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Bridging Individual Behavior and Technological Solutions in Climate Change Mitigation

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Abstract

Effectively combating climate change requires a dual approach: individual and industrial transformation. However, to mitigate climate change the synergies between individual Pro-Environmental Behavior (*PEB*) and climate engineering techniques, such as Carbon Capture and Storage (*CCS*), have often been neglected, thereby promoting only one of them. This study examines the relationship between *PEB* and the acceptance of *CCS*, taking into account attitudes toward climate change, norms, trust, and uncertainty aversion. Our analysis of survey data reveals a positive relationship between *PEB* and the acceptance of *CCS*, with *PEB* serving as a mediator linking attitudes toward climate change to *CCS*-acceptance. Our findings demonstrate the urgency of advancing *PEB* and technology-integrated strategies for climate mitigation. Therefore, this study contributes to the ongoing conversation about how to combine technological solutions with individual actions to successfully mitigate climate change.

Keywords

Pro-Environmental Behavior, Carbon Capture and Storage, Technology Acceptance, Attitudes, Climate Change

JEL Classifications

Q54, Q55, Q58

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1 Introduction

Reducing our carbon footprint is crucial in the fight against climate change. Significant reductions in CO_2 emissions are needed to meet the temperature target set by the 2015 Paris Agreement (UNFCC, 2016) and will require industrial and individual efforts. Industries could make use of climate engineering technologies, such as Carbon Capture and Storage (*CCS*), while individuals can contribute by adopting pro-environmental behaviors (*PEB*s).

At the recent United Nations Climate Change Conference (COP28 UAE), *CCS* was highlighted as a promising technique that might be pivotal in contributing to our efforts against climate change (Fridahl et al., 2023).[1] In 2024, the Federal Ministry for Economic Affairs and Climate Action in Germany outlined the main features of a carbon management strategy and introduced a proposed revision to the Carbon Dioxide Storage Act, which could potentially enable the application of *CCS* (and CCU).[2] This also includes the transport and offshore storage of CO_2. *CCS* is discussed as a possible key solution to reducing CO_2 emissions for industrial sources, as it has the potential to either remove carbon from the atmosphere or directly capture it from industrial sources (IPCC, 2022). By reducing CO_2 emissions from large-scale sources such as fossil fuel power plants and industrial generators, *CCS* could prevent the premature closure of fossil fuel power plants, thereby reducing the risk of a disruption to the security of the electricity supply (Spiecker et al., 2014). However, excessive reliance on climate engineering techniques may diminish the perceived urgency of adopting *PEB*s (Cologna et al., 2024). The exclusive reliance on *CCS* may also prove inadequate, as the current pace of technological advancement does not yet enable sufficient CO_2 capture, and certain sectors, such as the cement industry, remain challenging to decarbonize (IPCC, 2005).

At the individual level, it is possible to contribute to a reduction in future greenhouse gas emissions by engaging in pro-environmental behaviors (*PEB*s). *PEB* encompasses a range of behaviors that significantly impact the environment. These include environmentally conscious practices within the private sphere, such as conserving water, optimizing energy usage, minimizing plastic pollution, and selecting eco-friendly transportation options. Furthermore, within the public sphere, individuals can demonstrate their commitment to good environmental practices by, for instance, actively advocating for such practices or signing petitions (Stern, 2000; Kollmuss and Agyeman, 2002; Steg and Vlek, 2009). Nevertheless, *PEB* may also be insufficient in isolation due to the significant contributions of industrial and systemic sources to CO_2 and other greenhouse gases.

Mutually exclusive approaches are worrisome because overreliance on either technological solutions or behavioral changes alone reduces the likelihood of achieving established climate change mitigation goals. Consequently, there is a significant need for a societal and industrial transformation process, changing individual behavior but also implementing innovative industrial techniques to

[1] See also https://carbonremovals.org/

[2] In contrast to *CCS*, Carbon Capture and Utilization (CCU) does not store CO_2 underground; rather, it makes use of CO_2 to produce carbon-containing products, such as cement or textiles.

achieve climate change goals. Both, societal and industrial transformation processes require public adaption and acceptation. The objective of this study is to examine the relationship between *PEB* and acceptance of *CCS*, as both factors may relate to each other. We also consider factors such as increased awareness of the problem (i.e., knowledge and attitudes toward climate change), trust in institutions, perceived effectiveness of institutions to deal with climate change, and uncertainty aversion as they may have a significant impact on both, *PEB*s and *CCS*-acceptance.

Despite the limited public familiarity with negative emission technologies (Carlisle et al., 2020), acceptance of *CCS* remains low (e.g., Zuch and Ladenburg, 2023; Dütschke et al., 2015, 2016). Acceptance involves a positive attitude without active campaigning, as opposed to support, which involves promoting through actions such as discussing its benefits with others. Conversely, opposition involves active opposition, such as public protests (Arning et al., 2021). The acceptance of climate technologies may vary due to the differing functionalities of such technologies. For instance, *CCS* significantly intervenes in the natural environment, which lead to differing perceptions of these technologies compared to non-intervening alternatives, such as afforestation (Fenn et al., 2023). As a consequence, the acceptance of technologies that may have an impact on the environment and on climate change may be influenced by individuals' attitudes, feelings, and fears about the environment and climate change.

Research indicates a relationship between increased environmental awareness, environmental knowledge, and certain types of *PEB* (Hines et al., 1987; Kaiser and Fuhrer, 2003; Frick et al., 2004; Meinhold and Malkus, 2005; Pothitou et al., 2016; Geiger et al., 2018; Amoah and Addoah, 2021).[3] People that exhibit *PEB* have been found to hold a positive attitude toward the environment, to feel more connected to nature (Kals et al., 1999; Perkins, 2010; Schultz, 2001; Mayer and Frantz, 2004; Gkargkavouzi et al., 2019; Krettenauer et al., 2020)[4], and to possess a 'green' self-image (Binder and Blankenberg, 2017). Furthermore, they are generally high in climate anxiety (Ogunbode et al., 2022; Mathers-Jones and Todd, 2023; Gao et al., 2021).

People who are concerned about climate change may also be concerned about the well-being of the environment. This heightened concern may lead to an increased risk perception of *CCS*, potentially resulting in the rejection of climate engineering techniques that significantly intervene and impact the environment (Wallquist et al., 2011). Another argument posits that individuals who view technology as a solution to environmental problems may be reluctant to alter their lifestyle in order to protect the environment. This 'rebound-effect' implies that individuals who strongly rely on technological solutions may not fully acknowledge the importance of individual *PEB*. Consequently, they may not engage in *PEB* that necessitates personal changes (Gigliotti, 1992, 1994; Grob, 1991; Santarius and Soland, 2018) and climate change adaptive behavior (Stoll-Kleemann et al., 2001; Lorenzoni et al., 2007; Gardezi and Arbuckle, 2020). In a recent study, Cologna et al. (2024) show that the highly optimistic beliefs that technologies will be the solution to all problems are negatively

[3] For an early discussion of this relationship, see Kollmuss and Agyeman, 2002.

[4] See Mackay and Schmitt, 2019 for a meta-analysis of this relationship

associated with pro-environmental behavioral intentions, mediated by decreased concerns about climate change.

On the other hand, the increased risk perception may also lead to a higher acceptance level of new technologies that mitigate the consequences of climate change. Thus, acceptance may also be influenced by an individual's trust in the effectiveness of the specific technology. Cologna et al. (2024) exhibit that optimistic and pessimistic technology views lead to higher *PEB*, mediated by an increased concern for climate change. Furthermore, Berthold et al. (2022) have shown that the awareness of environmental constraints, such as resource scarcity, increases the adoption of *PEB* and the acceptance of new sustainable technologies. Thus, it is reasonable to assume that individuals who perceive climate change as a more serious issue are more likely to be in favor of *CCS* (e.g., Braun et al., 2018). Accordingly, we hypothesize, as pre-registered, that *PEB* is positively related to the acceptance of *CCS*. That is, the acceptance of *CCS* is higher the more people behave pro-environmentally.

Our hypothesis is critical to address, as public opposition can be a significant obstacle to the adoption of new technologies, and can even lead to the complete failure of new policies without proper public involvement. Introducing new environmental legislation without sufficient involvement of affected industries, municipalities, or the general public can lead to resistance and delays. For instance, the public concern about the environmental and seismic impact of hydraulic fracturing (fracking) has led to bans and moratoriums in several countries (e.g., Zhang et al., 2021).

Investigating whether environmental awareness is related to the acceptance of technologies promoted to protect the environment, such as *CCS*, is key to understanding the relationship between the two. As public support increases, political openness and endeavors to support the further development and implementation of *CCS* are likely to follow.

Previous research on individual attitudes toward technologies, including *CCS*, also indicates that attitudes are shaped by prior experience, knowledge, and familiarity (Dowd et al., 2014; Huijts et al., 2012; Linzenich et al., 2019; Wallquist et al., 2010). These attitudes influence the perceived risks and benefits and, consequently, the acceptance of the corresponding technology (Bearth and Siegrist, 2016; Jobin and Siegrist, 2020; Siegrist et al., 2000).[5] Consequently, an additional analysis of these factors is undertaken, in which we are able to identify subgroups among the general population that differ in their perceptions and attitudes toward *CCS*. This complements the overall results.

The findings of this study support the hypothesis that individuals who exhibit *PEB* have higher levels of *CCS*-acceptance. Furthermore,our results indicate that *PEB* mediates the effects of different variables on the acceptance of CCS: *PEB* fully mediates the relationship between attitudes and norms concerning climate change, as well as risk aversion. Moreover, *PEB* mediates the impact of climate change knowledge, ambiguity aversion as well as the perceived effectiveness and trust

[5] Research suggests that acceptance of *CCS* decreases when perceived risks outweigh perceived benefits. Conversely, acceptance diminishes when perceived benefits are outweighed by perceived risks (Arning et al., 2021; Huijts et al., 2007; Kraeusel and Möst, 2012; Linzenich et al., 2019).

in institutions. While effectiveness and trust also directly bolster *CCS*-acceptance. Furthermore, the analysis identified three distinct subclasses within the sample, each exhibiting unique attitudes towards *CCS*.

The remainder of this paper is structured as follows. Section 2 describes our survey data, including all elicited variables. Section 3 presents the results, followed by a discussion (Section 4) and the conclusion in Section 5.

2 Data

This paper uses the data of the 18th wave of the Planetary Health Action Survey (PACE) (see Jenny et al., 2022), a serial cross-sectional online survey with the aim to assess the general population's readiness to act against the climate crisis in Germany. The sample was non-probabilistic and quota-representative for age (18–74 years), gender (crossed) and federal states (not crossed). The survey was conducted in September 2023, with 1005 participants residential in Germany, via bilendi. We pre-registered our hypothesis prior to data collection (AsPredicted #144203).

The complete survey comprises eight distinct Sections, each focusing on a specific theme. A comprehensive overview of the procedure and an overview of all variables used and coded in this study can be found in Appendix A.[6]

2.1 Sample

We have 1002 respondents, that completed the survey and passed plausibility checks during the survey.[7] The sample includes 494 respondents being male and 504 being female, four respondents are classified as diverse. The average age of the respondents is 44 years ($SD = 14.99, Min = 18, Max = 74$). 60.58% of respondents have a university entrance qualification and 75.75% are employed. On average, 2.45 people live in each household ($SD = 1.29$), and 32.83% of the respondents have children.

2.2 Variables

The variables are presented in the order in which they appeared in the survey. The precise wording of the questions, the available response options, and the coding of the variables are provided in Appendix A.

To assess the determinants of the acceptance of *CCS*, we elicit the following variables additionally

[6] A comprehensive version of the questionnaire in German (the language of implementation), is accessible in the Supplementary Material, see `https://osf.io/e3mbt/`.

[7] An a-priori power analysis, pre-registered at AsPredicted (#144203) using G*Power, with an effect size of f = 0.05, alpha err prob = 0.05, Power (1-beta err prob) = 0.95 and Number of predictors = 12, predicts a total sample size of 528, with a power of 0.9501.

to *‘Acceptance of CCS’*: Awareness of *CCS*, Knowledge about *CCS*, personal norms on *CCS*, and attitudes toward *CCS*. In Section 3.3, we utilize these variables to identify specific subgroups within the population.

We initially assess prior awareness of *CCS* (*‘Awareness’*) by asking “Have you heard of carbon capture and storage (CCS) before this survey?”. Following this, we administered a set of eight binary (yes/no) knowledge-based questions to evaluate their existing comprehension of *CCS* (*‘CCS-Knowledge’*), with higher values, indicating more knowledge on *CCS*. Afterwards, participants were provided with the correct answers to the knowledge questions, followed by a short briefing on *CCS*.[8] In order to ensure the utmost neutrality, the information was formulated with the utmost care, taking into account the potential strong reactions of respondents who are unfamiliar with *CCS* (e.g., Pidgeon et al., 2012).

Following the briefing, we elicit our main dependent variable the degree of acceptance of *CCS*:

> “I am in favor of the use of Carbon Capture and Storage (CCS) in Germany” (*‘Acceptance CCS’*)

This variable is measured on a seven-point Likert scale, with higher values indicating a higher degree of acceptance. Subsequently, personal norms regarding *CCS* are elicited through the administration of a seven-point Likert scale, with higher values indicating a higher degree of agreement. Participants are asked to rate their level of agreement with the following statement: “If my friends and family knew about Carbon Capture and Storage (CCS), most of them would be in favor of it being deployed in Germany.” (*’Norm CCS’*).[9]

Additionally, respondents evaluated *CCS* on five dimensions using a seven-point semantic differential scale. The dimensions are unavoidable - avoidable, useful - useless, long-term - short-term, harmless - dangerous, and cheap - expensive. Based on a factor analysis, we create the variable *’Indispensable’* that is based on items unavoidable, useful and long-term, whereas the two other dimensions (*’Harmless’*, and *’Cheap’*) are used as requested in the questionnaire. The dimensions are coded, that higher values relate to unavoidable, useful, long-term, harmless and cheap.

To examine the relationship between *PEB* and the acceptance of *CCS*, a number of additional variables are elicited. These include *PEB*, as well as knowledge, attitudes and norms related to climate change. In addition, we elicit perceived efficacy of political measures, social norms on *PEB*, trust in institutions and uncertainty aversion.

[8]“To counteract climate change, Germany is currently discussing how to reduce carbon dioxide (CO_2) in the air. One possibility is Carbon Capture and Storage, or CCS for short. This is a process in which CO_2 is captured and stored in the ground. The CO_2 can come from the air, industry or power plants. It is injected into the ground either directly at the source or after injected into the ground, on land or in the seabed. The CO_2 mineralizes in the soil and is thus permanently stored as carbonate (rock)”.

[9]The question is designed to elicit the perceived acceptance of the social environment of the individual. As previous research has demonstrated that peers and reference groups exert a significant influence on an individual’s beliefs, attitudes, and behaviors (e.g., Welsch and Kühling, 2009; Levy and Razin, 2019; Köbrich León and Schobin, 2022), we postulate that an individual’s beliefs about the acceptance of their family and peers may also influence their own acceptance of technologies, creating a perceived personal norm.

According to Lange and Dewitte (2019), *PEB* can be assessed using a variety of methods, including self-reported assessments, field studies, and experimental approaches. Self-reported *PEB* can measures both, general behavior and specific actions (e.g., Binder and Blankenberg, 2017; del Saz Salazar and Pérez y Pérez, 2021). We assess *PEB* using a 20-item questionnaire that measures participants' self-reported behavior in four thematic blocks: housing and energy, mobility, food, and (other) consumption behaviors, capturing a wide range of *PEB*.[10] Environmental knowledge includes awareness of environmental problems and possible solutions. Studies have found a significant correlation between *PEB* and environmental knowledge (Amoah et al., 2018; Cologna et al., 2022). Similarly, knowledge about climate change also appears to influence the acceptance of *CCS* (Dowd et al., 2014). Consequently, we assess knowledge about climate change (*'Knowledge CC'*) that is derived from a series of 15 multiple-choice knowledge questions (see Table 7 in the Appendix A). These questions cover a diverse range of topics, including carbon emission trading, consequences of climate change, diet, and emissions.

To elicit attitudes toward climate change, we incorporate perceived personal risks associated with climate change, climate-related anxiety, and emotions. Additionally, we elicit perceived efficacy of climate policy measures.[11] In evaluating the perceived risk to one's own life posed by climate change (*'Risk of CC'*), participants are asked to rate the likelihood of experiencing various potential impacts in their personal lives. These include the spread of fomites, extreme weather events, pollution of air and water, and mental health problems. Subsequently, participants assess the perceived danger of these climate change consequences. The probability is multiplied by the respective severity.

Climate *'Anxiety'* is assessed using a semantic differential. Participants express their feelings toward climate change on three dimensions using the statement: "For me, climate change is ..." The three dimensions are 'something I think about all the time - something I never think about', 'frightening - not frightening', and 'worrisome - not worrisome'.

Personal emotions about climate change (*'CC Emotion'*) are measured by participants' responses to 13 statements about the consequences of climate change, such as "I am plagued by nightmares about climate change". All variables pertaining to attitudes toward climate change are coded in such a way that higher values indicate a greater degree of concern for climate change.

The perceived effectiveness of political measures (*'Effectiveness'*) for climate protection is measures by asking participants a general question about the effectiveness of current political measures and evaluating four specific measures related to cars, coal, oil and gas heating, and nutrition.

Social norms are defined as the behaviors that are commonly practiced and accepted within a society. These norms are informal rules that a group agrees upon, outlining behaviors that are required, allowed, or prohibited based on collective beliefs about appropriate actions in a specific context (Krupka and Weber, 2013; Ostrom, 2000; Goerges and Nosenzo, 2020). Injunctive norms

[10] Table 5 in the Appendix A presents the items and answer options.

[11] For information on the precise wording of the questions and the generation of the variables, see Section A in the Appendix.

refer to perceptions of what people believe they should do, while descriptive norms refer to perceptions of what people actually do. Klaus et al. (2020) find that norms strongly influence acceptance of various climate technologies, including *CCS*. In our measures, participants have to evaluate seven items related to descriptive norms on *PEB* ("People who are important to me exhibit the following behaviors:") *'Dnorm'* and seven items related to injunctive norms on *PEB* ("People who are important to me expect the following behaviors from me:") *'Inorm'*. The seven items are identical for both descriptive and injunctive norms, whereby higher values imply more of the corresponding behavior or higher expectations.

There is a considerable evidence that trust in institutions can have a significant impact on the acceptance of climate engineering techniques, including *CCS* (Fenn et al., 2023; Huijts et al., 2007; Glanz and Schönauer, 2021; Terwel et al., 2009; Wallquist et al., 2011; Offermann-van Heek et al., 2018). This survey specifically asks respondents to rate their *'Trust'* in institutions, either specific individuals or organizations, to deal with the climate crisis.[12]

Another important factor in technology adoption is uncertainty (Barham et al., 2014). It is reasonable to assume that it may also influence citizens' attitudes toward new sustainable technologies, such as *CCS*, especially when there is uncertainty surrounding them. Uncertainty has two components: Risk and Ambiguity. Risk aversion is aversion to a set of outcomes with a known probability distribution, while ambiguity aversion is aversion to uncertainty about the probabilities of outcomes. Both measures have been shown to be common characteristics of economic behavior (Barham et al., 2014; Klibanoff et al., 2005; Halevy, 2007). We elicit respondents' risk aversion (*'Risk aversion'*) and ambiguity aversion (*'Ambiguity aversion'*) using a variant of the Ellsberg urns (e.g., Halevy, 2007).

In the following Section, we use these variables to examine their relationship to *PEB* and *CCS*-acceptance in order to provide a more complete understanding of the dynamics at play and to increase the robustness of our findings on the relationship between *PEB* and *CCS*-acceptance.

3 Results

3.1 Attitudes toward Carbon Capture and Storage

The study indicates that a diverse range of opinions exists regarding *CCS*. Specifically, 29.34% of participants express opposition to *CCS*, 38.02% indicate support for it, and 32.63% are neutral.[13] We find prior knowledge of *CCS* to be low. Only 34.93% of participants are aware of *CCS* before taking part in the study. Accordingly, a notable 7.68% of participants answered two or fewer questions correctly, in contrast to the 8.59% who got seven or all eight questions right. The median number of correct responses to the eight questions is four, indicating that participants have a generally limited

[12] Specifically, the following institutions are rated: "your doctor", "science", "public media", "European Union (EU)", "Robert Koch Institute", "Federal Ministry of Health", and "Federal Government".

[13] Participants' responses are classified as opposing if their response is below four, neutral for responses equal to four, and in favor for responses larger than four on a seven-point Likert scale.

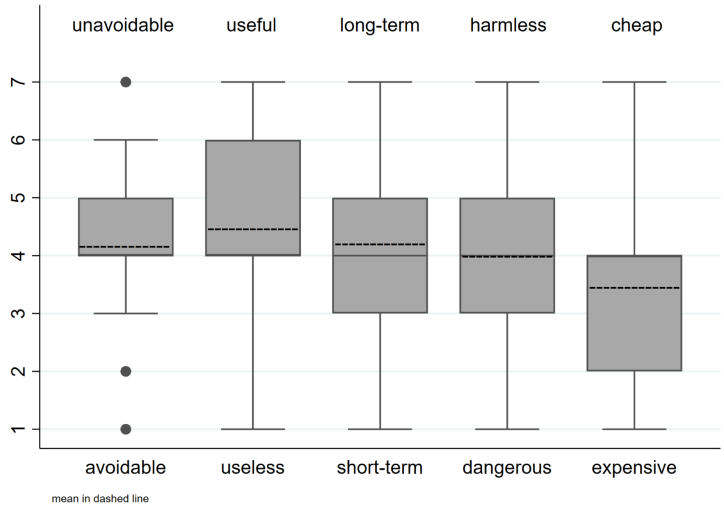


Figure 1: Evaluation of *CCS*

understanding of *CCS*, given the binary nature of the response options. This observation aligns with existing research, underscoring a widespread lack of knowledge and understanding about *CCS* among the general public across various countries (e.g., Huijts et al., 2007; Kraeusel and Möst, 2012; Dowd et al., 2014; Chen et al., 2015; Braun et al., 2018; Akerboom et al., 2021).[14]

Figure 1 illustrates the participants' evaluation of *CCS* as a climate change mitigation strategy, across five dimensions. The median value for all dimensions is four, indicating a neutral position. Nevertheless, there is a notable disparity in the distribution and mean values of these dimensions. Our findings indicate that the (un)avoidable dimension has the narrowest range of responses. Additionally, the majority perceive *CCS* as useful yet costly. Ratings for the time-related dimension (short-term versus long-term) and the harmless-dangerous dimension mostly hover around the middle values (three to five).

3.2 Mediation Analysis

Regarding our main hypothesis, we find that *PEB* positively correlates to the acceptance of *CCS* ($r = 0.194, p = 0.000$). Variables related to climate change (*Risk of CC*, *CC Emotions* and *Anxiety*), as well as *Trust* in institutions, uncertainty and norms, all significantly correlate with *CCS*-acceptance, while at the same time being significantly correlated with *PEB*.[15] Given the apparent intercorrelations between the explanatory variables, a mediation analysis is conducted to distinguish between direct and indirect effects, with the latter being mediated through *PEB*.

[14] For an overview about the awareness of *CCS* in the European Union, we refer to Toma et al. (2014).

[15] All variables correlate significantly at $p < 0.05$ with *PEB* and *CCS* (see Table 9 in Appendix B). The correlation between *Riskaversion* and *PEB* has a p-value of 0.057, while *Ambiguity* has a p-value of 0.076.

Table 1: Structural Equation Model

	(1) PEB	(2) CCS	(3) PEB	(4) CCS
PEB		0.133*		0.145*
		(0.065)		(0.066)
Risk of CC	0.048	-0.083	0.037	-0.082
	(0.029)	(0.057)	(0.029)	(0.057)
Anxiety	0.313***	-0.025	0.280***	-0.017
	(0.033)	(0.067)	(0.033)	(0.067)
CC Emotion	-0.220***	0.078	-0.160***	0.054
	(0.033)	(0.066)	(0.034)	(0.068)
Effectiveness	0.079*	0.383***	0.094*	0.368***
	(0.037)	(0.072)	(0.037)	(0.073)
Knowledge CC	0.070***	0.057**	0.067***	0.052**
	(0.010)	(0.020)	(0.010)	(0.020)
Dnorm	0.350***	-0.066	0.310***	-0.049
	(0.038)	(0.077)	(0.038)	(0.078)
Inorm	-0.007	0.075	-0.004	0.070
	(0.040)	(0.077)	(0.039)	(0.078)
Trust	-0.095**	0.281***	-0.069*	0.273***
	(0.033)	(0.065)	(0.033)	(0.066)
Risk aversion	0.080**	-0.033	0.069*	-0.018
	(0.030)	(0.058)	(0.030)	(0.058)
Ambiguity aversion	-0.052	-0.142*	-0.059*	-0.140*
	(0.030)	(0.059)	(0.030)	(0.059)
Age			0.010***	-0.005
			(0.002)	(0.004)
Female			0.171**	-0.080
			(0.055)	(0.110)
Higher Education			-0.015	0.131
			(0.057)	(0.113)
No children			0.109	0.142
			(0.059)	(0.116)
Constant	-0.651***	3.564***	-1.194***	3.718***
	(0.096)	(0.191)	(0.136)	(0.280)
var()	0.633***	2.375***	0.605***	2.362***
	(0.030)	(0.112)	(0.029)	(0.112)

Table notes. Estimation method: maximum likelihood; N = 893; OIM standard errors in parenthesis; $^{*}p \leq 0.05$, $^{**}p \leq 0.01$, $^{***}p \leq 0.001$.

Table 2: Indirect Effects

Variable	Coefficient
Risk of CC	0.006
	(0.005)
Anxiety	0.042*
	(0.021)
CC Emotions	-0.029*
	(0.015)
Effectiveness	0.011
	(0.007)
Knowledge CC	0.009*
	(0.005)
Dnorm	0.047*
	(0.023)
Inorm	-0.001
	(0.005)
Trust	-0.013
	(0.008)
Risk aversion	0.011
	(0.007)
Ambiguity aversion	-0.007
	(0.005)

Table notes. Standard errors in parenthesis; $^{*}p \leq 0.05$, $^{**}p \leq 0.01$,$^{***}p \leq 0.001$.

Table 1 presents the results of our structural equation model, displaying the direct effects of our independent variables of interest on *PEB* in Model 1 and on *CCS* in Model 2. Model 3 and 4 control for socio-economic variables and show that the results remain robust. The results of Model 2 indicate that the coefficient of *PEB* has a significant positive effect ($\beta = 0.133$) on the acceptance of *CCS*. Regarding our variables related to climate change, neither the perceived risk of climate change nor anxiety and emotions significantly affect the acceptance of *CCS*. However, *Anxiety* has a highly significant positive effect ($\beta = 0.313$) on *PEB*. Thus, those who are more anxious about climate change tend to behave more environmental friendly. In contrast, individuals who express negative emotions toward climate change exhibit significantly less *PEB* ($\beta = -0.220$). The perceived risk of climate change to one's own life has a positive effect on *PEB* ($\beta = 0.048$). However, the value is only marginally significant ($p = 0.099$).

Table 2 provides estimates of the respective indirect effects on the acceptance of *CCS*, mediated by *PEB*. It shows, that *PEB* fully mediates *Anxiety* and *CC Emotions* by enhancing the positive effect of anxiety by 0.042 standard deviations, while the negative effect of emotions is enhanced by - 0.029 standard deviations. Risk aversion and descriptive norms also have a significant positive effect on *PEB*. The effect of descriptive norms ($\beta = 0.350$) is also fully mediated by *PEB*, with an increase of 0.047 points in standard deviations. The effect of risk aversion ($\beta = 0.080$) is solely observed on *PEB*. We find no effect of injunctive norms, neither on *PEB*, nor on *CCS* acceptance.

Perceived effectiveness of political measures, trust in institutions, knowledge about climate change and ambiguity aversion significantly affect both, *PEB* and the acceptance of *CCS*. The higher the perceived effectiveness, and the higher the knowledge about climate change, the higher the acceptance of *CCS* and the more people behave pro-environmental friendly. The effect of knowledge ($\beta = 0.057$) on acceptance is further enhanced by the mediator *PEB*, with an additional 0.009 points of standard deviation. Higher trust in institutions also leads to higher acceptance, while leading to lower *PEB*. *PEB* even mediates the effect of trust on acceptance by diminishing the effect by - 0.13 points of standard deviations. However, the mediating effect is only significant at the 10%-level. Figure 2 displays the path diagram showing the mediating effect of *PEB* for knowledge on climate change and for trust in institutions. People high in ambiguity aversion show less pro-environmental friendly behavior ($\beta = -0.052$), but more acceptance of *CCS* ($\beta = -0.142$). For ambiguity aversion, *PEB* has no mediating effect, while the effect of ambiguity aversion on *PEB*, is only significant at 10%.

Notes: standardized β-coefficients.

Figure 2: Path diagram illustrating the indirect effects on acceptance of *CCS* via *PEB*

Figure 3 summarizes our main findings. According to our results, *PEB* has a full mediating effect for the variables attitudes and descriptive norms on climate change and risk aversion. That means these variables only have an indirect effect on *CCS* through *PEB*. Knowledge about climate change, ambiguity aversion as well as effectiveness of policies and trust in institutions affect both, *PEB* and acceptance of *CCS*, with *PEB* mediating the effect of knowledge and trust. In conclusion, the acceptance of *CCS* is influenced by multiple variables. Supporting our hypothesis, we find that *PEB* is related to the acceptance of CSS and has a fully mediating effect for variables related to climate change and uncertainty as well as trust in institutions and effectiveness of political measures.

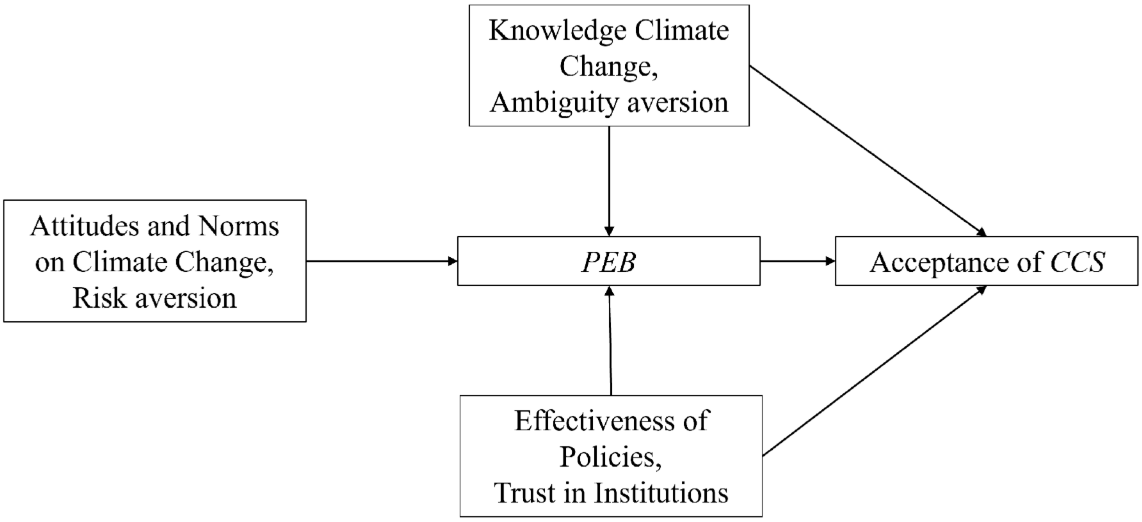


Figure 3: Relations between Variables

3.3 Subgroups and their Attitude toward *CCS*

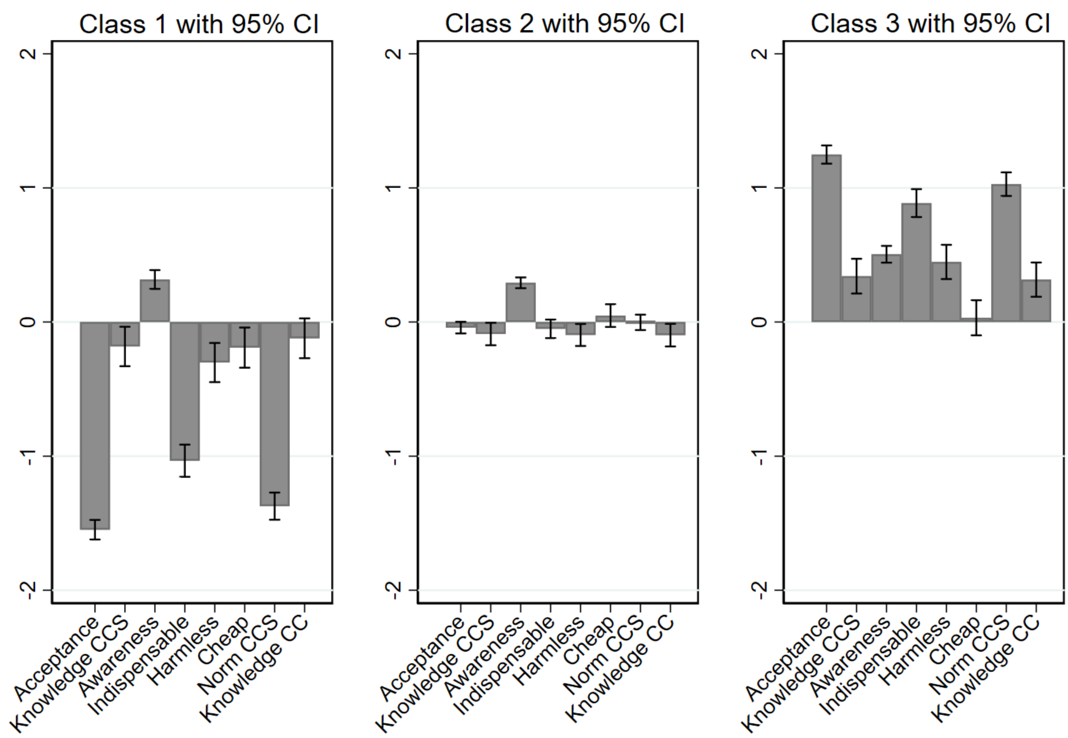
As previous studies have shown, acceptance of a particular technology is also influenced by attitudes toward that technology (e.g., Arning et al., 2019). Our findings indicate that attitudes toward *CCS* vary across our sample. Thus, we test for distinct subclasses within our sample by conducting an exploratory analysis, as pre-registered, to investigate how knowledge (about climate change and *CCS*), perceived attitudes toward *CCS*, and personal experiences with *CCS* are related to acceptance of *CCS*. In order to achieve this objective, we employ a latent class analysis (LCA). Given our expectation of the existence of distinct subclasses within our population, this approach allows us to gain a more nuanced understanding of those who reject (accept) *CCS*.

Factors strongly and positively correlated with *CCS*-acceptance include *CCS*-specific variables such as the index *Indispensable* ($r = 0.631$) and *Norms CCS* ($r = 0.765$). Compared with this, the correlation with *CCS* is moderate for the variable *Harmless* ($r = 0.254$) and low for the variable *Cheap* ($r = 0.074$).

In Figure 4 we display the marginal effects with 95% confidence intervals of the three classes we obtain from the LCA for the included variables. To enhance comparability, standardized variables are used.[16] An examination of the distribution of respondents across the three classes reveals an intriguing pattern: the classes are distinguished by varying degrees of acceptance of *CCS*. 18.36% of respondents are classifies to Class 1 with lower acceptance than the mean, while 24.68% are classified to Class 3, having a higher acceptance than the mean. The remaining 56.96% are classified as belonging to Class 2. In this class, the acceptance of *CCS* is insignificant, indicating that *CCS*-acceptance does not exert a significant influence on the membership of this specific class.

[16] In Table 10 in the Appendix the corresponding coefficients are displayed.

Class 1 includes respondents who are reluctant to accept *CCS*, have rarely heard of *CCS* before, have limited knowledge of climate change, and exhibit negative attitudes toward *CCS* across the board. Notably, they appear to strongly believe that their family and friends would also oppose the introduction of *CCS*. Class 3, which includes respondents who are more likely to accept *CCS*, is determined by whether they have heard of *CCS* before, their level of knowledge about climate change and *CCS*, and their evaluation of *CCS*. They evaluate *CCS* positively on all dimensions except the monetary factor, which has no effect. They also believe that their family and peers would evaluate *CCS* in a positive light.



Notes: Standardized variables are used, except for *Awareness* that is a dummy variable that equals 1 of the person has heard of *CCS* before this study. The mean values of the variables are presented, with bars representing the 95% confidence interval.

Figure 4: Latent Class Analysis

However, the majority of respondents are classified as belonging to Class 2, which is characterised by having rarely heard of *CCS* before, have a rather limited understanding of climate change and *CCS*, and view *CCS* as somewhat dangerous.[17]

[17] It should be noted that including *PEB* in the LCA would not alter the results. *PEB* would remain significant in all three classes, with relatively low *PEB* in Classes 1 and 2 and higher *PEB* in Class 3. This further supports the finding that individuals who engage in pro-environmental behaviors are more willing to accept *CCS*.

4 Discussion

A positive relationship between environmentally friendly behavior and the acceptance of *CCS* was observed. Moreover, *PEB* serves as a mediator, thereby increasing the indirect effects of anxiety and emotions. While anxiety positively affects *PEB*, more negative emotions and feelings toward climate change are associated with less *PEB*. These findings seem counterintuitive. Anxiety about climate change might positively influence *PEB* because it motivates individuals to take actions to mitigate their concerns, often increasing their sense of personal efficacy and leading to increased cognitive engagement with environmental issues. In contrast, negative emotions, such as despair or hopelessness, may lead to feelings of helplessness, thereby reducing the likelihood of engaging in *PEB* by reducing perceived control and efficacy. This may result in decreased motivation to act and to avoidance behaviors, as individuals may feel their efforts are senseless or overwhelming. However, as these are only suggestions, more research is needed to understand these emotional effects in order to create more effective environmental communication strategies that motivate positive action while countering the paralyzing effects of negative emotions.

Knowledge about climate change is a significant factor in influencing environmentally friendly behavior and acceptance of *CCS*. We find knowledge to have a direct effect on the acceptance of *CCS* and on *PEB*, and that the effect on acceptance is even enhanced by the mediating role of *PEB*. In addition, it is not only knowledge about climate change that is important, but also knowledge about *CCS*. Individuals with a higher level of knowledge about both tend to exhibit a higher level of acceptance of *CCS* (see Figure 4). Therefore, efforts to enhance acceptance should concentrate on expanding awareness of both climate change and *CCS*, as well as *PEB*. The enhancement of *CCS*-related knowledge may foster more informed engagement, positively impacting contact and evaluation, thereby fostering a more positive predisposition toward acceptance. The specific nature of these information campaigns is beyond the scope of this study and presents opportunities for further research.

The relationship between trust in institutions and *CCS*-acceptance and *PEB* is complex. While trust in institutions tends to lead to higher acceptance of *CCS*, it also tends to result in less environmentally friendly behavior. This latter effect mediates the effect of trust on *CCS*-acceptance. The challenge of devising effective strategies to combat climate change is particularly evident in this context. On the one hand, measures such as enhancing trust in institutions can have a direct, positive impact on the acceptance of new technologies, such as *CCS*. However, at the same time, they can also have an indirect, negative impact on acceptance through the mediator *PEB*. Nevertheless, the positive effect of trust on acceptance is considerably more pronounced than the counter effects of the mediator *PEB*.

As with trust, the perceived effectiveness of policy measures has a strong influence on the acceptance of *CCS*. These findings suggest that acceptance of *CCS* requires not only the communication of efficacy, but also the demonstration of tangible results and reliability in order to build public trust and confidence.

The results of the meditation analysis and the exploratory analysis showed the significant influence of descriptive norms on *PEB* and personal norms on the acceptance of *CCS*. Descriptive norms, which refer to the perceived behavior of the social environment, are positively related to *PEB*, have a large effect size, and are also strengthened in their effect by *PEB*. In addition, personal norms regarding *CCS* exert a strong influence on the profile of people who either accept or reject *CCS*. Consequently, the social environment and personal beliefs about the behaviors and attitudes of peers appear to be an important factor influencing not only one's own environmentally conscious behavior but also attitudes toward new technologies such as *CCS*.

Risk aversion affects acceptance only through *PEB*, on which it has a significant positive effect, with the more risk averse being more likely to engage in *PEB*. In contrast, ambiguity aversion has a negative effect on acceptance, with individuals who do not like unknown events being more likely to oppose *CCS*. This is consistent with previous research indicating that ambiguity aversion is an important factor in technology adoption (Barham et al., 2014), and should therefore be considered in future research.

Another notable finding is that we find monetary considerations to be relevant only for those who oppose *CCS*, while it is not an argument for those who accept *CCS*. This suggests that acceptance may be based on environmental considerations rather than costs, as these people tend to see *CCS* as indispensable. This distinction highlights the different priorities and motivations between groups, which could inform targeted communication and policy strategies to address specific concerns and barriers.

In order to develop effective measures to combat climate change, it is essential to understand the indirect effects of climate change and their magnitude. Our study thus provides a first indication of how to promote both the acceptance of *CCS* and environmentally friendly behavior. This understanding is crucial for developing communication and policy strategies that are aligned with the values, behaviors and norms of environmentally conscious individuals. It will ensure that the development and deployment of these technologies are consistent with the beliefs of the individuals involved, ultimately strengthening our collective response to environmental challenges.

Methodological limitations arise from the fact, that *PEB* is measured by self-report. While self-report methods for measuring *PEB* may be biased (Lange and Dewitte, 2019; Blankenberg et al., 2023), it would be nice to use other approaches to measure pro-environmental behavior in the next step. Furthermore, it would be beneficial to assess risk and ambiguity aversion in an incentivized manner. Nevertheless, it is notable that the observed results align with the anticipated outcomes, indicating that more precise measures may potentially yield even more robust results.

5 Conclusion

This study highlights the important influence of Pro-Environmental Behavior (*PEB*) on attitudes toward Carbon Capture and Storage (*CCS*). Our research demonstrates that *PEB* not only directly correlates with increased acceptance of *CCS* but also mediates the relationship between variables related to climate change and *CCS*-acceptance. Increasing awareness of climate issues and mitigating the negative effects of ambiguity aversion are crucial for fostering acceptance of *CCS*. Moreover, trust in institutions and the efficacy of political measures play essential roles in shaping positive attitudes toward *CCS*. Our findings suggest that a comprehensive approach that encompasses technological innovations, trust-building, and effective communication strategies are an important part of addressing the global problem of climate change. Our results also indicate considerable variability within the population, underscoring the need for targeted communication strategies that address specific misconceptions and provide actionable information. Such tailored approaches, particularly those that leverage social norms, are likely more effective than one-size-fits-all solutions in promoting environmental behaviors and acceptance of new technologies. The presented insights help to guide policymakers and stakeholders in developing targeted strategies that align with broader environmental goals, potentially accelerating the transition to a sustainable and climate-resilient future. This research sets the stage for future studies to refine these strategies and assess their effectiveness across different groups differing in attitudes, norms and behaviors. In order to effectively address climate challenges, we highlight the need for a dual approach that combines technological solutions with behavioral changes. We advocate for policies that simultaneously promote *PEB* and technological innovations like *CCS*, which require public participation in their development and implementation. It is important to focus on both strategies and not to ignore one of them.

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CrediT authorship contribution statement

Melanie Dunger: Conceptualization, Formal analysis, Investigation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision, Project administration **Janina Kraus:** Formal analysis, Writing - Original Draft, Writing - Review & Editing, Visualization

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Details of the methods used in the PACE survey are provided online (www.pace-studie.de / https://osf.io/e3mbt/).

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A Questionnaire and Variables

Table 3: Knowledge Questions *CCS*

	Question	Correct answer
1.	Is CCS a method of generating clean energy like wind or solar power?	No
2.	Can carbon capture and storage (CCS) processes capture CO_2 directly at factories?	Yes
3.	Can carbon capture and storage (CCS) processes capture CO_2 directly from the air?	Yes
4.	Can the CO_2 captured by CCS be sent into space for permanent storage?	No
5.	Can CCS also capture and store other greenhouse gases such as methane?	No
6.	Can the CO_2 captured by CCS be stored permanently on land, in shallow seas (e.g. the North Sea) or in the deep sea?	Yes
7.	Is the captured CO_2 mineralized when it is discharged into the deep sea?	Yes
8.	Can the CO_2 injected into the deep sea be firmly bound for many millions of years?	Yes
Table notes	The exact wording of the question was: ”You are now being asked questions on the subject of carbon capture and storage (CCS).” The responses to the questions were then presented in the correct format.	

Table 4: Evaluation of *CCS*

Left dimension		Right dimension
Semantic differential: To mitigate climate change Carbon capture and storage (CCS) processes are ...		
unavoidable		avoidable
useful		useless
long-term	seven-point Likert scale	short-term
dangerous		harmless [reverse coded]
expensive		cheap [reverse coded]

Table notes Applying a factor analysis on the five dimensions, suggests the use of two factors. Accordingly, we create the first standardized index-variable *Indispensable* that is based on the standardized items unavoidable, useful and long-term (Cronbach's $\alpha = 0.803$), each loading high (> 0.80) on this factor and each being highly correlated with each other ($r > 0.50$). However, as the second factor (containing the dimensions harmless and cheap) would have an insufficient (Cronbach's $\alpha = 0.499$) and as the two dimensions are only moderately correlated with each other (neither with the other dimensions), we decided to include each of them as a single item in our subsequent analysis (*Harmless* and *Cheap*). The dimensions are coded, that higher values relate to unavoidable, useful, long-term, harmless and cheap.

Table 5: Items in the Variable *PEB*

Category	Items	Response options
Living and Energy	(1.1) How large is the heated living space in your household per person? If you live in a household with several people, please divide the total living space by the number of people in the household.	[1]: up to 20 m^2, [2]: 21 - 30 m^2 , [3]: 31 - 40 m^2, [4]: 41 - 50 m^2, [5]: 51 - 60 m^2, [6]: 61 - 70 m^2, [7]: more than 70 m^2 [inverse coded]
	(1.2) How warm do you heat the occupied rooms in your home in winter?	[1]: very cold ($\leq 17°$C), [2]: cold (18°C), [3]: rather cold (19°C), [4]: medium (20°C), [5]: rather warm (21°C), [6]: warm (22°C), [7]: very warm ($\geq 23°$C) [inverse coded]
	(1.3) How do you air during the heating period?	[1]: always tilt windows, [2]: mostly tilt windows, [3]: rather tilt windows, [4]: in part both, [5]: rather airing in bursts, [6]: mostly airing in bursts, [7]: always airing in bursts
	(1.4) How well insulated is your house/ apartment?	[1]: very bad, [2]: bad, [3]: rather bad, [4]: average, [5]: rather good, [6]: good, [7]: very good
	(1.5) How long do you shower on average?	[1]: less than 2 minutes, [2]: 2-3 minutes, [3]: 4-5 minutes, [4]: 6-8 minutes, [5]: 9-11 minutes, [6]: 12-15 minutes, [7]: more than 15 minutes [inverse coded]
	(1.6) When buying electrical appliances, I opt for particularly energy-efficient appliances.	[1]: never, [2]: very rare, [3]: rare, [4]: occasionally, [5]: often, [6]: very often, [7]: always
Mobility	(2.1) Please enter the average distance you travel by carper year as a driver or passenger. Include all private journeys, such as driving to work, shopping or on vacation by car. If you do not know the exact distance, please make an estimate. How far do you travel by car per year?	[1]: up to 3,000km, [2]: 3,001 - 6,000 km, [3]: 6,001 - 9,000 km, [4]: 9,001 - 12,000 km, [5]: 12,001 - 15,000 km, [6]: 15,001 - 20,000 km, [7]: more than 20,000 km [inverse coded]
	(2.2) Please indicate how many hours you spend traveling by plane in an average year (without travel restrictions during the pandemic). Please only include private travel. How many hours on average do you spend traveling privately per year?	[1]: not a single, [2]: less than 1 hour, [3]: 1 - 2 hours [4]: 2 - 3 hours, [5]: 3 - 4 hours, [6]: 4 - 5 hours, [7]: more than 5 hours [inverse coded]
Diet	(3.1) I buy food from controlled organic cultivation.	[1]: never, [2]: very rare, [3]: rare, [4]: occasionally, [5]: often, [6]: very often, [7]: always
	(3.2) I buy food that has been transported by air. (There is no labeling requirement for goods transported by air; fresh fish (from African countries, Sri Lanka and the Maldives), fresh fruit and vegetables (e.g. asparagus from Peru, strawberries from Egypt, Israel or South Africa), ripe exotic fruits and superfoods (e.g. mangoes, papayas, goji berries, avocados) are particularly frequently transported by air).	[1]: never, [2]: very rare, [3]: rare, [4]: occasionally, [5]: often, [6]: very often, [7]: always [inverse coded]
	(3.3) I eat meat and sausage with my main meals.	[1]: never, [2]: very rare, [3]: rare, [4]: occasionally, [5]: often, [6]: very often, [7]: always [inverse coded]
	(3.4) I eat dairy products and eggs with my main meals.	[1]: never, [2]: very rare, [3]: rare, [4]: occasionally, [5]: often, [6]: very often, [7]: always [inverse coded]
	(3.5) I consume food before it spoils.	[1]:never, [2]: very rare, [3]: rare, [4]: occasionally, [5]: often, [6]: very often, [7]: always
Other Con-sume	(4.1) I only buy things that I really need.	[1]: never, [2]: very rare, [3]: rare, [4]: occasionally, [5]: often, [6]: very often, [7]: always
	(4.2) I opt for the environmentally friendly alternative	[1]: never, [2]: very rare, [3]: rare, [4]: occasionally, of a product, if there is one. [5]: often, [6]: very often, [7]: always
	(4.3) I buy particularly durable products.	[1]: never, [2]: very rare, [3]: rare, [4]: occasionally, [5]: often, [6]: very often, [7]: always
	(4.4) I buy products (e.g. clothing, electronics, furniture) second-hand.	[1]: never, [2]: very rare, [3]: rare, [4]: occasionally, [5]: often, [6]: very often, [7]: always
	(4.5) I use things for as long as possible instead of replace them with newer versions.	[1]:never, [2]: very rare, [3]: rare, [4]: occasionally, [5]: often, [6]: very often, [7]: always
	(4.6) I give / sell things that I no longer need to others.	[1]: never, [2]: very rare, [3]: rare, [4]: occasionally, [5]: often, [6]: very often, [7]: always
	(4.7) I throw things away that can be repaired.	[1]: never, [2]: very rare, [3]: rare, [4]: occasionally, [5]: often, [6]: very often, [7]: always [inverse coded]
Notes	The items are standardized and an index variable is calculated to represent overall *PEB* (Cronbach's $\alpha = 0.725$).	

Table 6: Variables *CC Risk, Anxiety, CC Emotion*, and *Effectiveness*

Variable	Items	Response options
Risk of CC	(1) Spread of disease vectors (e.g. mosquitoes or ticks) (2) Extreme weather events (3) Increasing heat and heatwaves (4) Air pollution (5) Contaminated water (6) Low food quality (e.g. due to a decreasing nutrient content) (7) Increasing allergens and increased pollen count (8) Psychological problems (e.g. trauma or depression) (9) Social consequences (e.g. conflicts or migration) or migration)	Please indicate the likelihood of these consequences of climate change occurring in your life. Response option from very unlikely to very likely on a seven-point Likert scale. Please indicate the perceived danger of the consequences of climate change on your life. Response option from harmless to extremely dangerous on a seven-point Likert scale.
CC Emotion	(1) Thinking about climate change makes it hard for me to concentrate. (2) Thinking about climate change gives me trouble sleeping. (3) I have nightmares about climate change. (4) I find myself crying because of crying about climate change. (5) I ask why I cannot deal better with climate change. (6) I consciously take time to think about my feelings about climate change. (7) I write down my thoughts on climate change and analyze them. (8) I ask myself why I react to climate change in this way and not in a different way. (9) My worries about climate change make it difficult for me to have fun with my family and friends. (10) I have difficulties reconciling my concerns about sustainability with the needs of my family. (11) My worries about climate change affect my ability to cope with work or schoolwork. (12) My worries about climate change are undermining my ability to realize/develop my full potential. (13) My friends say that I think too much about climate change.	. Please indicate how much these apply to you. Response option on a seven-point Likert scale ranging from 1 (= does not apply at all) to 7 (= fully applies)
Anxiety	For me, climate change is ... Something I think about all the time - something I never think about Frightening - not frightening Worrisome - not worrisome	Semantic differential on a seven-point Likert scale
Effective ness	(1) How effective are the current political climate climate protection measures overall? *How effective are the following measures for climate protection?* (2)No more first-time registrations of cars with combustion engines after 2030. (3) No installation of oil heating systems from 2026 and no installation of gas heating systems from 2028. Immediate replacement of particularly climate-damaging heating systems. (4) Coal phase-out by 2030 (instead of 2038 as currently planned). (5) Promotion of a healthy and climate-friendly, plant-based and low meat diet, e.g. in school meals.	Seven-point Likert scale ranging from 1 (= are completely useless) to 7 (= are extremely effective)
Table notes.	*Risk of CC:* The standardized probability is multiplied by the respective standardized severity, and the outcome variable is standardized once more (Cronbach's $\alpha = 0.934$). *CC Emotion:* Strong and significant correlations among these items, supported by a factor analysis, suggests a single underlying factor, lead to the creation of a standardized index, *CC Emotion*, which incorporates all these standardized items (Cronbach's $\alpha = 0.961$). *Anxiety:* We build the standardized composite index *Anxiety* based on the standardized items (Cronbach's $\alpha = 0.882$) and The index is coded in such a way that higher values indicate a greater degree of concern. *Effectiveness:* A factor analysis shows that there is a single underlying factor, which leads to the creation of a standardized index called *Effectiveness*, which includes the five standardized items (Cronbach's $\alpha = 0.866$).	

Table 7: Climate Change Knowledge Questions

Question	Response Options
(1) Which sector in Germany reduced its greenhouse gas emissions the least between 1990 and 2021?	[1]: traffic, [2]: *energy industry*, [3]: agriculture, [4]: buildings
(2) Which of the following is not an effective measure for adapting to climate change?	[1]: discount on gasoline, [2]: *construction of dikes*, [3]: Cultivation of climate- and weather-adapted plant varieties, [4]: Efficient cooling of buildings,
(3) What is a climate change mitigation measure?	[1]: *Mitigation means stopping, slowing down or reducing climate change.*, [2]: Mitigation means dealing with the climatic changes that have already occurred or are still expected., [3]: Mitigation involves adapting social systems to ensure that the costs of climate protection are distributed more fairly., [4]: Containment means putting climate protection on the political agenda.
(4) Which construction project is not a typical construction project in a so-called 'sponge city'?	[1]: *Building insulation with foam sponges*, [2]: Water-permeable road surfaces, [3]: *Facade greening*, [4]: Inner-city tree planting
(5) Which of the following is not an effective measure to mitigate climate change?	[1]: *Animal-based diet*, [2]: Expansion of renewable energy sources, [3]: Urban greening, [4]: CO2 pricing
(6) What is carbon emissions trading?	[1]: *The market on which limited greenhouse gas emissions are freely traded.*, [2]: The market on which liquid CO2 is freely traded., [3]: The use of a CO2 tax instead of VAT., [4]: High interest rates for projects with high CO2 emissions.
(7) Which disease could spread more easily due to climate change?	[1]: *malaria*, [2]: herpes, [3]: tetanus, [4]: Mad cow disease
(8) Which industrialized country briefly withdrew from the Paris Agreement in 2020?	[1]: *USA*, [2]: Germany, [3]: China, [4]: Russia
(9) Which of the following age groups is considered a risk group for heat-related illnesses?	[1]: *65+ years*, [2]: 10 - 25 years, [3]: 25 - 40 years, [4]: 40 - 65 years
(10) Which emission source in Germany does not count as a "public emission"? Emissions ...	[1]: *...through vacation trips by car*, [2]: ...from municipal hospitals, [3]: ...from the municipal waste disposal system, [4]: ...through the construction of highways
(11) What is the original basic principle of sustainability?	[1]: *Resources must not be used up faster than they can be renewed*, [2]: Resources must be used in an environmentally friendly way, [3]: Resources must be distributed fairly, [4]: Resources must be used efficiently
(12) Which of the following phenomena is the main cause of the rise in the Earth's temperature over the last 20 years?	[1]: *Increased emissions of greenhouse gases (the so-called "greenhouse effect")*, [2]: Depletion of the ozone layer (the so-called "ozone hole"), [3]: Change in ocean currents, e.g. "el Niño", [4]: Change in the tilt of the earth's axis
(13) What is a zoonosis?	[1]: *An infectious disease that can be transmitted between animals and humans.*, [2]: An infectious disease transmitted exclusively from person to person., [3]: An infectious disease transmitted exclusively from animal to animal., [4]: An infectious disease transmitted from plants to animals.
(14) What do the so-called "tipping points" in the global climate system mean?	[1]: *Some effects of climate change can no longer be stopped after a certain point and are therefore irreversible.*, [2]: Some effects of climate change are no longer dangerous after a certain point and no longer require countermeasures., [3]: Some effects of climate change are no longer measurable after a certain point., [4]: At a certain point, some effects of climate change no longer interact with other effects of climate change.,
(15) To produce meat than the equivalent amount of vegetables in terms of calories is ...	[1]: *ten times more polluting*, [2]: equally polluting, [3]: twice as polluting, [4]: half as polluting

Table notes. Correct answers in *italics*

Table 8: Descriptive and Injunctive Norms and Trust

Variable	Question	Items
Dnorm / Inorm	People who are important to me exhibit the following behaviors: ranging from 'never' to 'always' on a seven-point Likert scale People who are important to me expect the following behavior from me: ranging from 'do not agree at all' to 'fully agree' on a seven-point Likert scale.	(1) Saving Energy (e.g., use energy-saving devices) (2) Save water (e.g. showering instead of bathing, turning off the tap when brushing your teeth) (3) In winter, not heating the home warmer than 17℃. (4) Refraining from private air travel. (5) Avoiding the consumption of meat. (6) Only buying things that you absolutely need. (7) Do not eat milk and egg products.
Trust	Please indicate your level of confidence in the ability of the individuals and organizations below to effectively address the climate crisis. Response options on a seven-point Likert scale ranging from 1 (= very little trust) to 7 (= very much trust).	(1) Your physician (2) Science (3) Public media (4) European Union (EU) (5) Robert Koch Institute[18] (6) Federal Ministry of Health (7) Federal Government
Table notes.	*Dnorm and Inorm:* We build a standardized index-variable *Dnorm* (Cronbach's $\alpha = 0.801$) for the descriptive norms and *Inorm* (Cronbach's $\alpha = 0.905$) for the injunctive norms, respectively, with each consisting of the seven items. Although factor analysis yields two factors for each type of norm, we use a single factor for each measure because we are not interested in distinguishing between statements, but rather between descriptive and injunctive norms per se. *Trust:* The PACE survey are also asked for trust in "People and groups who share content on social networks (e.g. Facebook, Telegram). We exclude this item from our analysis, since it does not relate to a specific person or group that act in the public sphere. A factor component analysis provide a one-factor solution. Therefore, we construct the standardized index-variable *Trust* using the standardized items (Cronbach's $\alpha = 0.889$).	

Risk- and Ambiguityaversion We elicit the respondents' risk and ambiguity aversion using a variant of the Ellsberg urns (e.g., Halevy, 2007). Respondents were presented with a hypothetical scenario involving a box containing five blue and five yellow balls. They were then asked to guess the color of a randomly chosen ball. A correct guess would result in a €10 reward, while an incorrect guess would result in no reward. To measure risk aversion (*Riskaverse*), respondents were asked how much they would in maximum be willing to pay to bet on one of the colors. The lower the amount they were willing to pay, the higher their level of risk aversion. The second variant aimed to capture ambiguity aversion. It involved a box containing 10 balls with unknown numbers of blue and yellow balls. Participants were asked to state how much they were in maximum willing to pay to bet on a color. The difference between the willingness to pay for the first box with known probabilities and the second box with unknown probabilities served as our measure of ambiguity aversion.[19] Based on their stated answers, we calculate the difference between risk and ambiguity aversion and use this as our measure of *Ambiguity* with higher values indicating higher ambiguity aversion.

[19] Note that this task was not incentivized and that the respondents did not receive further training.

B Additional Results

Table 9: Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Acceptance CCS	1.000								
(2) PEB	0.194*	1.000							
(3) Risk of CC	-0.163*	-0.079*	1.000						
(4) Anxiety	0.250*	0.409*	-0.167*	1.000					
(5) CC Emotion	0.096*	-0.172*	-0.158*	0.171*	1.000				
(6) Effectiveness	0.364*	0.257*	-0.246*	0.519*	0.302*	1.000			
(7) Knowledge CC	0.161*	0.389*	-0.040	0.230*	-0.427*	0.065*	1.000		
(8) Dnorm	0.174*	0.326*	-0.283*	0.253*	0.329*	0.379*	-0.099*	1.000	
(9) Inorm	0.176*	0.175*	-0.244*	0.279*	0.426*	0.412*	-0.200*	0.678*	1.000
(10) Trust	0.323*	0.126*	-0.251*	0.335*	0.212*	0.575*	0.040	0.363*	0.317*
(11) Riskaverse	-0.074*	0.060	0.054	-0.074*	-0.127*	-0.064*	0.060	-0.033	-0.109*
(12) Ambiguity	-0.069*	-0.056	0.005	0.027	0.112*	0.032	-0.185*	0.057	0.064*
(13) Awareness	0.136*	0.098*	0.035	-0.009	0.095*	0.107*	0.082*	0.094*	0.076*
(14) Knowledge CCS	0.176*	0.137*	0.006	0.076*	-0.087*	0.099*	0.302*	-0.044	-0.092*
(15) Indispensable	0.631*	0.139*	-0.191*	0.242*	0.075*	0.297*	0.128*	0.154*	0.160*
(16) Harmless	0.254*	-0.052	-0.025	0.030	-0.118*	0.009	0.025	-0.012	0.006
(17) Cheap	0.074*	-0.102*	-0.101*	0.040	0.064*	0.059	-0.149*	0.115*	0.126*
(18) Norm CCS	0.765*	0.165*	-0.169*	0.288*	0.171*	0.372*	0.093*	0.195*	0.217*

	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(10) Trust	1.000								
(11) Riskaverse	-0.033	1.000							
(12) Ambiguity	0.032	0.399*	1.000						
(13) Awareness	0.126*	0.026	0.000	1.000					
(14) Knowledge CCS	0.097*	-0.021	-0.103*	0.263*	1.000				
(15) Indispensable	0.233*	-0.075*	-0.054	0.059	0.132*	1.000			
(16) Harmless	0.105*	-0.099*	-0.056	0.003	0.072*	0.178*	1.000		
(17) Cheap	0.094*	-0.091*	0.032	-0.127*	-0.096*	-0.011	0.332*	1.000	
(18) Norm CCS	0.308*	-0.084*	-0.051	0.114*	0.150*	0.546*	0.182*	0.072*	1.000

Pairwise correlation, $*p < 0.05$

Table 10: Latent Class Analysis

	LCA			
	Class 1	Class 2	Class 3	var(e.)
Constants	0.000	1.132***	0.296**	
	(.)	(0.091)	(0.108)	
Acceptance CCS	-1.549***	-0.042	1.248***	0.173***
	(0.037)	(0.022)	(0.035)	(0.011)
Awareness	0.317***	0.292***	0.505***	0.219***
	(0.036)	(0.020)	(0.032)	(0.010)
Knowledge CCS	-0.182*	-0.089*	0.342***	0.959***
	(0.075)	(0.043)	(0.066)	(0.043)
Indispensable	-1.034***	-0.051	0.887***	0.607***
	(0.061)	(0.035)	(0.053)	(0.029)
Harmless	-0.302***	-0.097*	0.448***	0.927***
	(0.074)	(0.042)	(0.065)	(0.042)
Cheap	-0.191*	0.048	0.031	0.991***
	(0.076)	(0.043)	(0.067)	(0.044)
Norm CCS	-1.373***	-0.003	1.028***	0.392***
	(0.052)	(0.029)	(0.045)	(0.021)
Knowledge CC	-0.121	-0.098*	0.316***	0.966***
	(0.076)	(0.043)	(0.065)	(0.043)
Percentage	18.36%	56.96%	24.68%	

Table notes. Latent Class Analysis. Standard errors in parenthesis
$^{*}p \leq 0.05$, $^{**}p \leq 0.01$,$^{***}p \leq 0.001$.

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