

Secondary Publication



Lehrer, Lena; Geiger, Mattis; Sprengholz, Philipp; u. a.

Study protocol of the planetary health action survey PACE : a serial cross-sectional survey to assess the readiness to act against climate change

Date of secondary publication: 18.11.2025

Version of Record (Published Version), Article

Persistent identifier: urn:nbn:de:bvb:473-irb-111423x

Primary publication

Lehrer, Lena; Geiger, Mattis; Sprengholz, Philipp; u. a. (2024): Study protocol of the planetary health action survey PACE : a serial cross-sectional survey to assess the readiness to act against climate change, in: BMJ Open, London: BMJ Publishing Group, Vol. 14, Nr. 11, e091093, pp. 1–11, doi: 10.1136/bmjopen-2024-091093.

Legal Notice

This work is protected by copyright and/or the indication of a licence. You are free to use this work in any way permitted by the copyright and/or the licence that applies to your usage. For other uses, you must obtain permission from the rights-holders.

This document is made available under a Creative Commons license.



The license information is available online:

<https://creativecommons.org/licenses/by-nc/4.0/legalcode>

BMJ Open Study protocol of the planetary health action survey PACE: a serial cross-sectional survey to assess the readiness to act against climate change

Lena Lehrer ,^{1,2} Mattis Geiger,^{1,2} Philipp Sprengholz,^{2,3} Mirjam Jenny,^{1,2} Hellen L Temme,^{1,2} Parichehr Shamsrizi,^{1,2} Sarah Eitze,^{1,2} Cornelia Betsch ^{1,2}

To cite: Lehrer L, Geiger M, Sprengholz P, *et al*. Study protocol of the planetary health action survey PACE: a serial cross-sectional survey to assess the readiness to act against climate change. *BMJ Open* 2024;**14**:e091093. doi:10.1136/bmjopen-2024-091093

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (<https://doi.org/10.1136/bmjopen-2024-091093>).

The parts of this protocol were presented at the Planetary Health Annual Meeting 2022 ([https://www.thelancet.com/journals/lanph/article/PIIS2542-5196\(22\)00281-9/fulltext](https://www.thelancet.com/journals/lanph/article/PIIS2542-5196(22)00281-9/fulltext)) and will be presented at the 53rd DGPs Congress/15th ÖGP Conference (book of abstracts not available online yet; conference website: <https://dgps2024.univie.ac.at/program/>).

Received 11 July 2024
Accepted 21 October 2024



© Author(s) (or their employer(s)) 2024. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

For numbered affiliations see end of article.

Correspondence to

Lena Lehrer;
lana.lehrer@bnitm.de

ABSTRACT

Introduction Climate change is a paramount global health threat with multifaceted implications. Societal change is required to mitigate the negative effects of climate change, as well as help people adapt to the associated health risks. This requires situation-specific, large-scale data to help scientists and policymakers understand public perceptions and behaviours and identify the levers to increase public readiness to act against climate change and protect health. The Planetary Health Action Survey (PACE) assesses this readiness to act as a regular monitoring of representative samples in Germany. The ongoing monitoring seeks to develop and refine an integrated conceptual model of the trait-like readiness to act, comprising policy acceptance, political participation and individual behaviours as indicators of the trait. It also proposes a set of determinants to explain different levels of readiness to act. This study protocol provides newly developed valid measurement instruments and the methodological details of the monitoring.

Method and analysis PACE assesses indicators of the readiness to act and a set of sociocognitive factors predicting the readiness to act in continuous cross-sectional data collections. The latter comprise climate change knowledge, trust in institutions, perceived health risks, self-efficacy, social norms and perceived effectiveness of policy measures. The online questionnaire is updated regularly. Data collection involves non-probabilistic quota samples from Germany ($n \approx 1000$ at each collection).

Ethics and dissemination The project adheres to the ethical guidelines of the University of Erfurt and the German Research Foundation. Ethical clearance was granted by the University's Institutional Review Board (No #20220525/No #2024-01). Participants are guaranteed confidentiality and anonymity, and informed consent is obtained before participation. Results will be published in peer-reviewed journals. Additionally, we aim to inform and empower the public and support stakeholders (media, policymakers, climate protection organisations) in preparing climate communication and assisting policymakers through the project website including an interactive tool, detailed reports and short summaries for practitioners.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The Planetary Health Action Survey (PACE) contributes to understanding climate change and health risks by considering various facets of individual and societal change.
- ⇒ It allows for observing changes over time and adjusting the model to include current topics and debates.
- ⇒ Measurement instruments in the monitoring are of highest psychometric quality; they have been developed with approaches that maximise objectivity, reliability and validity.
- ⇒ While the large sample is representative for age, gender and federal state, limitations of an incentivised online recruiting and questionnaire have to be considered.
- ⇒ Overall, PACE provides a broad foundation for future health and crisis communication and helps informing climate change and health communication, policymaking and interventions.

INTRODUCTION

Among all major ongoing global crises of the 21st century, climate change is ranked one of the most dangerous by WHO¹ and has been called ‘the biggest global health threat’ by experts of the Lancet Countdown.² Health and climate change interact in numerous ways. The main driver of climate change is high levels of carbon emissions resulting mainly from burning fossil fuels,³ which can directly lead to health issues, such as cardiovascular and lung diseases.^{4–6} More importantly, the main consequences of climate change also affect human health. For example, rising temperatures present a lethal threat,⁷ as evidenced by >60 000 heat-related deaths estimated in Europe alone for 2022.⁸ In the USA, heat is responsible for more fatalities than any other weather-related hazard.⁹ Other health risks triggered or amplified by climate change are allergic reactions and



respiratory problems^{10 11} or the aggravation of infectious diseases such as malaria or dengue.^{12–14} A comprehensive overview of the health consequences caused by the climate crisis can be found in the annually updated Lancet Countdown on health and climate change.¹⁵ Beyond costing human lives, decreasing well-being and increasing morbidity,¹⁶ economic damage and the related monetary costs for societies caused by climate change already have a massive health impact, which will increase in the future. Loss of labour productivity due to increased heat, for example, is estimated at annual costs of around half a trillion dollars by 2050 in the USA alone.¹⁷ This will likely further weaken the welfare and health systems, which, until now, are not sufficiently prepared for the rising burden of disease.^{6 18 19} In sum, climate change interacts with existing and upcoming health threats and aggravates them. The term ‘planetary health’ acknowledges this issue because it assumes that ‘human health and the health of our planet are inextricably linked, and that our civilisation depends on human health, flourishing natural systems and the wise stewardship of natural resources’.²⁰ Thus, planetary health encompasses the holistic approach of considering the interdependence of human health, the environment, biodiversity and ecosystems and therefore goes beyond the term climate and health, which focuses specifically on how climate change impacts human health. Understanding human behaviour within this nexus is key. This protocol therefore details the Planetary Health Action Survey (PACE), which aims to understand the readiness to act against climate change as a crucial human trait with regard to planetary health, how individual differences in this readiness can be explained and how it can be increased, for example, by identifying levers for making climate and health communication and policy more effective by rooting it in large-scale behavioural data.

Readiness to act against climate change

Given the health threats highlighted above, there is an urgent need to adapt to and mitigate climate change. To instigate behavioural change and explain what drives more climate-friendly behaviours, it is necessary to understand the individual differences in the readiness to act. In the present work, we assume that the readiness to act is a trait-like psychological construct determining individual and collective action against climate change. It comprises three aspects that are situated both at the individual and societal levels: individual CO₂ emission-related behaviour, acceptance of climate protection policies and political participation against climate change. To change this trait, an individual needs to understand the necessity for change and be willing to act in a climate-friendly way to support mitigation. One example is the reduced consumption of food with high environmental impact, for example, meat and dairy products, which has been rated a high-impact behaviour for climate change.²¹ Yet, simply understanding this issue is not sufficient for ensuring large-scale behavioural change. Individual habits, tastes,

attitudes, values, self-efficacy and social norms are some of the many aspects that inhibit the adoption of new healthy and climate-friendly behaviors at the individual level.²² Furthermore, there can be practical barriers like skills or income, for example, when someone is not experienced with cooking without meat and cannot afford expensive meat or dairy replacements.

Consequently, behavioural change only by the individual is not sufficient to mitigate climate change and, therefore, must be supported with structural measures.²³ Policy changes are needed and can range from targeted taxation (eg, tax increase for meat) to requirements (eg, planetary health diets for school canteens) or subsidies (eg, climate-friendly vegetarian food options).²⁴ These policies, however, need to be accepted by citizens to guarantee their sustainability and effectiveness.²⁵ Thus, on a societal level, the individual needs to support transformative political action. In the case of food regulations, for example, people might otherwise try to bypass the regulations or compensate for them by engaging in additional climate-damaging behaviours.^{26–28} Evidence from behavioural sciences can help to understand the reasons for the public support of system-level strategies and assist in designing policies that are broadly accepted^{25 29} and communication activities that are supporting acceptance.

In democracies, individuals can actively influence policymaking via political participation, which is another crucial component in achieving effective societal change and climate change mitigation.^{30–32} Engaging in political participation enhances individual’s ‘ecological handprint’, a concept focused on promoting positive environmental change, complementing the harm-reduction focus of the ‘ecological footprint’.³³ An example of enlarging one’s handprint in the context of climate-friendly nutrition could be citizens signing petitions for higher subsidies for regional organic farms. Political participation has been defined in various ways. While some scholars distinguish between political and civic engagement,³⁴ political engagement can be split into civic indicators (eg, being active member in a group or organisation), electoral indicators (eg, regular voting), political voice (eg, signing petitions) and attentive indicators (eg, watching television news regularly).³⁵ Another distinction was proposed on an empirical basis by Gopal and Verma,³⁶ who spoke of conventional or traditional forms of participation (eg, voting), unconventional or non-institutional (eg, taking part in demonstrations), knowledge-seeking (eg, searching on the internet about politics) and influential forms (eg, trying to convince friends to vote). Thus, political participation is a broad concept comprising many behaviours.

In sum, it becomes apparent that effectively dealing with the climate crisis requires all three levels: changes in individual behaviour, policy acceptance and political participation. The necessity of evidence-based, effective communication and policymaking that takes human behaviour into account^{25 37–39} has recently been emphasised by numerous leading international authorities and

bodies, such as the United Nations,⁴⁰ the Intergovernmental Panel on Climate Change,⁴¹ WHO Europe⁴² and the UK House of Lords.⁴³ The present research aims to support this work by providing empirical evidence across all three levels, with a particular focus on mitigation, and offering a solid theoretical foundation.

Research gaps

There are already a fair number of reviews that consider the factors predicting individual health and climate-friendly behaviour,^{44–46} policy acceptance⁴⁷ and political participation.⁴⁸ Various studies have collected evidence, listing a range of factors such as intentions, habits and perceived behavioural control as the predictors of environmental behaviour⁴⁹; perceived fairness, effectiveness, knowledge and trust as the predictors of policy acceptance⁴⁷ and efficacy beliefs and perceived injustice as the predictors of political participation.⁴⁸ Yet, little is known about how individual differences in the various aspects of our trait-like construct, readiness to act, covary and how these relationships with predictors affect both the communalities among the indicators (ie, a general readiness to act construct) and specific variance components (ie, individual differences attributable to only one aspect of readiness, but not to the overarching construct or other aspects). PACE is an ongoing psychological monitoring for assessing the indicators and predictors of readiness to act and aims at bridging the identified gaps. It will generate empirical findings about the distributions and relations between the variables to understand (i) whether specific aspects of the readiness to act lack support or which behaviours are not exhibited and need to be explained and supported better, (ii) which factors affect individual differences in the readiness to act, (iii) which target groups show an extremely low or high readiness to act and, therefore, should be focused on and (iv) how public discussions, external events (such as heat waves) or policy changes affect the predictors and indicators of the readiness to act.

Planetary Health Action Survey

The PACE study design was inspired by the COVID-19 Snapshot Monitoring COSMO, which monitored the psychological situation during the COVID-19 pandemic in repeated data collections⁵⁰; studies following this approach were conducted in several countries.⁵¹ The overall goal of PACE is to better understand the readiness to act against climate change, what predicts it, and how the predictors and indicators of the readiness to act change over time. To this end, we aim to (i) devise, test and revise an integrated conceptual model (figure 1), (ii) develop valid and psychometrically sound instruments to assess the key factors of the model, (iii) use the model in serial cross-sectional monitoring, (iv) identify causal links in the model by experimental tests of underlying assumptions and (v) test the impact of different communication tools to contribute insights for designing and implementing effective climate and health communication. To achieve goals iv and v, additional experimental designs are needed, which will be explicated and preregistered elsewhere; the present study protocol focuses on the regular monitoring of predictors and indicators of the readiness to act (i–iii).

To devise a first list of sociocognitive factors possibly explaining the individual differences in readiness to act, which is indicated by the three behavioural or action-related constructs (individual behaviour, policy acceptance and political participation), we have combined existing behavioural process models: protection motivation theory (PMT),⁵² the health belief model,⁵³ theory of planned behaviour,⁵⁴ the health action process approach⁵⁵ and self-determination theory.⁵⁶ We have also considered topic-specific models, such as the integrated comprehensive action determination model⁵⁷ on climate-relevant behaviour and the integrative public policy acceptance framework,⁵⁸ as well as variations of PMT explicitly related to the climate change context.⁴⁴

As shown in figure 1, we include risk perceptions as a predictor because many (health) behaviour models focus on risk perception,^{52 53} making the understanding of

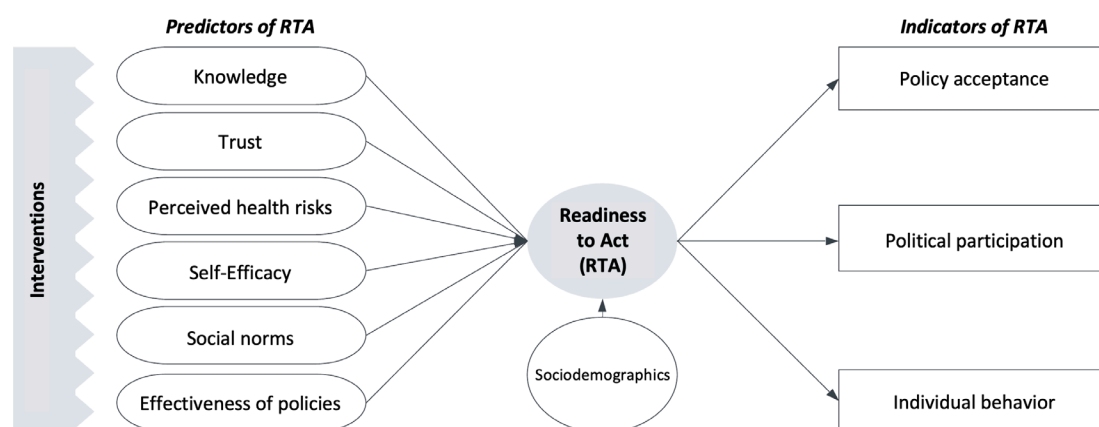


Figure 1 Planetary Health Action Survey (PACE) conceptual working model. Explaining readiness to act (RTA) against climate change by sociocognitive factors.

health risks related to climate change one of the starting points for behaviour change. Trust does not seem to play a dominant role in most health behaviour models but has been considered in policy-related models.⁵⁸ When it comes to public health crises, citizens might not be able to judge the appropriateness and effectiveness of policy measures and, thus, have to trust in what politicians tell them. In addition, because accepting policies is part of the readiness to act, greater acceptance is also assumed to be related to greater trust in institutions recommending or implementing these policies, such as the government.^{47 58} Therefore, we have added trust in relevant institutions as a predictor of the model. Many models assume that those who perceive climate protection as a social norm will act on that norm. As a result, social norms, that is, whether members of a person's close social circle show certain behaviours (descriptive norms) or expect such behaviour from the person (injunctive norms), are also assumed to predict the readiness to act.⁵⁹ Furthermore, higher outcome expectancies—represented by perceived response efficacy and self-efficacy—are also assumed to be linked to higher readiness to act.^{52–54 57} Because a better understanding of the climate crisis is necessary for behavioural change, it is assumed that knowledge of climate change can influence the readiness to act.^{60 61} Finally, we consider this model to be an initial theoretical framework. This means that further aspects might be added. In addition, because of the focus on the readiness to act, the model does not aim to explain complex relations between predictors, which are only modelled as correlations. The 'Methods and analysis' section provides a definition of each construct and how it is measured in PACE.

METHODS AND ANALYSIS

Sample and data collection

The cross-sectional data are collected for a German population based on a non-probabilistic quota sample, which represents the adult general population (aged 18–74 years) for the characteristics of age by gender and federal state according to census data for Germany.⁶² The recruitment via email and incentivisation of the participants are performed through an access panel provider (Bilendi), and the questionnaires are implemented through the platform Unipark by Tivian. Participants were eligible when they fitted the open quota. As the data are intended to be primarily descriptive and correlational, no a priori power analyses or similar calculations have been conducted. The sample size has been selected to ensure representativeness of the German population regarding the above-mentioned quota, which can be reached with a target sample size of $n=1000$ for each survey.

Design

PACE is designed as serial cross-sectional monitoring with a duration of approximately 25 min for each survey. It includes items assessing the above proposed indicators

(for all three aspects) as well as predictors of the readiness to act. In addition, items or experiments capturing contemporary topics (eg, saving gas during the European gas crisis), events (eg, climate protests, heat waves) or developments (eg, policy changes) complement the basic set of items. Extensions are not part of this protocol. In the beginning, the surveys are implemented every 4–8 weeks; this is to be able to estimate the stability of constructs (eg, to test whether risk perceptions vary with external events such as heat waves). In addition, frequent waves are needed to improve the measurement instruments. Depending on the stability of the constructs or external events, the timing of the surveys will be adapted. The first pilot survey was run in July 2021; wave 1 following this protocol was launched in April 2022. Pilot data already indicated that the measured constructs are more stable than initially assumed, which makes highly frequent data collection appear unnecessary. Data collections are ongoing; there is currently no fixed end point because the crisis is likely to gain relevance.

Instruments

In the questionnaire, items assessing the predictors of the readiness to act are collected first (sociodemographics, knowledge, trust, risk perception, self-efficacy, social norms, effectiveness), followed by those assessing the indicators of the readiness to act (policy acceptance, political participation, individual behaviour). The items per construct are presented in randomised order. Note that, to ensure the accuracy of the developed instruments and optimise the explanation of variance over the course of the study, items or even constructs may be added, changed or excluded based on theoretical considerations and psychometric analyses. Online supplemental material 1 provides a table with an overview of each of the following constructs with its definition, a sample item and its response scale (full list of items: <https://osf.io/e3mbt/>). The current state of the model and corresponding questionnaire will be published on the project's website (<https://projekte.uni-erfurt.de/pace/method/>). Two of the instruments, which are quite comprehensive, will be published along with their validation elsewhere in the future (scales for individual behaviour and climate change knowledge).

Readiness to act

We define the readiness to act as a trait-like latent construct summarising individual and collective action against climate change with the following indicators: policy acceptance, political participation and individual behaviour.

Policy acceptance

We define policy acceptance as the degree to which an individual agrees with climate-protective policies for mitigating climate change. It is measured by asking for participants' agreement with selected policies. These have been taken from a list proposed by the Citizens'

Climate Council in Germany,⁶³ which was developed during a participatory process that involved 160 citizens and scientists. Besides some general policy statements, the policies pertain to energy and housing, mobility and diet and food production. A pilot study assessed 96 items representing all policies. We then used an ant colony approach (ACO).⁶⁴ Like ants searching for food, ACO finds efficient paths through complex data spaces, revealing patterns, clusters and relationships within the data. 27 policies were identified and their effectiveness was validated by expert evaluations. The policies' effectiveness was consecutively assessed and validated via an expert survey (n=5). From the 27 policies, we selected the three policies per category that were evaluated as being the most effective (general statements, housing and energy, mobility, diet and food production). To achieve greater variance within the scale, we added another five items that showed the lowest support in the pilot study, resulting in a total of 17 items. Policies can be added based on ongoing public debates or policy plans (eg, regarding new laws on regulating heating systems in Germany⁶⁵). A sample item of the policy acceptance measures is, for example, 'subsidies should only be available for climate-friendly farms', which is rated from strongly disagree (1) to strongly agree (7).

Political participation

Political participation 'can be loosely defined as citizens' activities affecting politics'.⁶⁶ In this study, we define political participation as the degree to which individuals have participated in political activities related to climate protection. Previous studies in the context of climate change and climate protection have used single or few very specific items to capture different forms of activism.⁶⁷ To capture political participation in a broad sense, we sampled items from nine frequently used and established scales^{35 36 68-74}; in a first qualitative step, two authors (LL and MG) excluded redundant items and combined similar statements into 25 categories. Then, based on existing items, one item was developed for each category. After translation to German and minor rephrasing to improve comprehensibility, those items were tested as indicators of general participation (ie, not contextualised to climate change). We then selected 11 items with the best distributional properties reflecting the three focal aspects of political participation, similar to the distinction made by Gopal and Verma: conventional participation, activism and peer group-related participation.³⁶ Lastly, we rephrased the items so that they related to the domain of climate change and climate action. Some sample items are, "I sign petitions for more climate protection" (conventional participation), "I take part in protests, strikes or rallies for more climate protection" (activism) or "I discuss climate change with my friends, relatives or colleagues" (peer group-related participation). Items are rated from never (1) to always (7).

Individual behaviour

We define individual behaviour as the degree to which a person exhibited climate-friendly behaviour (behaviour that produces little greenhouse gas emissions) in the past year.⁶¹ Earlier psychological self-reports of this construct often include non-impactful behaviour.⁷⁵ Social desirability can bias self-reported environmental actions to at least a small extent.⁷⁶ As an alternative, CO₂ calculators assess climate-friendly behaviour in a more valid way (eg, <https://uba.co2-rechner.de/>). However, they are complicated to integrate into regular online surveys. Therefore, we have revised the Short Impact-Based Scale of sustainable behaviour⁶¹ and validated it with data from the CO₂ calculator by the German Environment Agency.⁷⁷ This updated instrument consists of 21 questions on mobility, housing and energy consumption, diet and other consumption behaviour, which represent the most impactful behaviours (in Germany) in terms of CO₂ emissions. Answers are mostly collected as behavioural frequency ratings with seven ordinal response options ranging from never to always. As an example, we ask the respondents to rate their behaviour for the statement "I buy organic food" on a scale from never (1) to always (7). Some items have alternative numerically anchored rating scales by, for example, kilometres driven by car, average room temperature in winter or duration of a typical shower. One item asking for the type of power consumed (renewable power vs conventional power) is dichotomous. To calculate the total score, items are weighted in a formative approach to approximate the actual CO₂ footprint as measured in the CO₂ calculator.⁷⁸ When used as dependent variable in experimental studies, item instructions can be changed to measure intentions for future behaviour (eg, "In the upcoming year, how often will you buy organic food?").

Predictors of the readiness to act

The following sections elaborate on the variables assumed to predict the readiness to act.

Demographics

Sociodemographics may affect the readiness to act and, thus, are also useful for segmentation to identify relevant target groups for communication or other interventions. Therefore, we assess age, gender, number of children below the age of 18 years, level of education, community size (number of inhabitants of the place of residence), state of residence, relationship status, household size, experiences of migration, language spoken in the household, chronic conditions, employment and self-employment and income. In addition, we assess political orientation as the preference for a political party within the German electoral system ("If there were a federal election next Sunday, which party would you vote for?"). Questions containing sensitive information allow either the option to skip the question (for migration, chronic condition, income) or include a non-response option (for party preference).



Knowledge

Climate change-related knowledge is defined as factual knowledge about climate change, including knowledge about ecology, societal aspects of climate change and measures to mitigate or adapt to climate change. We developed a climate change knowledge test based on a qualitative interview study⁷⁹ and the environmental knowledge test developed by Geiger *et al.*⁶¹ 58 items were created to cover a broad item difficulty range (easy, medium, hard) and three categories: ecological knowledge, knowledge regarding societal aspects of climate change and knowledge regarding measures to mitigate climate change or to adapt to it. Items were tested in earlier PACE waves. As the final climate change knowledge test, we selected five items per category that reflected the best possible item difficulty distribution. Each question is a single-choice item with a selection of four response options each, for example, 'Which of the following phenomena is the main cause of the increase in the Earth's temperature over the last 20 years? (a) increased emission of greenhouse gases (the so-called 'greenhouse effect') (correct), (b) reduction of the ozone layer (the so-called 'ozone depletion'), (c) change in the ocean currents, for example, 'El Niño', (d) change in the tilt of the Earth's axis'. The answer options are presented in random order.

Trust in institutions

Trust in institutions to deal with the climate crisis is defined as a compound of trust in several institutions dealing with climate change. It can be seen as a cognitive attitude that can motivate trustworthy behaviour, for example, compliance with recommendations or legal policies.⁸⁰ The respondents were asked how much they trust in different actors and institutions, such as the media, science, government and the European Union, '... to be able to deal well and properly with climate change?'.^{81–83} Trust ratings ranged from very little trust (1) to very much trust (7) and are summarised across stakeholders.

Perceived health risks

Health risk perception due to climate change is defined as the degree to which individuals consider substantial health risks that arise due to climate change as probable and severe. Thus, as suggested in different health-related models and established in recent monitoring studies,³⁷ risk perception can be assessed via the perceived severity and probability of health risks linked to climate change. The 10 items created are based on factual risks^{6 84} and contain, for example, the spread of vectors for communicable diseases or extreme weather events. Participants are asked how likely (probability) and how severely (severity) they think they will be affected by these health risks during their lifetimes. The answer options ranged from highly unlikely (1) to highly likely (7) and harmless (1) to extremely dangerous (7). Because of their high correlation, the severity and probability items per risk are averaged for the analysis.

Self-efficacy

Self-efficacy encompasses someone's belief in their ability to perform the actions required to achieve a certain goal and, thus, to exert control over one's own behaviour, motivation or environment.^{85 86} In this context, it describes a person's belief that they are able to carry out the individual emission-reducing actions required to achieve a lower CO₂ footprint. The items ask about how difficult or easy it is for the respondent to perform certain individual climate protection behaviours.^{37 87} We selected four items for the most CO₂-intense behaviours from our measure of individual behaviours from each of the four aspects (mobility, housing and energy consumption, diet and other consumption behaviour, see above) with the question "How difficult or easy do you find it to behave in the following ways?" for example, refraining from private air travel, with answers ranging from extremely difficult (1) to extremely easy (7).

Social norms

Social norms represent the degree to which a certain behaviour is commonly exerted and approved by one's close social circle.⁸⁸ Experience of social norms in emission-related behaviour refers to the extent to which a certain behaviour is common and endorsed in the social environment. In the present study, social norms are assessed with questions focusing on whether relevant other people show (descriptive norms) climate-friendly behaviours and expect (injunctive norms) those behaviours from the respondent.^{89 90} Behaviours that have the greatest CO₂ impact per individual behaviour category (heating/energy, mobility, food, other consumption) were selected, for example, 'avoiding the consumption of meat'. For each of these, the respondents can indicate whether the people in their close social circle show this behaviour (descriptive norms) on a scale from never (1) to always (7) and whether close people expect one to show the behaviour (injunctive norms) from strongly disagree (1) to strongly agree (7). The two norms are aggregated into one score because of their high correlation.

Perceived effectiveness of policy measures

The perceived effectiveness of policies is defined as how effective individuals believe certain policies are for mitigating climate change. In the literature, it has been conceptualised as the likelihood of a policy actually addressing a threat.⁹¹ Therefore, the items ask how effective a certain policy would be in reducing the progression of climate change.⁹² There is one item for each policy category (energy/housing, mobility, diet and food production). The items were chosen because they were the least accepted during scale development. The participants indicate how effective they find the measures, for example, 'no new registration of cars with combustion engines after 2030', ranging from not effective at all (1) to very effective (7).

Statistical analysis plan

The statistical analysis is conducted with R. Collaborative development of the analysis code and a website presenting the results to the public is done using Git. Only complete datasets will be used for analysis. Thus, there is no missing data, except for the few items containing sensitive demographic data as described above.

We use confirmatory factor analyses to evaluate the readiness to act and all predictors regarding their psychometric properties (validation). Next, we run structural equation models that allow us to evaluate the multiple regression effects of the predictors on readiness to act on a latent level. Model estimators are chosen based on indicator properties (weighted least squares mean and variance adjusted (WLSMV) if categorical indicators are present and estimators from the maximum likelihood (ML) family for all other models). Missing data in the model analyses are handled according to the estimator used: listwise deletion for WLSMV models and full-information ML imputation for ML models. Throughout the development process and ongoing study, scales are evaluated at each wave for their psychometric properties. Specifically, we replicate measurement models and estimate the reliability of their constructs. We also always estimate correlations between all constructs (convergent and divergent validities). If necessary, for example, in case of low psychometric quality of newly developed scales, we improve the scales over the course of the monitoring. These changes will be indicated in later publications. Pilot data were already used for validation, to check model fits and factor loadings. The data quality is assessed by checking for response patterns. To maintain and foster the level of participants' diligence, attention checks are implemented.

Patient and public involvement

While the present study does not involve a traditional patient relationship, the research process includes elements of participation and consultation with participants, as well as other stakeholders. For example, the scale used to assess the acceptance of policy measures was developed based on recommendations from a citizen council, developed through a participatory process that involved politicians, scientists and randomly selected members of the public.⁶³ Similarly, we incorporate topics from ongoing societal debates to ensure relevance. The results of the study will be disseminated to both the scientific community and the public, ensuring accessibility for all (see details below). We also maintain ongoing communication with public stakeholders, including the Robert Koch Institute (RKI) and the Federal Centre for Health Education (BZgA), to inform our work and facilitate the application of our findings in their respective fields. While we have not directly assessed the burden of completing the questionnaire, participant completion time is tracked via the survey software.

ETHICS AND DISSEMINATION

Ethics approval and consent to participate

The project is performed in accordance with the general ethical guidelines established by the University of Erfurt and by the German Research Foundation. The Institutional Review Board (IRB) at the University of Erfurt provided ethical clearance IRB (No #20220525/No #2024-01). Recruitment of participants takes place through access panel providers (currently Bilendi) that follow their own ethical guidelines, which have been approved to be in line with the IRB guidelines. Participants are guaranteed confidentiality and anonymity. They are actively asked for written consent after being informed about the study, including its purpose, duration, data collection methods and their rights as participants. The data are collected anonymously without any possibility of identifying individuals, which makes a fixed maximum data retention period obsolete. Nevertheless, participants are given the option to skip sensitive questions to ensure their comfort and autonomy. Lastly, a comprehensive debriefing at the end of the survey provides participants with additional information and contact possibilities to handle potential emotionally challenging situations concerning climate change and health risks.

Dissemination of insights

The results will be published in peer-reviewed journals. Furthermore, we aim to inform and empower the public, supporting various stakeholders (media, policymakers, climate protection organisations) in preparing climate communication measures and supporting policymakers in their decision-making.²⁵ For this, a website (<http://www.pace-studie.de/>) is continuously updated and offers an overview for laypeople. An interactive explorer (<https://projekte.uni-erfurt.de/pace/explorer/>) allows website users to view and stratify data over time. An external public dashboard (<https://klimadashboard.de/>) uses the data to provide insights into the societal aspects of climate crises. Additional reports summarise the results of each wave and are available on the study's website. A brief summary is sent out to experts and policymakers via email and posted on social media.

DISCUSSION

PACE strives to develop and test a sound theoretical model that can explain the readiness to act against climate change and allows for testing interventions for change in the readiness to act that will foster the implementation of scientific findings. It conceptualises the readiness to act as a trait-like construct that affects individual behaviour and in addition also the acceptance of policies and political participation. It identifies a set of predictors that can explain the differences in people's readiness to act. Given that there is sufficient evidence for the determinants and their impact on the readiness to act, future PACE waves will also causally test the relations between the predictors and indicators of the readiness to act with experiments,



as well as pretest interventions building on the identified mechanisms. By disseminating its results to a broad audience, PACE strives to break silos between academia, policymaking and civil society and feed the results from the academic sphere into societal debates while allowing policymakers and communicators to learn from the results. The data will also be used to identify target groups for communication, that is, especially those with lower readiness to act. Furthermore, the data will help identify the predictors that should be addressed in interventions because they are the most likely ones to affect people's readiness to act. Prior research assumes that targeting different predictors in interventions might be necessary to evoke different desirable behaviours.⁹³ The format of regular monitoring further allows for examining the predictors and indicators of climate-relevant behaviour over time,⁹⁴ enhancing the understanding of how policy changes or extreme events such as heat waves or floods impact one's readiness to act. The long-term implementation and iterative process further allow for a steady optimisation of the psychometric qualities of the questionnaire, as well as adaptation to sudden and unexpected events, thus increasing the practical relevance of the study.

The PACE model deviates from classical theoretical models that often focus on behavioural intentions as a major outcome variable.^{53 54 57} The literature reveals large gaps between intentions and actual behaviour, that is, a consensus in science and collective action, respectively, which certainly deserves and receives attention from researchers.^{95 96} To better understand complex relations of readiness to act aspects and their predictors, we have chosen a different approach by using reports on actual past behaviours, as well as current acceptance of policies and political participation to overcome this shortcoming. We strive to explain current attitudes and behaviours to potentially change them by systematically addressing their predictors in interventions.⁹³ Future research should nevertheless compare the predictive validity of both intentions and past behaviours for future climate-friendly behaviours.

The present study has a number of strengths. It considers citizens in their role as consumers (captured here with individual behaviour), and in their passive (acceptance of policies) and active roles (political participation) in the political and societal transformation process. We consider the social and structural situatedness of behaviour, particularly in terms of social norms and individual sociodemographic influences. This perspective roughly corresponds to a broader triad: attitude, behaviour and context.^{60 97} This follows the idea that we need to surpass the major focus on individual responsibility in solving climate change to achieve the much-needed transformation towards sustainability.^{98 99}

As an additional strength, the psychometric quality of our measures must be emphasised. All measures for the survey have been developed with approaches that maximise objectivity, reliability and validity. The measurement of individual behaviour explicitly refers to high-impact

behaviour only, tackling a shortcoming that has been criticised in earlier models.⁹⁹ The acceptance of political measures emerged from a list of measures developed within a citizens' council together with experts.⁶³ In addition, political participation deliberately refers to a broad range of behaviours sampled from multiple existing scales, going beyond institutionalised ways of participation, such as voting behaviour. On the predictor side, coherence with the outcome variables should be emphasised (eg, items assessing self-efficacy or social norms match the behaviours assessed as individual behaviour; the effectiveness of measures matches the policy acceptance items, ie, addresses the same policies). The knowledge items have been created for this survey using a mixed methods approach and are optimised regarding the difficulty of the items.

Still, there are some limitations. Because PACE is assessed as an incentivised online survey with a fixed financial incentive for participation, some participants may rush through it and pay little attention to single items. For this reason, the survey uses attention checks that have proven to reduce this challenge^{100 101} as they remind people that they should be careful when answering items. Furthermore, social desirability cannot be neglected as potentially affecting the responses. Nevertheless, although social desirability can positively skew self-reported environmentally friendly behaviours, this effect has been estimated to be small.⁷⁶ Additionally, social desirability bias is presumably low in our data, given that the incentives for cheating are low for participants.¹⁰² Yet, we strived to develop measures that lower social desirability, such as for individual behaviour (asking for frequencies and circumstances) or the frequency of political participation.¹⁰³ To minimise potential dropout bias, several steps are taken, for example, the estimated duration of participation is communicated transparently before the start of the questionnaire. Furthermore, a progress indicator (in %) shows how much of the questionnaire has already been completed. As the survey takes >20 min and involves intense reading, this may lead to a sample with German speaking, highly educated participants. The sampling strategy further excludes people who do not have internet access. However, possible distortions resulting from using an online panel provider with quota sampling can only be minimised, but never avoided, and will therefore be communicated transparently in the respective analyses. Still, we are certain that the type of recruitment and sampling currently represent the best compromise of practicability and representativity for our purposes. In the future, other relevant quotas or changes in data collection methods may be used and implemented (eg, using quotas for education, political orientations, including people <18 and >74 years of age, offering computer-assisted questionnaires on tablets or face-to-face interviews for elderly persons, non-German speakers, etc) or the instruments developed for PACE may be adapted to other national contexts by translating

the instruments into other languages and applying them in other countries. The questionnaire easily allows for these changes in application.

Finally, we acknowledge that, so far, PACE focuses primarily on mitigation of the climate crisis, although the models we refer to^{45 52} are often used in the adaptation context. We are aware that adaptation measures are also essential and increasingly relevant as climate change progresses.¹⁰⁴ Adaptation measures are considered in some constructs, for example, knowledge, but not in all constructs. An extension of the model (eg, explaining adaptation behaviours during heat waves) is likely to be implemented in the future.

Importantly, engagement with stakeholders takes place throughout the study. Next to scientific collaborations within the academic community, this engagement involves policymakers, civil society, the media and the public. To foster the application of our insights in policy-making, members of the PACE team regularly take part in conferences, workshops and professional trainings addressing knowledge transfer for policymakers. Some of our project partners are federal agencies, serving as support to practical policy, like the Robert Koch Institute and the Federal Ministry of Health. The project team meets with these partners to exchange results and novel evidence centred around the project. We also serve as authors on reports and policy papers addressing current issues. This effort goes beyond German borders as we are also connected with global organisations like WHO, The Organisation for Economic Cooperation and Development or the European Center for Disease Control. Similarly, we engage with civil society organisations by taking part in conferences, workshops and professional trainings, conducting joint research projects and being part of their advisory boards. These activities allow us to support the organisations' work scientifically, and to inform our research by real-world questions. Additionally, we engage with the media and serve as experts for the German Science Media Center. Finally, we engage with citizens by taking part in public events like research nights or science festivals. In the context of other related studies, we also invite citizens into our maker space to co-create communication materials.

As detailed above, the findings could be used to identify levers to increase readiness to act against the climate crisis. By making policymakers aware of those levers (see above), policies and accompanying communication campaigns could be designed more effectively. If experimental work finds, for example, that explaining the mechanisms behind specific policies (eg, effectiveness of a speed limit on highways) and detailing why they work increases public support, then communication campaigns should include that type of information. Ideally, the PACE infrastructure could be used by policymakers to monitor public support and correct misjudgements of public opinion to address issues timely and effectively. Content for large-scale communication could be pretested experimentally before launching costly campaigns.

In sum, the present study contributes to a deeper understanding of the readiness to act against climate change and protect one's health from its consequences while adopting both an individual and contextual approach to understanding the readiness to act. Complementing the survey data with future experimental data helps provide valuable causal evidence that can be used to facilitate health promotion, climate protective behaviours and societal transformation processes.

Author affiliations

¹Implementation Research, Health Communication, Bernhard-Nocht-Institut für Tropenmedizin, Hamburg, Germany

²Institute for Planetary Health Behaviour, Health Communication, University of Erfurt, Erfurt, Germany

³Health Psychology, University of Bamberg, Bamberg, Germany

Acknowledgements We would like to acknowledge the contribution of the following organisations in the PACE project: the University of Erfurt, the Robert Koch Institute (RKI), the Federal Centre for Health Education (BZgA), the Leibniz Institute of Psychology (ZPID), the Science Media Center (SMC) and the Bernhard Nocht Institute for Tropical Medicine (BNITM). Their support has been invaluable to the success of this project.

Contributors The ongoing research is planned, performed and analysed by the whole PACE team. LL conducted extensive literature analyses to build the first PACE model; CB, LL and PSp devised the project and the first conceptual working model, which was updated and statistically improved with the help of MG. Scales were developed by MG, LL, MJ, HLT, PSh and CB. The first questionnaires were programmed by LL and PSp. Scale validation and first analyses were undertaken by PSp, MG and SE. LL translated the scales and took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analyses and manuscript. CB is the principal investigator and guarantor of this study.

Funding The work is supported by the Klaus Tschira Foundation (grant number #00.003.2022), the Federal Ministry of Health (BMG) via the Robert Koch Institute (RKI) and the Federal Center for Health Education (BZgA). Additional internal funding comes from University of Erfurt (UE) and Bernhard Nocht Institute for Tropical Medicine (BNITM).

Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the 'Methods' section for further details.

Patient consent for publication Consent obtained directly from patient(s).

Provenance and peer review Not commissioned; externally peer reviewed.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iDs

Lena Lehrer <http://orcid.org/0000-0002-4767-1421>

Cornelia Betsch <http://orcid.org/0000-0002-2856-7303>



REFERENCES

- 1 WHO. Ten threats to global health in 2019, 2019. Available: <https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019> [Accessed 16 Aug 2023].
- 2 Costello A, Abbas M, Allen A, *et al*. Managing the health effects of climate change. *Lancet* 2009;373:1693–733.
- 3 Masson-Delmotte V, Zhai P, Pirani A, *et al*. Climate change 2021: the physical science basis. contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change. Cambridge University Press; 2021.
- 4 Calderón-Garcidueñas L, González-Maciel A, Reynoso-Robles R, *et al*. Alzheimer's disease and alpha-synuclein pathology in the olfactory bulbs of infants, children, teens and adults \leq 40 years in Metropolitan Mexico City. APOE4 carriers at higher risk of suicide accelerate their olfactory bulb pathology. *Environ Res* 2018;166:348–62.
- 5 Vohra K, Vodonos A, Schwartz J, *et al*. Global mortality from outdoor fine particle pollution generated by fossil fuel combustion: Results from GEOS-Chem. *Environ Res* 2021;195:110754.
- 6 Romanello M, Di Napoli C, Drummond P, *et al*. The 2022 report of the Lancet Countdown on health and climate change: health at the mercy of fossil fuels. *Lancet* 2022;400:1619–54.
- 7 Adams WM, Jardine JF, eds. *Exertional heat illness: a clinical and evidence-based guide*. Cham: Springer International Publishing, 2020.
- 8 Ballester J, Quijal-Zamorano M, Méndez Turrubiates RF, *et al*. Heat-related mortality in Europe during the summer of 2022. *Nat Med* 2023;29:1857–66.
- 9 US Department of Commerce N. Weather related fatality and injury statistics, 2023. Available: <https://www.weather.gov/hazstat/> [Accessed 16 Aug 2023].
- 10 Anderegg WRL, Abatzoglou JT, Anderegg LDL, *et al*. Anthropogenic climate change is worsening North American pollen seasons. *Proc Natl Acad Sci U S A* 2021;118:e2013284118.
- 11 Höflich C. Pollenassoziierte allergische Erkrankungen in Zeiten des Klimawandels – neue Daten zur Entwicklung in Deutschland. *AL* 2019;42:103–10.
- 12 Mora C, McKenzie T, Gaw IM, *et al*. Over half of known human pathogenic diseases can be aggravated by climate change. *Nat Clim Chang* 2022;12:869–75.
- 13 Rocklöv J, Dubrow R. Climate change: an enduring challenge for vector-borne disease prevention and control. *Nat Immunol* 2020;21:479–83.
- 14 WHO, UNICEF. Global vector control response 2017–2030. 2017.
- 15 Romanello M, Napoli C di, Green C, *et al*. The 2023 report of the Lancet Countdown on health and climate change: the imperative for a health-centred response in a world facing irreversible harms. *Lancet* 2023;402:2346–94.
- 16 Rocque RJ, Beaudoin C, Ndjaboue R, *et al*. Health effects of climate change: an overview of systematic reviews. *BMJ Open* 2021;11:e046333.
- 17 Extreme heat: the economic and social consequences for the United States. Washington, DC: Atlantic Council, 2021.
- 18 Day E, Fankhauser S, Kingsmill N, *et al*. Upholding labour productivity under climate change: an assessment of adaptation options. *Clim Pol* 2019;19:367–85.
- 19 Ebi KL, Semenza JC, Rocklöv J. Current medical research funding and frameworks are insufficient to address the health risks of global environmental change. *Env Health* 2016;15:108.
- 20 Whitmee S, Haines A, Beyrer C, *et al*. Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. *Lancet* 2015;386:1973–2028.
- 21 Ivanova D, Barrett J, Wiedenhofer D, *et al*. Quantifying the potential for climate change mitigation of consumption options. *Environ Res Lett* 2020;15:093001.
- 22 Marteau TM, Hollands GJ, Fletcher PC. Changing human behavior to prevent disease: the importance of targeting automatic processes. *Science* 2012;337:1492–5.
- 23 Maibach E. Social marketing for the environment: using information campaigns to promote environmental awareness and behavior change. *Health Promot Int* 1993;8:209–24.
- 24 Intergovernmental Panel on Climate Change. Policies, instruments and co-operative agreements. In: *Climate change 2007. Mitigation climate change. Contribution of working group III to the fourth assessment report*. IPCC, Cambridge: Cambridge University Press, 2007: 745–808.
- 25 Jenny MA, Betsch C. *How large-scale behavioural data can support climate action and system-level change*. 2022.
- 26 Brehm JW. *A theory of psychological reactance*. 1966.
- 27 Miron AM, Brehm JW. Reactance Theory - 40 Years Later. *Z f Sozialpsychol* 2006;37:9–18.
- 28 Sprengel P, Tannert S, Betsch C. Explaining Boomerang Effects in Persuasive Health Communication: How Psychological Reactance to Healthy Eating Messages Elevates Attention to Unhealthy Food. *J Health Commun* 2023;28:384–90.
- 29 Carattini S, Kallbekken S, Orlov A. How to win public support for a global carbon tax. *Nature New Biol* 2019;565:289–91.
- 30 Leiserowitz AA. Building public and political will for climate change action 2020. Available: <https://environment.yale.edu/news/article/building-public-and-political-will-for-climate-change-action> [Accessed 16 Aug 2023].
- 31 Ockwell D, Whitmarsh L, O'Neill S. Reorienting climate change communication for effective mitigation: forcing people to be green or fostering grass-roots engagement? *Sci Commun* 2009;30:305–27.
- 32 Stern PC. New Environmental Theories: Toward a Coherent Theory of Environmentally Significant Behavior. *J Soc Issues* 2000;56:407–24.
- 33 Guillaume JHA, Sojamo S, Porkka M, *et al*. Giving Legs to Handprint Thinking: Foundations for Evaluating the Good We Do. *Earths Future* 2020;8:e2019EF001422.
- 34 Zukin C, Keeter S, Andolina M, *et al*. *A new engagement? Political participation, civic life, and the changing American citizen*. Oxford University Press, 2006.
- 35 Andolina M, Keeter S, Zukin C, *et al*. *A guide to the index of civic and political engagement*. Coll Park MD Cent Inf Res Civ Learn Engagem, 2003.
- 36 Gopal K, Verma R. Political Participation: scale development and validation. *Int J Appl Bus Econ Res* 2017;15.
- 37 Betsch C, Wieler L, Bosnjak M, *et al*. Germany COVID-19 Snapshot Monitoring (COSMO Germany): Monitoring knowledge, risk perceptions, preventive behaviours, and public trust in the current coronavirus outbreak in Germany 2020. *PsychArchives* 2020.
- 38 Eni Enrico Mattei F, Kolstad CD, Stavins RN. Assessment and communication of the social science of climate change: Bridging research and policy. *Rev Environ Energy Econ* 2015.
- 39 Victor DG. Climate change: Embed the social sciences in climate policy. *Nature New Biol* 2015;520:27–9.
- 40 UN secretary-general's guidance note on behavioural science. 2024. Available: <https://www.un.org/en/content/behaviouralscience/> [Accessed 16 Aug 2023].
- 41 IPCC. Climate change 2022. Mitigation of climate change: contribution of working group III to the sixth assessment report of the intergovernmental panel on climate change 2022.2023. Available: <https://www.cambridge.org/core/product/identifier/9781009157926/type/book>
- 42 World Health Organization. Seventy-second regional committee for Europe: Tel Aviv, 12–14 September 2022: case examples of applying behavioural and cultural insights (BCI) to health-related policies, services and communication processes. World Health Organization. Regional Office for Europe, 2022.
- 43 House of Lords Environment and Climate Change Committee. In our hands: behaviour change for climate and environmental goals. Authority of the House of Lords; 2022.
- 44 Grothmann T, Patt A. Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Glob Environ Change* 2005;15:199–213.
- 45 Grothmann T, Reusswig F. People at Risk of Flooding: Why Some Residents Take Precautionary Action While Others Do Not. *Nat Hazards* 2006;38:101–20.
- 46 Westcott R, Ronan K, Bambrick H, *et al*. Expanding protection motivation theory: investigating an application to animal owners and emergency responders in bushfire emergencies. *BMC Psychol* 2017;5:13:13.
- 47 Drews S, van den Bergh JCJM. What explains public support for climate policies? A review of empirical and experimental studies. *Clim Pol* 2016;16:855–76.
- 48 van Zomeren M, Postmes T, Spears R. Toward an integrative social identity model of collective action: a quantitative research synthesis of three socio-psychological perspectives. *Psychol Bull* 2008;134:504–35.
- 49 Klöckner CA. A comprehensive model of the psychology of environmental behaviour—A meta-analysis. *Glob Environ Change* 2013;23:1028–38.
- 50 Betsch C, Wieler LH, Habersaat K. Monitoring behavioural insights related to COVID-19. *The Lancet* 2020;395:1255–6.
- 51 WHO Regional Office For Europe. COVID-19 Snapshot Monitoring (COSMO Standard): Monitoring knowledge, risk perceptions, preventive behaviours, and public trust in the current coronavirus outbreak - WHO standard protocol. *PsychArchives* 2020.

- 52 Rogers RW. A Protection Motivation Theory of Fear Appeals and Attitude Change1. *J Psychol* 1975;91:93–114.
- 53 Rosenstock IM. The Health Belief Model and Preventive Health Behavior. *Health Educ Monogr* 1974;2:354–86.
- 54 Ajzen I. The theory of planned behavior. *Organ Behav Hum Decis Process* 1991;50:179–211.
- 55 Schwarzer R. Health action process approach (HAPA). *Gesundheitspsychologie Von Bis Z.* 2002.241–5.
- 56 Deci EL, Ryan RM. *Intrinsic motivation and self-determination in human behavior*. New York: Plenum, 1985.
- 57 Klöckner CA, Blöbaum A. A comprehensive action determination model: Toward a broader understanding of ecological behaviour using the example of travel mode choice. *J Environ Psychol* 2010;30:574–86.
- 58 Grelle S, Hofmann W. When and Why Do People Accept Public-Policy Interventions? An Integrative Public-Policy-Acceptance Framework. *Perspect Psychol Sci* 2024;19:258–79.
- 59 Reid AE, Cialdini RB, Aiken LS, et al. Social norms and health behavior. In: SteptoeA, ed. *Handbook of behavioral medicine*. New York: Springer, 2010: 263–74.
- 60 Bamberg S, Möser G. Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *J Environ Psychol* 2007;27:14–25.
- 61 Geiger SM, Geiger M, Wilhelm O. Environment-Specific vs. General Knowledge and Their Role in Pro-environmental Behavior. *Front Psychol* 2019;10:718.
- 62 Münnich R. *Stichprobenoptimierung Und Schätzung Im Zensus 2011 / Ralf Münnich*. Wiesbaden: Statistisches Bundesamt, 2012.
- 63 Klima B. *Unsere Empfehlungen für die deutsche Klimapolitik*. Berlin. 2021.
- 64 Leite WL, Huang I-C, Marcoulides GA. Item Selection for the Development of Short Forms of Scales Using an Ant Colony Optimization Algorithm. *Multivariate Behav Res* 2008;43:411–31.
- 65 Eddy M. Ugly fight over climate bill exposes cracks in german coalition. N Y Times; 2023. Available: <https://www.nytimes.com/2023/05/30/world/europe/germany-climate-coalition.html>
- 66 van Deth JW. What is political participation? In: *Oxford research encyclopedia*. Oxford University Press, 2016.
- 67 Leiserowitz A, Roser-Renouf C, Marlon J, et al. Global Warming's Six Americas: a review and recommendations for climate change communication. *Curr Opin Behav Sci* 2021;42:97–103.
- 68 Milbrath LW, Goel ML. *Political participation: how and why do people get involved in politics?*. 1977.
- 69 Corning AF, Myers DJ. Individual Orientation Toward Engagement in Social Action. *Polit Psychol* 2002;23:703–29.
- 70 Engels A, Hüther O, Schäfer M, et al. Public climate-change skepticism, energy preferences and political participation. *Glob Environ Change* 2013;23:1018–27.
- 71 Latkin CA, Dayton L, Lee D-I, et al. Correlates of Levels of Willingness to Engage in Climate Change Actions in the United States. *Int J Environ Res Public Health* 2021;18:9204.
- 72 Theocharis Y, van Deth JW. The continuous expansion of citizen participation: a new taxonomy. *Eur Pol Sci Rev* 2018;10:139–63.
- 73 Campbell E, Kotcher J, Maibach E, et al. *Who is willing to participate in non-violent civil disobedience for the climate?* New Haven, CT: Yale University and George Mason University, Yale Program on Climate Change Communication, 2022.
- 74 Barnes S, Kaase M. Konventionelle politische partizipation. In: *Zusammenstellung Sozialwissenschaftlicher Items Skalen ZIS*. 1997.
- 75 Wynes S, Nicholas KA. The climate mitigation gap: education and government recommendations miss the most effective individual actions. *Environ Res Lett* 2017;12:074024.
- 76 Vesely S, Klöckner CA. Social Desirability in Environmental Psychology Research: Three Meta-Analyses. *Front Psychol* 2020;11:1395.
- 77 Umweltbundesamt. CO2-rechner des umweltbundesamtes 2023. Available: https://uba.co2-rechner.de/de_DE/ [Accessed 18 Aug 2023].
- 78 Geiger M, Bähr K, Betsch C, et al. in preperation It's not easy bein' green: Individual differences in pro-environmental behavior.
- 79 Temme H, Geiger M, Lehrer L, et al. in preperation Perspectives on Climate Change Knowledge – A Mixed-Methods Study.
- 80 Vinck P, Pham PN, Bindu KK, et al. Institutional trust and misinformation in the response to the 2018-19 Ebola outbreak in North Kivu, DR Congo: a population-based survey. *Lancet Infect Dis* 2019;19:529–36.
- 81 Hagen B, Middel A, Pijawka D. European Climate Change Perceptions: Public support for mitigation and adaptation policies. *Env Pol Gov* 2016;26:170–83.
- 82 Sleeth-Keppler D, Perkowitz R, Speiser M. It's a Matter of Trust: American Judgments of the Credibility of Informal Communicators on Solutions to Climate Change. *Env Comm* 2017;11:17–40.
- 83 Maibach E, Roser-Renouf C, Leiserowitz A. *Global warming's six Americas 2009: An audience segmentation analysis*. 2009.
- 84 The Lancet Oncology. Climate change and skin cancer: urgent call for action. *Lancet Oncol* 2023;24:823.
- 85 Bandura A. *Social foundations of thought and action*. Englewood Cliffs NJ, 1986.
- 86 Bandura A. Self-efficacy: toward a unifying theory of behavioral change. *Psychol Rev* 1977;84:191–215.
- 87 Renner B, Schwarzer R. The motivation to eat a healthy diet : How intenders and nonintenders differ in terms of risk perception, outcome expectancies, self-efficacy, and nutrition behavior. *Pol Psychol Bull* 2005;36:7–15.
- 88 Cialdini RB, Kallgren CA, Reno RR. A focus theory of normative conduct: A theoretical refinement and reevaluation of the role of norms in human behavior. *Adv Exp Soc Psychol* 1991;24:201–34.
- 89 Cialdini RB. Crafting Normative Messages to Protect the Environment. *Curr Dir Psychol Sci* 2003;12:105–9.
- 90 Saleem MA, Ismail H, Ali RA. Actions Speak Louder than Words: Investigating the Interplay between Descriptive and Injunctive Norms to Promote Alternative Fuel Vehicles. *Sustainability* 2021;13:9662.
- 91 Roser-Renouf C, Nisbet MC. The measurement of key behavioral science constructs in climate change research. *Int J Sustain Commun* 2008;3:37–95.
- 92 Singh AS, Zwickle A, Bruskotter JT, et al. The perceived psychological distance of climate change impacts and its influence on support for adaptation policy. *Environ Sci Policy* 2017;73:93–9.
- 93 van Valkengoed AM, Abrahamse W, Steg L. To select effective interventions for pro-environmental behaviour change, we need to consider determinants of behaviour. *Nat Hum Behav* 2022;6:1482–92.
- 94 Zettler I, Lilleholt L, Böhm R, et al. Comparing responses in repeated cross-sectional and panel studies: Results across eight weeks during the first COVID-19 lockdown in Denmark. *Psychol Assess* 2021;33:691–704.
- 95 Moser SC, Dilling L. Communicating climate change: closing the science-action gap. *Oxf Handb Clim Change Soc* 2011;2011:161–74.
- 96 Sheeran P, Webb TL. The Intention–Behavior Gap. *Social & Personality Psych* 2016;10:503–18.
- 97 Guagnano GA, Stern PC, Dietz T. Influences on Attitude-Behavior Relationships: A Natural Experiment with Curbside Recycling. *Env Behav* 1995;27:699–718.
- 98 Chater N, Loewenstein GF. The i-Frame and the s-Frame: How Focusing on the Individual-Level Solutions Has Led Behavioral Public Policy Astray. *SSRN J* 2022.
- 99 Whitmarsh L, Poortinga W, Capstick S. Behaviour change to address climate change. *Curr Opin Psychol* 2021;42:76–81.
- 100 Berinsky AJ, Margolis MF, Sances MW. Separating the Shirkers from the Workers? Making Sure Respondents Pay Attention on Self-Administered Surveys. *Am J Political Sci* 2014;58:739–53.
- 101 Berinsky AJ, Margolis MF, Sances MW, et al. Using screeners to measure respondent attention on self-administered surveys: Which items and how many? *PSRM* 2021;9:430–7.
- 102 MacCann C, Pearce N, Jiang Y. The General Factor of Personality Is Stronger and More Strongly Correlated With Cognitive Ability Under Instructed Faking. *J Individ Differ* 2017;38:46–54.
- 103 Nielsen KS, Cologna V, Bauer JM, et al. Realizing the full potential of behavioural science for climate change mitigation. *Nat Clim Chang* 2024;14:322–30.
- 104 Intergovernmental Panel on Climate Change (IPCC). *Climate change 2022 – Impacts, adaptation and vulnerability: working group II contribution to the sixth assessment report of the intergovernmental panel on climate change*. 1st edn. Cambridge University Press, 2023. Available: <https://www.cambridge.org/core/product/identifier/9781009325844/type/book>