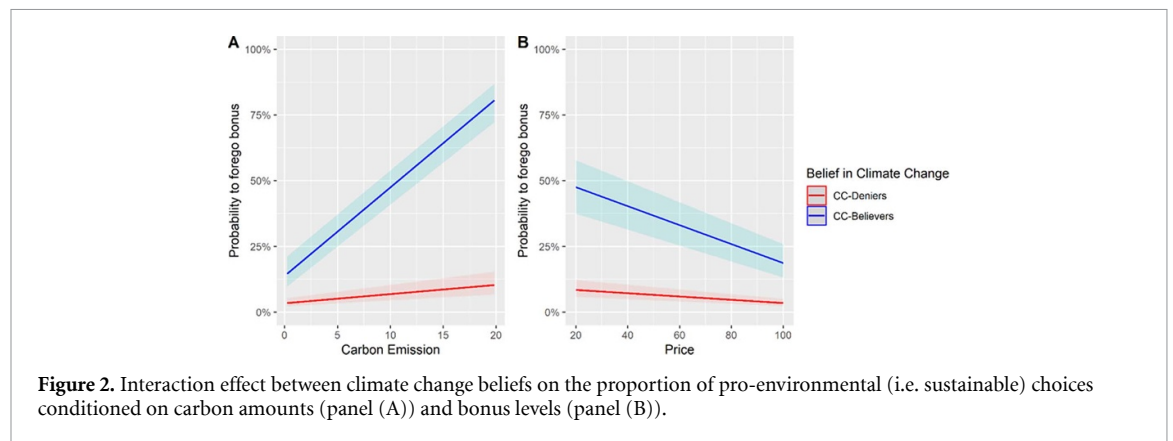
## 4. Discussion

Past meta-analytical research on the downstream behavioural consequences of (dis-)belief in climate change has concluded that 'in terms of the consequences, a salient message from the data is that climate change beliefs have only a modest impact on the extent to which people are willing to act in climate-friendly ways' (Hornsey *et al* 2016, p 625).

**Table 2.** Results from mixed-effects logistic regressions with session fixed effects used to estimate marginal effects plotted in figure 2 (panel B) and control models.

Predictors	Model 1			Model 2			Model 3		
	OR	CI	<i>p</i>	OR	CI	<i>p</i>	OR	CI	<i>p</i>
(Intercept)	0.39	0.27–0.55	<.001	0.26	0.15–0.42	<.001	0.28	0.16–0.48	<.001
Belief in climate change	1.98	1.74–2.27	<.001	1.99	1.74–2.27	<.001	1.79	1.51–2.12	<.001
Bonus level	0.99	0.98–0.99	<.001	0.99	0.98–0.99	<.001	0.99	0.98–0.99	<.001
Belief in climate change × bonus level	1.00	1.00–1.00	.007	1.00	1.00–1.00	.007	1.00	1.00–1.00	.008
Gender (1 if female)	—	—	—	1.38	1.14–1.68	.001	1.28	1.04–1.57	.019
Political ideology	—	—	—	—	—	—	0.97	0.91–1.03	.376
Environmental attitudes	—	—	—	—	—	—	1.17	0.96–1.43	.121
Income FE	—	No	—	—	Yes	—	—	Yes	—
Session FE	—	Yes	—	—	Yes	—	—	Yes	—
Random effects									
$\sigma^2$	3.29			3.29			3.29		
$\tau_{00}$	4.76 participant			4.69 participant			4.73 participant		
ICC	0.59			0.59			0.59		
<i>N</i>	2266 participants			2263 participants			2133 participants		
Observations	56 246			56 171			52 937		
Marg. $R^2$ /Cond. $R^2$	0.132/0.645			0.140/0.645			0.137/0.646		

Note: differences in sample size occur due to missing values.



**Table 3.** Results from linear regression with mean pro-environmental decisions (i.e. average number of foregone bonus opportunity) as dependent variable.

Predictors	Model 1			Model 2			Model 3		
	<i>B</i>	CI	<i>p</i>	<i>B</i>	CI	<i>p</i>	<i>B</i>	CI	<i>p</i>
(Intercept)	0.26	0.22–0.31	<.001	0.19	0.12–0.26	<.001	0.20	0.12–0.27	<.001
Belief in climate change	0.07	0.06–0.08	<.001	0.07	0.06–0.08	<.001	0.06	0.04–0.08	<.001
Gender (1 if female)	—	—	—	0.06	0.03–0.08	<.001	0.05	0.02–0.07	<.001
Education	—	—	—	0.00	–0.00 to 0.01	.270	0.01	–0.00 to 0.01	.253
Political ideology	—	—	—	—	—	—	–0.00	–0.01 to 0.04	.147
Environmental attitudes	—	—	—	—	—	—	0.02	–0.01 to 0.00	.269
Session (dummy coded)	—	Yes	—	—	Yes	—	—	Yes	—
Income category (dummy coded)	—	No	—	—	Yes	—	—	Yes	—
Observations	2266			2263			2133		
$R^2$ / $R^2$ adjusted	0.202/0.199			0.216/0.209			0.212/0.204		

Note: differences in sample size occur due to missing values.

Our research re-assesses this conclusion using a behavioural game attaching actual environmental consequences to laboratory behaviour. In contrast to the findings based on self-reports, our study shows strong behavioural effects in a high-powered sample. People high in scepticism about climate change are largely unresponsive to the environmental harms attached to their behaviour, no matter how small the personal financial benefits are. People who believe in climate change react to environmental harms with lower propensity to accept financial bonuses. This finding is robust to demographic controls. Our results suggest that the effects particularly emerge under specific incentives, an effect that is often masked when using self-reported behaviours that tap into the average propensity to act pro-environmentally.

Our results further show that climate change beliefs are weakly correlated with pro-environmental behaviour when environmental costs are low or personal benefits are high. Thus, similar to research on the environmental attitude-behaviour gap (Kollmuss and Agyemang 2002), we find that belief in climate change are not always and fully reflected in pro-environmental behaviour. One reason for this gap may stem from the lack of cognitive resources, such as self-control capacity (Langenbach *et al* 2020, Nielsen 2017), which refers to people's ability to align their behaviour with their long-term goals. Another potential barrier inhibiting the translation of climate change beliefs into behaviour may result from pessimistic second-order beliefs. Even people who in principle believe in anthropogenic climate change may not act upon their individual belief if they have reasonable doubt that others join their efforts. Climate change mitigation, as a global public good, requires collective action and second-order beliefs may thus undermine individual willingness to act (Jachimowicz *et al* 2018, van der Linden 2021).

Taken together, our results make a conceptual and methodological contribution to the literature on downstream, behavioural consequences of climate scepticism. On the conceptual side, our results call for a further integration of the full spectrum of the social sciences. Using behavioural economic paradigms can be leveraged to study social scientific hypotheses without using self-reports of behaviours while maintaining control over decision-making parameters. Ample evidence showcases that it is not sufficient to draw conclusion based on hypothetical answers or self-reported recalls of past behaviour as much variance remains unexplained (Kormos and Gifford 2014).

On the methodological side, research has thus far established only a weak link of climate change denial and behaviour through an excessive reliance on behavioural intentions or self-reports. Our results show that within-participant manipulation of personal benefits and environmental harms can unravel decision-making patterns that previously remained

hidden, as highlighted by the fact the strongest behavioural difference occurred under strong incentives. Merely observing average pro-environmental behaviour in the CET shows similar effects as presented in the meta-study (Hornsey *et al* 2016).

On the practical side of psychological research on climate change mitigation, our study shows that simple behavioural games may help to move forward environmental social science, similar to the use of games in other fields studying social behaviour (Camerer 2003). However, typical of experimental tasks (Levitt and List 2007), the CET also provides first and foremost qualitative insights into the motivation underlying pro-environmental behaviour. As other games, it does not necessarily allow accurate parameter estimates of real-world trade-offs. Nevertheless, the insights derived from experimental games can substantially contribute to our understanding of the various motives governing pro-environmental behaviour.

Finally, understanding the relationship between climate change beliefs and behaviour may help us to design optimal policy responses. There is a strong consensus that climate change mitigation requires institutions that 'govern the commons' and experimental economics has delivered crucial insights into how beliefs and cooperative behaviour are causally linked and leveraged by institutions (Ockenfels *et al* 2020).

## Data availability statement

The data that support the findings of this study are openly available at the following URL/DOI: <https://osf.io/c5rde/>.

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## References

- Acatech *et al* 2017 *Annual Report 2017*
- Anderegg W R L, Prall J W, Harold J and Schneider S H 2010 Expert credibility in climate change *Proc. Natl Acad. Sci.* **107** 12107

- Berger S and Wyss A M 2021 Measuring pro-environmental behaviour using the carbon emission task *J. Environ. Psychol.* **75** 101613
- Camerer C 2003 *Behavioural Game Theory: Experiments in Strategic Interaction* (Princeton, NJ: Russell Sage Foundation, Princeton University Press)
- Charness G, Gneezy U and Halladay B 2016 Experimental methods: pay one or pay all *J. Econ. Behav. Organ.* **131** 141–50
- Clayton S, Devine-Wright P, Stern P C, Whitmarsh L, Carrico A, Steg L, Swim J and Bonnes M 2015 Psychological research and global climate change *Nat. Clim. Change* **5** 640–6
- Creutzig F, Fernandez B, Haberl H, Khosla R, Mulugetta Y and Seto K C 2016 Beyond technology: demand-side solutions for climate change mitigation *Annu. Rev. Environ. Resour.* **41** 173–98
- Dunlap R E, van Liere K D, Mertig A G and Jones R E 2000 New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: a revised NEP scale *J. Soc. Issues* **56** 425–42
- Ethics Commission for a Safe Energy Supply 2011 Germany's energy transition—a collective project for the future
- Gifford R 2011 The dragons of inaction: psychological barriers that limit climate change mitigation and adaptation *Am. Psychol.* **66** 290–302
- Hall M P, Lewis N A and Ellsworth P C 2018 Believing in climate change, but not behaving sustainably: evidence from a one-year longitudinal study *J. Environ. Psychol.* **56** 55–62
- Heath Y and Gifford R 2006 Free-market ideology and environmental degradation: the case of belief in global climate change *Environ. Behav.* **38** 48–71
- Hornsey M J, Harris E A, Bain P G and Fielding K S 2016 Meta-analyses of the determinants and outcomes of belief in climate change *Nat. Clim. Change* **6** 622–6
- Hough-Guldberg O *et al* 2018 Chapter 3: impacts of 1.5 °C global warming on natural and human systems *Global Warming of 1.5 °C. An IPCC Special Report on the Impacts of Global Warming of 1.5 °C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty* (Geneva: IPCC Secretariat)
- Ivanova D, Stadler K, Steen-Olsen K, Wood R, Vita G, Tukker A and Hertwich E G 2016 Environmental impact assessment of household consumption: environmental impact assessment of household consumption *J. Ind. Ecol.* **20** 526–36
- Jachimowicz J M, Hauser O P, O'Brien J D, Sherman E and Galinsky A D 2018 The critical role of second-order normative beliefs in predicting energy conservation *Nat. Hum. Behav.* **2** 757–64
- Kaiser M, Bernauer M, Sunstein C R and Reisch L A 2020 The power of green defaults: the impact of regional variation of opt-out tariffs on green energy demand in Germany *Ecol. Econ.* **174** 106685
- Kollmuss A and Agyeman J 2002 Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behaviour? *Environ. Educ. Res.* **8** 239–60
- Kormos C and Gifford R 2014 The validity of self-report measures of proenvironmental behaviour: a meta-analytic review *J. Environ. Psychol.* **40** 359–71
- Lakens D 2021 Sample size justification *Working Paper* (available at: <https://psyarxiv.com/9d3yff/>)
- Lange F and Dewitte S 2019 Measuring pro-environmental behaviour: review and recommendations *J. Environ. Psychol.* **63** 92–100
- Lange F, Steinke A and Dewitte S 2018 The pro-environmental behaviour task: a laboratory measure of actual pro-environmental behaviour *J. Environ. Psychol.* **56** 46–54
- Langenbach B P, Berger S, Baumgartner T and Knoch D 2020 Cognitive resources moderate the relationship between pro-environmental attitudes and green behavior *Environ. Behav.* **52** 979–95
- Levitt S D and List J A 2007 What Do Laboratory Experiments Measuring Social Preferences Reveal About the Real World? *J. Econ. Perspec.* **21** 153–74
- Nielsen K S 2017 From prediction to process: A self-regulation account of environmental behavior change *J. Environ. Psychol.* **51** 189–98
- Ockenfels A, Werner P and Edenhofer O 2020 Pricing externalities and moral behaviour *Nat. Sustain.* **3** 872–7
- Tavoni A, Dannenberg A, Kallis G and Loschel A 2011 Inequality, communication, and the avoidance of disastrous climate change in a public goods game *Proc. Natl Acad. Sci.* **108** 11825–9
- van der Linden S 2021 Reflections and projections on a decade of climate science *Nat. Clim. Change* **11** 279–85