Research article

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Validation of the Inventory of Climate Emotions (ICE) in a German sample

Validierung des Inventory of Climate Emotions (ICE) in einer deutschen Stichprobe

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Author statement

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Abstract

The confrontation with the consequences of the climate crisis can elicit strong emotions. These so-called climate emotions are important drivers behind pro-environmental behavior. However, they have also been associated with impaired mental health. In the light of the huge challenges we face, understanding the complex mechanisms behind emotions, behavior and mental health is crucial. The Inventory of Climate Emotions (ICE) presents the first validated scale to assess a multitude of different emotional responses (anger, contempt, enthusiasm, powerlessness, guilt, isolation, anxiety and sorrow) to the climate crisis. In this study, we translated and validated the ICE in a representative German sample ($N = 966$). We replicated the 8-factor structure and all subscales showed acceptable to good internal consistency. Furthermore, we replicated a positive association between multiple climate emotions (powerlessness, guilt, isolation, anxiety, sorrow) and general depressive and anxiety symptoms. Climate emotions were generally positively associated with pro-environmental behavior, the only exception being climate contempt, which was negatively associated with pro-environmental behavior. In conclusion, we present a validated German translation of the ICE and provide evidence for a negative association of specific climate emotions and mental health as well as a positive association of specific climate emotions and pro-environmental behavior.

Keywords

climate emotions, pro-environmental behavior, climate anxiety, climate anger, mental health.

Impact statement

In our study, we validated the German version of the Inventory of Climate Emotions (ICE), a scale that captures a wide range of emotional responses to the climate crisis. We found that emotions such as powerlessness, guilt, isolation, anxiety, and sorrow were linked to both poorer mental health and increased pro-environmental behavior. These findings are highly relevant for practitioners in environmental education, psychology, and climate communication: they highlight that climate emotions can be both a source of psychological strain and a driver of sustainable action. Interventions should therefore aim to support individuals in coping with these emotions while maintaining their motivational potential. The validated ICE scale offers a practical tool for assessing individual emotional responses to the climate crisis in German speaking countries.

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Zusammenfassung

Die Auseinandersetzung mit den Folgen der Klimakrise kann starke Emotionen auslösen. Solche Klimaemotionen sind wichtige Treiber für umweltfreundliches Verhalten, stehen aber auch im Zusammenhang mit psychischer Belastung. Angesichts der großen Herausforderungen ist es entscheidend, die komplexen Zusammenhänge zwischen Emotionen, Verhalten und psychischer Gesundheit besser zu verstehen. Das Inventory of Climate Emotions (ICE) ist das erste validierte Instrument zur Erfassung verschiedener emotionaler Reaktionen auf die Klimakrise, darunter Wut, Verachtung, Zuversicht, Machtlosigkeit, Schuld, Isoliertheit, Angst und Kummer. In dieser Studie haben wir das ICE ins Deutsche übersetzt und in einer repräsentativen deutschen Stichprobe ($N = 966$) validiert. Die achtfaktorielle Struktur konnte bestätigt werden und alle Subskalen zeigten eine zufriedenstellende bis gute interne Konsistenz. Zudem zeigte sich, dass bestimmte Klimaemotionen (z. B. Machtlosigkeit, Schuld, Isoliertheit, Angst, Kummer) positiv mit depressiven und Angstsymptomen assoziiert waren. Gleichzeitig standen diese Emotionen in positivem Zusammenhang mit umweltfreundlichem Verhalten – mit Ausnahme von Verachtung, die negativ damit korrelierte. Insgesamt präsentieren wir eine validierte deutsche Version des ICE und zeigen, dass Klimaemotionen sowohl mit psychischer Belastung als auch mit umweltfreundlichem Verhalten in Verbindung stehen.

Schlüsselwörter

Klimaemotionen, umweltfreundliches Verhalten, Klimaangst, Klimawut, psychische Gesundheit

Impact-Statement

In unserer Studie haben wir die deutsche Version des Inventory of Climate Emotions (ICE) validiert – einer Skala, die ein breites Spektrum emotionaler Reaktionen auf die Klimakrise erfasst. Wir fanden heraus, dass Emotionen wie Machtlosigkeit, Schuld, Isoliertheit, Angst und Kummer sowohl mit einer schlechteren psychischen Gesundheit als auch mit verstärkt umweltfreundlichem Verhalten zusammenhängen. Diese Ergebnisse sind besonders relevant für Fachkräfte in Umweltbildung, Psychologie und Klimakommunikation: Sie verdeutlichen, dass Klimaemotionen einerseits eine psychische Belastung darstellen, andererseits aber auch nachhaltiges Handeln fördern können. Interventionen sollten daher darauf abzielen, Menschen beim Umgang mit diesen Emotionen zu unterstützen, ohne deren motivierendes Potenzial zu mindern. Die validierte ICE-Skala stellt ein praxistaugliches Instrument dar, um individuelle emotionale Reaktionen auf die Klimakrise im deutschsprachigen Raum systematisch zu erfassen.

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1 Introduction

The climate crisis is an existential threat to human and planetary health (Romanello et al., 2021). The implications of the climate crisis include prolonged and more intense periods of extreme heat, drought and floods (IPCC, 2023). In December 2015, 196 countries signed the legally binding Paris Agreement, whose aim is to "limit the temperature increase to 1.5°C above pre-industrial levels" (United Nations Framework Convention on Climate Change, 2016). However, almost ten years later, greenhouse gas emissions are continuing to rise and the global mean temperature has already increased to 1.1°C above pre-industrial levels in the decade 2011-2020 (IPCC, 2023).

The threatening consequences of the climate crisis and the inactivity of world leaders to address the issue accordingly evoke strong emotions in large parts of the population. Hickman et al. (2021) surveyed 10,000 adolescents and young adults from ten different countries. Across all countries, 59% of participants reported to be extremely or very worried about the impact of the climate crisis. Furthermore, they found that the climate crisis made the participants feel afraid (67%), sad (67%), anxious (62%), powerless (56%), angry (57%), and guilty (50%). Emotional responses to the climate crisis and its impacts are often referred to as climate emotions (Marczak et al., 2023). While most of these emotions may be uncomfortable, our emotions are a crucial driver of our behavior. Van der Linden (2015) found that affect towards the climate crisis explained more variance in climate risk perception and willingness to take mitigation efforts than variables like personal experience, values, knowledge or social norms.

While the body of literature investigating climate emotions has grown rapidly over the last years, there has been a lack of validated questionnaires to measure them. There are two popular validated questionnaires to measure climate anxiety: Hogg eco-anxiety scale (HEAS; Heinzel et al., 2023; Hogg et al., 2021) and the Climate Anxiety Scale (CAS; Clayton & Karazsia, 2020; Wullenkord et al., 2021). Climate anxiety is "the chronic fear of environmental doom" and can include anxiety, worry, stress, hopelessness, despair, irritability, or bodily symptoms of anxiety (Clayton et al., 2017). Both HEAS and CAS, however, may not be applicable to every research question or population. The CAS has been criticized for not actually measuring the emotional experience, but rather the functional impairments caused by it (Wullenkord et al., 2021). In addition, while psychometric properties of the original scale were acceptable, the psychometric properties of the German translations were not (Wullenkord et al., 2021). Recent efforts to validate alternative factor models proposed for the CAS lead to mixed results (Hogg et al., 2023). While the HEAS reported good psychometric properties, it was developed based on the Generalized Anxiety Disorder Scale-7 (GAD-7) (Spitzer et al., 2006) and therefore focuses on the frequency of impairments by different aspects of eco-anxiety ("Over the last 2 weeks, how often have you been bothered by the following problems [...]"). The four subscales measure emotional responses, behavioral symptoms, rumination, and anxiety about personal impact. The frequency Likert scale ranges from "not at all" to "nearly every day". Thus, using the HEAS in the general population can lead to rather steep distributions and a lack of variance (e.g. see Heinzel et al., 2023). Most importantly, both the HEAS and the CAS focus

only on climate / eco-anxiety and a validated scale to measure a variety of climate emotions is needed.

Another validated scale is the Climate Change Distress and Impairment Scale (Hepp et al., 2023), which can be divided into a distress and impairment subscale. Here, multiple uncomfortable emotions like sadness, anger and anxiety are summarized into one score. Climate change distress captures a larger variety of climate emotions compared to the HEAS and CAS. However, uncomfortable climate emotions cannot be investigated separately with the Climate Change Distress and Impairment Scale, thereby limiting possible applications. Other climate emotions, like anger or guilt, have been measured using single item questions in previous research (Chu & Yang, 2019; Contreras et al., 2024; Gregersen et al., 2023; Hickman et al., 2021; Stanley et al., 2021). Single item measures in psychological research come with several shortcomings, e.g., they tend to be more vulnerable to random measurement errors or individual interpretation (Hoeppner et al., 2011). Furthermore, single item measures for anxiety have been reported to have lower reliability than corresponding full scales (Gogol et al., 2014). Thus, while single item measures may be helpful in research concerning unambiguous and narrow constructs, complex human experiences – like emotions – should be measured with multiple items (Allen et al., 2022).

The Inventory of Climate Emotions (Marczak et al., 2023) presents the first validated tool to measure eight distinct climate emotions – anger, contempt, enthusiasm, powerlessness, guilt, isolation, anxiety, and sorrow. Climate anger describes feeling angry, furious or frustrated due the perception that other people (e.g., politicians) are not doing enough to mitigate climate change. In contrast, climate contempt describes feeling angry or annoyed due the perception that the dangers of climate change are exaggerated, thereby resembling the concept of climate change denial. Climate enthusiasm describes feeling hopeful or enthusiastic due to witnessing public mobilization or implementation of climate policies. Climate powerlessness describes feeling confused or powerless around the question of what an individual can do to mitigate climate change. Climate guilt describes the feeling of remorse around one's own contributing effect on climate change. Climate isolation describes the feeling of loneliness around the idea of being alone with one's thoughts and feelings about climate change. Lastly, climate sorrow describes the feeling of sadness or grief around the perception of irrevocable loss due to the climate crisis (Marczak et al., 2023). The questionnaire uses 32 items, with 4 items measuring each emotion. The original Polish version was validated via confirmatory factor analysis in a representative sample of 319 adults (Marczak et al., 2023). While this is a represents a relatively small sample for an eight-factor analysis, the English and Norwegian versions were validated in a representative sample of 485 Irish, 659 Australian and 491 Norwegian adults, respectively (Marczak et al., 2024; Rice et al., 2025). The authors confirmed the 8-factor structure and demonstrated high cross-cultural measurement invariance, which indicates that the ICE is understood similarly in different Western countries. Furthermore, the authors could show that the emotions were similarly related to external variables. For example, climate anger, climate guilt and climate anxiety were positively associated with both pro-climate perceptions and pro-environmental policy support across countries, while climate contempt was negatively associated with pro-climate perceptions and policy support across countries. These studies indicate that the ICE is a

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valid instrument for assessing climate emotions and has the potential to explain variance in important outcomes such as policy support. However, they also highlight several limitations. First, the climate powerlessness scale shows low internal consistency and limited convergent validity (Marczak et al., 2023, Marczak et al., 2024; Rice et al., 2025). Second, although the eight-factor model demonstrated good fit across studies, climate sorrow did not emerge as a factor in the exploratory factor analysis on which the ICE was built. Instead, the original analysis suggested a seven-factor solution, and climate sorrow was added on theoretical grounds. Finally, all validation studies reported high correlations between climate anxiety, climate anger, and climate sorrow (ranging from $r = 0.65$ to $r = 0.79$; Marczak et al. 2023; Marczak et al. 2024; Rice et al., 2025), raising questions about the conceptual distinctiveness of these three subscales.

When considering distinct emotional reactions, there is strong evidence for a positive association between climate anger and collective climate action (Gregersen et al., 2023; Kleres & Wettergren, 2017; Landmann & Rohmann, 2020; Stanley et al., 2021), individual mitigation efforts (Chu & Yang, 2019; Contreras et al., 2024; Stanley et al., 2021), pro-environmental policy support (Gregersen et al., 2023; Marczak et al., 2023) and the intention to punish wrongdoers (Harth et al., 2013). However, there are also examples of studies that could not identify an association of climate anger and collective climate action (Fernandes-Jesus et al., 2020; Landmann & Naumann, 2023), collective climate action intention (Bamberg et al., 2015; Rees & Bamberg, 2014), individual mitigation efforts (Gregersen et al., 2023) or pro-environmental policy support (Chu & Yang, 2019).

The relationship between climate anxiety and pro-environmental behavior is highly debated. In accordance with the eco-paralysis hypothesis (Innocenti et al., 2023) some studies present a negative association between perception of powerlessness and taking action against climate change (Aitken et al., 2011; Stanley et al., 2021; Williams & Jaftha, 2020). However, the majority of studies report a positive association between climate anxiety and collective climate action (Kleres & Wettergren, 2017; Ogunbode et al., 2022; Thomson & Roach, 2023), individual mitigation efforts (Chu & Yang, 2019; Hogg et al., 2024; Kühner et al., 2024; Ogunbode et al., 2022; Whitmarsh et al., 2022), and pro-environmental policy support (Chu & Yang, 2019; Wullenkord et al., 2021). Based on this observation climate anxiety has been discussed as a healthy and constructive response to the climate crisis (Cunsolo et al., 2020; Hogg et al., 2024). However, in other studies, climate anxiety was not associated with pro-environmental behavior (Clayton & Karazsia, 2020; Contreras et al., 2024; Marczak et al., 2023; Whitmarsh et al., 2022). To summarize, even though the eco-paralysis hypotheses is popular, empirical evidence supports a positive association between climate anxiety and collective climate action which supports the idea of climate anxiety being a constructive response to the climate crisis.

Another emotion that has been investigated in previous studies is climate hope. A recent meta-analysis revealed a positive association between climate hope and public pro-environmental behavior (e.g. going to protests or talking to friends and family; Geiger et al., 2023). However, the operationalization of hope differed immensely between different studies. Ojala (2015) identified two different kinds of

hope: constructive hope and denial-based hope. While constructive hope was positively associated with pro-environmental behavior, denial-based hope had a negative effect.

For climate-guilt, experimental studies found that inducing climate guilt increased pro-environmental behavioral intentions (Harth et al., 2013; Moore & Yang, 2020), support for pro-environmental groups (Mallett et al., 2013) and signing a pro-environmental petition (Rees et al., 2015). A correlational meta-analysis also found a positive association of guilt and pro-environmental behavior (Shipley & van Riper, 2022).

1.1 The current study

This study aimed to translate the ICE into German and validate the 8-factor structure in a German sample. Furthermore, we wanted to investigate the association of the distinct climate emotions with pro-environmental behavior and other important variables and test construct validity. We wanted to investigate convergent validity by investigating the association between climate emotions and the established HEAS subscales (Hogg et al. 2021). Moreover, personal risk perception, self-efficacy and collective efficacy were chosen to test discriminant validity as they are found alongside climate emotions in theoretical models explaining different forms of pro-environmental behavior (Fritsche et al. 2018; Lehrer et al. 2024). As presented in the introduction, climate emotions have been of great interest when trying to explain pro-environmental behavior and mental health indicators. Thus, we investigated the association of climate emotions and pro-environmental social influence, dietary CO_2 emissions, collective climate action, policy support, wellbeing, depression and anxiety and resilience to test for predictive validity.

Personal risk perception describes the perceived risk the climate crisis poses to an individual's life (van der Linden, 2015). Emotions like anger, sorrow, and anxiety are expected to stem from high personal risk perception (Fritsche et al., 2018; Parreira & Mouro, 2023), while climate contempt is linked to perceiving climate threats as exaggerated, suggesting a negative association.

Self-efficacy is the belief in one's ability to mitigate climate change (Hamann & Reese, 2020). High self-efficacy should promote climate enthusiasm, while low self-efficacy may be associated with climate powerlessness. Climate guilt may arise when people believe they could reduce emissions but don't act accordingly (Marczak et al., 2023).

Collective efficacy, or the belief that joint efforts can mitigate climate change, is also expected to be positively associated with climate enthusiasm (Hamann & Reese, 2020; Marczak et al., 2023).

Climate anxiety has been associated with decreased wellbeing and increased depression and anxiety symptoms (Hogg et al., 2024; Lawrance et al., 2022). Based on this, we assumed powerlessness, isolation, anxiety, and sorrow to negatively relate to wellbeing and positively to depression and anxiety.

Resilience is the ability to adapt and recover from stress (Smith et al., 2008). While not widely studied in the climate context, we expected climate anxiety and powerlessness to be negatively associated with resilience, due to their impact on coping resources and perceived agency.

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As climate contempt is negatively associated with climate anxiety (Marczak et al., 2024; Marczak et al., 2023) we assumed that it should be negatively associated with all subscales of the HEAS. In contrast, climate enthusiasm, being optimism-oriented, was expected to be negatively related to behavioral symptoms, while powerlessness, guilt, and isolation were expected to correlate positively with affective symptoms. Climate guilt was also expected to relate to anxiety about personal impact due to conceptual overlap. Given that HEAS measures climate anxiety, we assumed positive associations between climate anxiety and all its subscales. Due to the high correlation between climate anxiety and climate sorrow (Marczak et al., 2024; Marczak et al., 2023), we assumed the same pattern for climate sorrow.

The association between pro-environmental behavior and climate emotions has been discussed above. We expected pro-climate emotions to correlate positively with pro-environmental behavior (social influence behavior, collective climate action) and policy support, while climate contempt would show negative associations. For dietary CO_2 emissions, the pattern is reversed: stronger mitigation efforts mean lower emissions.

We hypothesized that 1) the 8-factor structure found in the Polish, Norwegian and Irish sample would be replicated in a German sample, 2) The internal consistency of the 8 ICE subscales would be Cronbach's alpha > 0.7, and 3) the 8 ICE subscales would show significant correlations with other measures (see Table 1).

Table 1

Expected associations between the ICE subscales and external measures.

	Anger	*Contempt*	*Enthusiasm*	*Powerlessness*	*Guilt*	*Isolation*	*Anxiety*	*Sorrow*
Personal risk perception	+	–					+	+
Self-efficacy			+	–	+			
Collective efficacy			+					
Wellbeing				–		–	–	–
Depression and anxiety				+		+	+	+
Resilience				–			–	
Eco-anxiety: Affective symptoms		–		+	+	+	+	+
Eco-anxiety: Anxiety about personal impact		–			+		+	+
Eco-anxiety: Rumination		–					+	+
Eco-anxiety: Behavioral symptoms		–	–				+	+
Social influence	+	–			+		+	+
CO_2 footprint (diet)	–	+	–		–		–	–
Collective climate action	+	–					+	+
Pro-environmental policy support	+	–	+		+		+	+

Note. + = expected positive association; – = expected negative association.

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2 Methods

This study was preregistered on the Open Science Framework (OSF; https://osf.io/d3gyv/. Supplementary material (supplementary tables, data, questionnaires, pilot study material, the analysis script, and the analysis report) can be accessed via the OSF (https://osf.io/xtw2p, in the folder "SUPPL_MATERIAL_German_ICE_Validation"). There were some deviations from the preregistration concerning the data analysis. Reasoning for these deviations can be found in Supplementary Table 1. The study was approved by the local ethics committee of TU Dortmund (GEKTUDO-2024-15).

In the preregistration, the variable "CO_2 footprint (diet)" was labeled "eco-friendly diet" and expected effects were therefore reversed compared to Table 1. As we have converted the answer of participants into CO_2 emissions (see 2.3. Measures), we made these changes to make the results easier to interpret.

2.1 Translation of the ICE into German

For a list of all versions of the translation, see Supplementary Table 2. For the translation of the ICE into German, we employed the TARPD (translation, review, adjudication, pre-test, documentation) method (Walde & Völlm, 2023). In the first step, five of the authors (DM, PB, MNB, ALF, FP) – whose mother tongue is German – independently translated the English items provided by Marczak et al. (2023) into German. After this, a revision team (DM, PB, ALF, FP, SH) went over all suggested translations, discussed similarities and differences and decided on one joint translation (Supplementary Table 2, translation 1). This version was then forwarded to two bilingual (German/English) professional translators to be back-translated into English. The review team revised the backtranslations and made some minor changes to the items (Supplementary Table 2, translation 2). After this, the questionnaire was tested in a pilot study. The results of the pilot study were discussed by the revision team and some additional changes to the items were made (Supplementary Table 2, final translation).

2.1.1 Translation pilot study

The aim of the pilot study was to test if the German version of the ICE was comprehensible and relevant. For this, we followed the guidelines for translation, adaptation and validation of scales suggested by Sousa and Rojjanasrirat (2011). We tested 10 participants in a two-phase study (M_{age} = 34.6, SD_{age} = 16.42; 50% women, 10% diverse; 50% identified as part of the climate movement). In phase one, participants received the German ICE (Supplementary Table 2, translation 2). Instead of regularly completing the questionnaire, they were asked to rate each item's comprehensiveness and relevance for the emotion it was supposed to measure. For every item, participants could rate the item as either "comprehensible" or "incomprehensible" and as "relevant" or "irrelevant". Moreover, for every subscale (e.g., climate anger) the participants were asked if the four items measure this emotion "completely" or "incompletely". After participants completed the questionnaire, phase two was a semi-structured interview. For every item that had been marked as either "incomprehensible" or "irrelevant", participants were asked why they had rated the item as such and if they had a suggestion, on how to increase the

comprehensibility or relevance of the item. The same was done for every subscale the participant had rated as incomplete. Lastly, all participants were asked if they felt like any emotion related to the climate crisis was missing from the questionnaire. Each session lasted about 20 minutes and participants received a compensation of 10€ for their participation. All participants gave written informed consent and were treated according to the Declaration of Helsinki.

2.2 Participants

For the main study, we quota sampled 1156 participants via the service provider Bilendi (Bilendi GmbH, Uhlandstr. 47, 10719 Berlin – Germany) in an online survey presented in Unipark (QuestBack GmbH, Oslo, Norway). We acquired this large representative sample (for age, gender and federal state) for multiple research questions (https://osf.io/xtw2p). Gender was assessed by asking participants, "How would you describe your gender?". Possible answers were "male", "female", and "diverse". Post-hoc sample size calculation for structural equation modeling (effect size: 0.3 (medium), statistical power: 0.95, number of latent variables: 8, number of observed variables: 32, probability level: 0.05) resulted in a minimum sample size of 256. During the questionnaire, participants who did not meet our quota or failed any of two attention checks were excluded from finishing the questionnaire. Participants who completed the questionnaire in under 11 minutes were marked as speeders and excluded from the questionnaire. This cut-off value was determined by Bilendi on the basis of the median answering time (median = 21.5 minutes, cut off = 11 minutes). Of 1156 participants completing the survey, 134 participants were removed due to being speeders.

Inspecting the data, we noticed some unusual response patterns. Some participants gave the same answer for every climate emotion item (e.g., always choosing the first option), which doesn't seem plausible given that some emotions are negatively correlated (Marczak et al., 2023). Due to this, we additionally filtered the data for conspicuous response styles. This exclusion criterion was not pre-registered, but seemed important to the authors for meaningful data interpretation. We used the *longstring* function from the R *careless* package (version 1.2.2.) to identify the longest string of identical answers for every participant. We excluded participants whose longest string deviated more than two standard deviations from the mean (> 22.21). Based on this, 56 participants were removed, totaling in sample of 966 individuals (51% women, 0% diverse, M_{age} = 49.88 years, SD_{age} = 16.15 years, age range = 18 – 80 years). Demographics (age, gender, federal state, household income, education, country of birth) of the participants are found in Supplementary Table 3. The majority of participants (≈57%) reported an annual household income between €24,000 and €80,000 after tax, while 10% chose not to disclose their income. Almost all participants were born in Germany (96%). With respect to educational background, just over half had completed *Abitur* (12-13 years, 52%), followed by *Realschule* (10 years, 34%) and *Hauptschule* (9-10 years, 12%). Regarding professional qualifications, the most common were apprenticeships (31%), vocational or business school degrees (18%), and university degrees (Bachelor: 13%, Master: 15%, PhD: 2%). All participants gave informed consent.

2.3 Measures

In this manuscript, we will only describe the analyzed measures. A complete overview of tested measures and the analysis plan for those constructs can be found in the Supplementary Materials. All items were presented in German. The ICE items were presented in a random order; for the rest of the questionnaires the order of subscales and the order of items within each subscale were random.

2.3.1 ICE

The German version of the ICE consists of 32 items and 8 subscales measuring the following climate emotions: anger, contempt, enthusiasm, powerlessness, guilt, isolation, anxiety and sorrow. It consists of different statements (e.g., "I feel angry that the political and economic system that we live in harms the climate.", see Table 4 for all items) and participants are asked to state, how much they agree with this statement on a 5-point Likert scale (1 = "strongly disagree" to 5 = "strongly agree"). Internal consistency is reported in Table 4.

2.3.2 Personal climate change risk perception

Personal risk perception was measured with an adapted German version (Eichinger et al., 2022) of the risk perception questionnaire published by van der Linden (2015). It consisted of three items (e.g., "In your judgment, how likely are you, sometime during your life, to experience serious threats to your health or overall well-being, as a result of climate change?") which the participants answered on a 5-point Likert scale (1 = "very likely/very large/very worried" to 5 = "very unlikely/very small/not worried at all"). Cronbach's α of this scale was 0.86.

2.3.3 Efficacy in achieving climate protection

Efficacy was measured based on previous research by Hamann and Reese (2020). We measured collective efficacy and self-efficacy with regard to achieving climate protection with six items each. The items (e.g., "I believe that I as an individual can promote environmental protection") were answered on a 7-point Likert scale (1 = "strongly disagree" to 7 = "completely agree"). Cronbach's α of both scales was 0.95.

2.3.4 Wellbeing

The WHO-5 (Bruin et al., 1996) is a questionnaire which measures the general well-being over the last two weeks. It consists of 5 items (e.g., "In the last two weeks I felt happy and was in a good mood") on a 5-point Likert scale, with 1 meaning "never" and 5 meaning "the whole time". Cronbach's α of this scale was 0.92.

2.3.5 General depression and anxiety

The Patient Health Questionnaire 4 (Löwe et al., 2010) is a questionnaire measuring general depression and anxiety symptoms over the last two weeks. It consists of 4 items (e.g., "Little interest or pleasure in your activities") answered on a 4-point Likert scale, with 1 meaning "never" and 4 meaning "almost every day". Cronbach's α of this scale was 0.89.

2.3.6 Resilience

The Brief Resilience Scale (Chmitorz et al., 2018; Smith et al., 2008) is a questionnaire measuring general resilience. The participants are asked how much the agree with 6 statements (e.g., "I tend to recover quickly after difficult times") on a 6-point Likert scale, with 1 meaning "completely disagree" and 5 meaning "completely agree". Cronbach's α of this scale was 0.86.

2.3.7 Eco-Anxiety

HEAS (Heinzel et al., 2023; Hogg et al., 2021) is a questionnaire measuring impairments experienced when thinking about the climate crisis or other environmental calamities over the last 2 weeks on four subscales: affective symptoms, rumination, behavioral symptoms, and anxiety about personal impact. It consists of 13 items (e.g., "Not being able to stop or control worrying"). The participants are asked to answer on a 4-point Likert scale, with 0 meaning "not at all" and 3 meaning "almost every day". Cronbach's α of the subscales was 0.92 for affective symptoms, 0.92 for rumination, 0.81 for behavioral symptoms, and 0.89 for anxiety about personal impact.

2.3.8 Pro-environmental social influence

Social influence behavior describes the effort participants took to motivate people in their social surroundings (e.g., friends, family) towards more climate protection over the last 6 months. It was published by Eichinger et al. (2022) and was based on Ojala (2012). It consists of 4 items (e.g., "In the last 6 months I tried to convince family members, friends or acquaintances to do more for climate protection.") and participants are asked to answer on a 6-point Likert scale, with 1 meaning "not at all" and 6 meaning "exactly right". Cronbach's α of this scale was 0.88.

2.3.9 Dietary CO_2 emissions (footprint behavior)

The dietary CO_2 footprint was measured using the diet-related items of the WWF ecological footprint calculator (https://www.wwf.de/themen-projekte/klimaschutz/wwf-klimarechner). It consisted of 6 questions concerning what the participants had eaten over the last 6 months (e.g., "How often do you drink or eat milk and dairy products such as yoghurt, cheese, butter or cream?). Based on the answers we calculated the CO_2 emissions for every participant. The CO_2 emissions corresponding to each item were taken from the WWF website.

2.3.10 Collective climate action

The ecological handprint questionnaire (Spliesgart et al., in press) measures collective climate action and any efforts to contribute to structural change to mitigate the climate crisis over the last 6 months. It consists of 8 items (e.g., "In the last 6 months I participated in actions or protests for climate protection") that were answered on a 6-point Likert scale, with 1 meaning "not at all" and 6 meaning "exactly right". Cronbach's α of this scale was 0.93.

2.3.11 Pro-environmental policy support

Pro-environmental policy support was measured with 24 items with concrete climate protection measures (e.g., "At least two per cent of the total area of each federal state is to be made available for the expansion of solar and wind energy systems"). The 24 items were published by the Planetary Health Action Survey (PACE; Lehrer et al., 2024). For each item, participants were asked to indicate how much they agree with the climate protection measures on a 7-point Likert scale, with 1 meaning "completely disagree" and 7 meaning "completely agree". Cronbach's α of this scale was 0.95.

2.4 Statistical analysis

All analyses were conducted in RStudio 2023.12.1 using R version 4.3.1 (2023-06-16 ucrt). Distributions of all ICE items can be found in the analysis report ("1. Descriptives ICE").

2.4.1 Confirmatory factor analysis

First, we tested if the ICE subscales were normally distributed using Shapiro-Wilk normality test (Shapiro & Wilk, 1965) and Mardia's multivariate normality test (Mardia, 1970). Shapiro-Wilk test revealed that none of the ICE subscales were normally distributed and Mardia's test revealed multivariate non-normality concerning skew and kurtosis. Thus, the confirmatory factor analysis was fitted using maximum likelihood estimation with robust standard errors and a Satorra-Bentler test statistic ("MLM"). The confirmatory factor analysis and the calculation of Cronbach's α were conducted using the *cfa* function from *lavaan* package (version 0.6.16).

2.4.2 Convergent validity

To investigate the association of ICE subscales with other constructs, we used Spearman's Rho correlation. Based on the number of our hypotheses (see Table 1), we used the Bonferroni-Holm (Holm, 1979) method to determine if a correlation was significant or not (0.05/56 = 0.0009).

To investigate convergent validity, we calculated the average variance extracted (AVE), which is the amount of variance captured by a construct compared to the amount of variance that is attributed to the measurement error. This step was not preregistered, but recommended after preregistration by an expert in the field.

2.4.3 Additional analyses

Some of our hypotheses concerning the association of climate emotions and other constructs were not confirmed, specifically the association between climate powerlessness and self-efficacy and the association between climate enthusiasm and the behavioral HEAS subscale. To get a deeper understanding of the complex relationships, we performed exploratory (not pre-registered) correlational analyses on the item level. Results are displayed in the analysis report ("5.1. Efficacy and Powerlessness" & "5.2. Enthusiasm and HEAS Behavior").

Like reported in previous studies (Marczak et al., 2024; Marczak et al., 2023), climate emotions correlated highly with each other (see Table 2) and showed similar

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association patterns with external variables (see Table 4). To investigate the possibility that all climate emotions load onto one higher order factor, we calculated a second CFA. Here, all eight first-order climate emotions loaded onto a single overarching "climate emotion" factor.

3 Results

3.1 Pilot study

Detailed results of the pilot study can be found in Supplementary Tables 4 and 5. Most items were rated as being comprehensible by the participants. Three participants rated item 11 as incomprehensible, as they were not sure what "concrete actions (*konkretes Handeln*)" the item referred to. We changed the item to refer to "concrete measures (*konkrete Maßnahmen*)" accordingly. This was done after consultation with the first author of the ICE (Marczak et al., 2023). Four participants rated item 31 as incomprehensible due to a similar reason, as they could not tell which concrete "possibilities (*Möglichkeiten*)" the item referred to. We chose to rearrange the item to make it clear that we mean all possibilities that may be relevant for the individual. We refrained from adding any concrete possibilities or examples as we did not want to change the meaning of the item in comparison to the original. Furthermore, multiple items were rated as being irrelevant, mostly because they were seen as redundant.

Interestingly, seven of our participants rated the climate anger scale as being incomplete. Participants reported that they were missing an item measuring the anger towards behaviors of individuals (e.g., driving big cars).

3.2 Distribution and correlations

Figure 1 shows the distribution of the eight ICE subscales. As can be seen in Table 2, almost all climate emotions are significantly correlated to one another. Most climate emotions are positively associated with each other, with the exception of climate contempt, which is negatively associated with most other climate emotions. The only non-significant associations are between climate powerlessness and enthusiasm and climate powerlessness and contempt. The highest associations are between climate sorrow and climate anxiety ($r = .75$, $p < 0.001$), climate sorrow and climate anger ($r = .74$, $p < 0.001$), and climate anger and climate anxiety ($r = .70$, $p < 0.001$).

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Figure 1

Variability and distribution of the ICE subscales. The boxplots show the median and the 1.5 interquartile range. The violin plots show the distribution of each subscale.

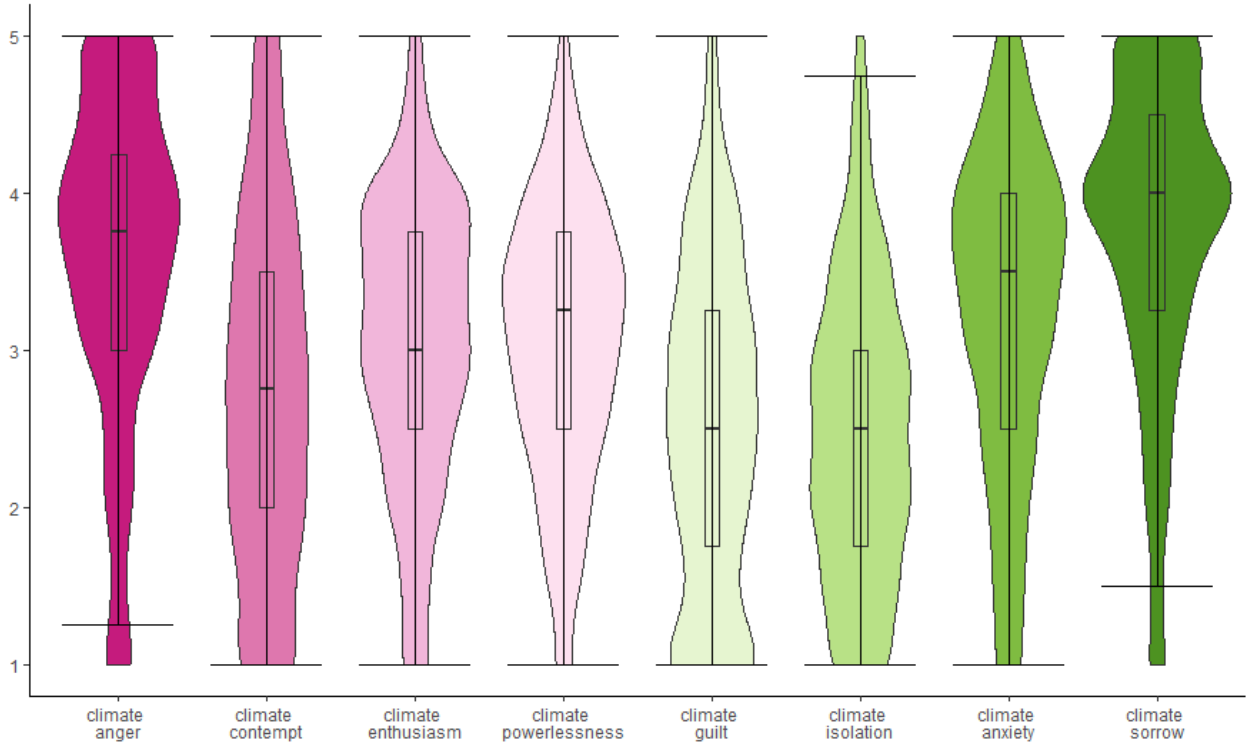

Table 2

Spearman' rho correlations of ICE subscales and their means and standard deviations (SD).

	Anger	*Contempt*	*Enthusiasm*	*Powerlessness*	*Guilt*	*Isolation*	*Anxiety*	*Mean (SD)*
Anger								3.59 (1.02)
Contempt	-0.55*** [-0.59–-0.50]							2.76 (1.11)
Enthusiasm	0.28*** [0.22–0.33]	-0.24*** [-0.30–-0.18]						3.05 (0.91)
Powerlessness	0.30*** [0.24–0.36]	-0.02 [-0.08–0.05]	0.06 [-0.001–0.12]					3.05 (0.86)
Guilt	0.52*** [0.47–0.56]	-0.35*** [-0.40–-0.29]	0.37*** [0.32–0.43]	0.48*** [0.43–0.52]				2.53 (1.04)
Isolation	0.49*** [0.44–0.54]	-0.20*** [-0.28–-0.14]	0.27*** [0.21–0.33]	0.39*** [0.33–0.44]	0.63*** [0.59–0.67]			2.50 (0.94)
Anxiety	0.70*** [0.66–0.73]	-0.47*** [-0.51–-0.42]	0.33*** [0.27–0.38]	0.47*** [0.42–0.52]	0.66*** [0.63–0.70]	0.63*** [0.59–0.67]		3.25 (1.00)
Sorrow	0.74*** [0.71–0.77]	-0.53*** [-0.57–-0.48]	0.30*** [0.24–0.36]	0.33*** [0.28–0.39]	0.54*** [0.50–0.58]	0.43*** [0.38–0.48]	0.75*** [0.72–0.77]	3.75 (0.96)

Note. Shows the correlation coefficient *r*, the asterisks indicate the uncorrected *p*-value (*** < 0.001.). Brackets show 95% confidence intervals.

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3.3 Confirmatory factor analysis

Results of the CFA are depicted in Table 3. The model shows a good fit (*scaled* $\chi 2(436) = 1148.985$, $p < .001$, *SRMR* = 0.057, *scaled RMSEA* = 0.041, *scaled TLI* = 0.95, *scaled CFI* = 0.95), thereby confirming the 8-factor structure and H1. H2 was also confirmed, as all subscales showed an internal consistency of Cronbach's $\alpha > 0.7$. A figure including all factor loadings, covariances, and error variance can be found in the analysis report ("3. Confirmatory Factor Analysis").

To test for an overarching second-order "climate emotion" factor, we conducted a second CFA. Results can be found in the analysis report under "5.3. Second Order Factor Model". Fit indices indicated worse fit than the first-order model (*scaled* $\chi 2(456) = 1648.955$, $p < .001$, *SRMR* = 0.077, *scaled RMSEA* = 0.052, *scaled TLI* = 0.91, *scaled CFI* = 0.92) and Chi-Square Difference Test (Schermelleh-Engel et al., 2003) indicated that the second-order model fit the data significantly worse than the first-order model ($\chi^2_{diff} = 526.57$, $df_{diff} = 20$, $p < 0.001$). The inferior fit of the second-order model suggests that ICE emotions are not adequately represented by a single higher-order construct.

3.4 Convergent validity

Convergent validity is given when AVE > 0.5, which was the case for all factors except climate powerlessness (AVE = 0.39) (see Table 3). One way to determine discriminant validity is to check if the mean correlation between a factor and its indicators (i.e., items) is higher than the squared correlation between latent factors (Fornell & Larcker, 1981). Discriminant validity was given for all climate emotions (see analysis report under "4.1. Discriminant validity").

Table 4 shows the associations between the ICE subscales and external measures as defined in Table 1. As can be seen, most of the associations assumed in H3 were confirmed. We could not confirm a negative association between climate powerlessness and self-efficacy, a negative association between climate enthusiasm and climate contempt, and the behavioral symptom HEAS subscale, or a negative association between dietary CO_2 footprint and climate enthusiasm, as well as climate guilt.

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Table 3

German items of the ICE and parameter estimates of the confirmatory factor analysis.

Factor, Cronbach's α and AVE	*English item*	*German item*	*B*	*SE*	*β*
Climate anger α = 0.89 AVE = 0.67	I feel angry that the political and economic system that we live in harms the climate.	Ich bin wütend, dass das politische und wirtschaftliche System, in dem wir leben, dem Klima schadet.	1.00	0.00	0.81
	I am outraged that politicians allowed climate change to come this far.	Ich bin empört, dass Menschen in politischen Entscheidungspositionen den Klimawandel so weit haben kommen lassen.	1.04 [0.97–1.11]	0.04	0.84
	I feel outraged at corporations that harm the climate.	Ich bin empört über Konzerne, die dem Klima schaden.	0.93 [0.86–1.00]	0.04	0.78
	I feel anger when I think of politicians who delay efforts to mitigate climate change.	Ich empfinde Wut beim Gedanken an Menschen in politischen Entscheidungspositionen, die Klimaschutzmaßnahmen verzögern.	1.14 [1.07–1.21]	0.04	0.84
Climate contempt	It annoys me to watch people succumb to climate hysteria.	Es nervt mich zu sehen, wie Menschen der Klimahysterie verfallen.	1.00	0.00	0.78
α = 0.86 AVE = 0.64	I am annoyed by the constant publicity around climate change.	Ich bin genervt von der ständigen Berichterstattung über den Klimawandel.	1.18 [1.11–1.24]	0.03	0.90
	I am bored of hearing about climate change.	Es langweilt mich, vom Klimawandel zu hören.	1.10 [1.02–1.17]	0.04	0.85
	I am surprised that people experience strong emotions in connection with climate change.	Ich bin verwundert, dass Menschen angesichts des Klimawandels starke Gefühle empfinden	0.62 [0.54–0.69]	0.04	0.55
Climate enthusiasm	The increasing public engagement with climate change gives me hope.	Die zunehmende öffentliche Auseinandersetzung mit dem Klimawandel gibt mir Hoffnung.	1.00	0.00	0.81
α = 0.84 AVE = 0.56	I believe that there are emerging solutions that will allow us to stop climate change.	Ich glaube, dass sich Lösungen abzeichnen, die es uns ermöglichen werden, den Klimawandel zu stoppen.	0.83 [0.74 -0.91]	0.04	0.65
	Concrete actions for the climate allow me to be optimistic about the future.	Konkrete Maßnahmen für den Klimaschutz lassen mich optimistisch in die Zukunft blicken.	0.85 [0.77–0.92]	0.04	0.73
	Social mobilization in the fight against climate change makes me feel that together we can achieve this goal.	Die gesellschaftliche Mobilisierung im Kampf gegen den Klimawandel gibt mir das Gefühl, dass wir gemeinsam dieses Ziel erreichen können.	1.03 [0.95–1.10]	0.04	0.79
Climate powerlessness	I feel confused about what I can do to reduce climate change.	Ich bin ratlos, was ich tun kann, um den Klimawandel zu begrenzen.	1.00	0.00	0.75
α = 0.72 AVE = 0.39	I am overwhelmed by how many aspects of life would need to be changed to limit climate change.	Es überfordert mich, wie viele Lebensbereiche verändert werden müssten, um den Klimawandel zu begrenzen.	0.74 [0.64–0.85]	0.05	0.56
	As an individual, I feel powerless with little agency over what happens with the climate.	Als einzelne Person fühle ich mich machtlos – mit wenig Einfluss darauf, was mit dem Klima passiert.	0.65 [0.54–0.75]	0.05	0.48
	I feel helpless when I think of how difficult it is to live in a climate-friendly way.	Ich fühle mich hilflos, wenn ich daran denke, wie schwierig ein klimafreundliches Leben ist.	0.95 [0.84–1.06]	0.05	0.69

Table continued on next page

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Table 3 ***(continued)***

German items of the ICE and parameter estimates of the confirmatory factor analysis.

Factor, Cronbach's α and AVE	*English item*	*German item*	*B*	*SE*	*β*
Climate guilt α = 0.90 AVE = 0.68	I have a guilty conscience about not doing enough to mitigate climate change.	Ich habe ein schlechtes Gewissen, nicht genug für den Klimaschutz zu tun.	1.00	0.00	0.85
	It upsets me that I have a big negative impact on the climate.	Es belastet mich, dass ich einen großen negativen Einfluss auf das Klima habe.	0.92 [0.87–0.97]	0.03	0.82
	I feel guilty that my lifestyle contributes to climate change.	Ich fühle mich schuldig, weil mein Lebensstil zum Klimawandel beiträgt.	0.93 [0.88–0.98]	0.03	0.82
	I am angry at myself for not doing enough to limit my negative impact on the climate.	Ich bin verärgert über mich selbst, weil ich meinen negativen Einfluss auf das Klima nicht genug reduziere.	0.90 [0.85–0.95]	0.03	0.81
Climate isolation α = 0.81 AVE = 0.53	I feel like one of the few people who actually understand what climate change entails.	Ich habe das Gefühl, zu den wenigen Menschen zu gehören, die das Ausmaß des Klimawandels wirklich verstehen.	1.00	0.00	0.58
	I feel lonely because most of the people around me don't care about climate change as much as I do.	Ich fühle mich einsam, weil der Klimawandel die meisten Menschen in meinem Umfeld weniger kümmert als mich.	1.44 [1.59–0.99]	0.08	0.84
	I feel lonely because it's difficult to talk about my climate change concerns with other people.	Ich fühle mich einsam, weil es schwierig ist, mit anderen über meine Sorgen zum Klimawandel zu sprechen.	1.32 [1.17–1.47]	0.08	0.80
	I feel alienated because society considers concern for climate change as something strange.	Ich fühle mich entfremdet von der Gesellschaft, weil Sorgen über den Klimawandel als merkwürdig gelten.	1.16 [1.02–1.30]	0.07	0.67
Climate anxiety α = 0.85 AVE = 0.60	Thinking about climate change makes me fear for the future of our children.	Der Gedanke an den Klimawandel lässt mich um die Zukunft unserer Kinder fürchten.	1.00	0.00	0.82
	I am overwhelmed by the awareness of the approaching climate disaster.	Das Bewusstsein über die nahende Klimakatastrophe überwältigt mich.	0.96 [0.90–1.02]	0.03	0.79
	Everything seems uncertain because of climate change.	Angesichts des Klimawandels erscheint alles ungewiss.	0.69 [0.63–0.76]	0.04	0.63
	I fear how climate change will affect me and my loved ones.	Ich fürchte mich davor, wie der Klimawandel mich und meine Liebsten treffen wird.	1.00 [0.94–1.05]	0.03	0.82
Climate sorrow α = 0.88 AVE = 0.65	The thought of so many species going extinct under the pressure of climate change fills me with sorrow.	Der Gedanke, dass so viele Arten durch den Klimawandel aussterben, erfüllt mich mit Kummer.	1.00	0.00	0.80
	The thought that the world I know is disappearing forever because of climate change makes me sad.	Der Gedanke, dass die Welt, wie ich sie kenne, durch den Klimawandel für immer verschwindet, macht mich traurig.	1.15 [1.07–1.23]	0.04	0.84
	I feel sorry about the possibilities we are losing forever because of climate change.	Ich bedauere die Möglichkeiten, die wir durch den Klimawandel für immer verlieren werden.	0.97 [0.89–1.05]	0.04	0.76
	I am sad that so many living creatures suffer because of climate change.	Ich bin traurig, dass so viele Lebewesen wegen des Klimawandels leiden.	0.97 [0.90–1.03]	0.03	0.81

Note. Shows the correlation coefficient *r*, the asterisks indicate the uncorrected *p*-value (*** < 0.001). Brackets show 95% confidence intervals.

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Table 4

Associations between the ICE subscales and external psychological constructs.

	Anger	Contempt	Enthusiasm	Powerlessness	Guilt	Isolation	Anxiety	Sorrow
Personal risk perception	**0.63*** [0.55–0.70]	**-0.52*** [-0.60–-0.42]	0.28* [0.18 – 0.38]	0.28* [0.18–0.38]	0.54* [0.45–0.62]	0.49* [0.39–0.57]	**0.73*** [0.67–0.78]	**0.69*** [0.62–0.74]
Self-efficacy	0.40* [0.30–0.50]	-0.33* [-0.42–-0.22]	**0.57*** [0.49–0.65]	0.01[a] [-0.07–0.08]	**0.44*** [0.34–0.53]	0.39* [0.29–0.48]	0.44* [0.35–0.53]	0.42* [0.32–0.51]
Collective efficacy	0.50* [0.41–0.58]	-0.47* [-0.56–-0.38]	**0.54*** [0.45–0.62]	0.07 [-0.03–0.17]	0.41* [0.31–0.50]	0.29* [0.19–0.39]	0.48* [0.39–0.56]	0.53* [0.44–0.61]
Wellbeing	-0.07 [-0.17–0.03]	-0.00 [-0.07–0.06]	0.16* [0.05–0.26]	**-0.22*** [-0.32–-0.12]	-0.14* [-0.24–-0.03]	**-0.15*** [-0.25–-0.05]	**-0.16*** [-0.26–-0.05]	-0.06[a] [-0.16–0.04]
Depression and anxiety	0.16* [0.05–0.26]	0.02 [-0.07–0.10]	-0.05 [-0.15–0.05]	**0.26*** [0.16–0.36]	0.25* [0.15–0.35]	**0.30*** [0.20–0.40]	**0.29*** [0.18–0.38]	**0.14*** [0.04–0.25]
Resilience	-0.05 [-0.14–0.05]	0.05 [-0.05–0.15]	0.12* [0.02–0.22]	**-0.14*** [-0.24–-0.03]	-0.10 [-0.20–0.00]	-0.12* [-0.22–-0.02]	**-0.15*** [-0.25–-0.04]	-0.06 [-0.15–0.04]
Eco-anxiety: Affective symptoms	0.41* [0.31–0.50]	**-0.19*** [-0.30–-0.09]	0.18* [0.08–0.28]	**0.32*** [0.21–0.42]	**0.47*** [0.38–0.56]	**0.51*** [0.42–0.59]	**0.59*** [0.51–0.66]	**0.43*** [0.33–0.52]
Eco-anxiety: Anxiety about personal impact	0.52* [0.43–0.60]	**-0.31*** [-0.41–-0.21]	0.29* [0.19–0.39]	0.36* [0.26–0.46]	**0.61*** [0.53–0.68]	0.52* [0.43–0.60]	**0.61*** [0.53–0.68]	**0.51*** [0.41–0.59]
Eco-anxiety: Rumination	0.45* [0.35–0.54]	**-0.18*** [-0.28–-0.07]	0.28* [0.17–0.37]	0.32* [0.21–0.41]	0.50* [0.41–0.59]	0.54* [0.45–0.62]	**0.55*** [0.46–0.62]	**0.42*** [0.32–0.51]
Eco-anxiety: Behavioral symptoms	0.29* [0.18–0.39]	-0.07[a] [-0.17–0.03]	0.14*[a] [0.03–0.24]	0.26* [0.16–0.36]	0.36* [0.25–0.45]	0.45* [0.35–0.54]	**0.41*** [0.31–0.50]	**0.27*** [0.16–0.37]
Social influence	**0.44*** [0.35–0.53]	**-0.28*** [-0.38–-0.18]	0.45* [0.35–0.53]	0.17* [0.06–0.27]	**0.49*** [0.39–0.57]	0.50* [0.41–0.59]	**0.52*** [0.43–0.60]	**0.46*** [0.36–0.54]
CO_2 footprint (diet)	**-0.21*** [-0.32–-0.11]	**0.27*** [0.17–0.37]	-0.10[a] [-0.20–0.01]	0.11* [0.00–0.21]	0.01[a] [-0.07–0.10]	-0.01 [-0.09–0.07]	**-0.12*** [-0.22–-0.02]	**-0.23*** [-0.33–-0.12]
Collective climate action	**0.42*** [0.32–0.51]	**-0.26*** [-0.36–-0.16]	0.42* [0.32–0.51]	0.17* [0.06–0.27]	0.52* [0.43–0.60]	0.53* [0.44–0.61]	**0.51*** [0.42–0.60]	**0.41*** [0.31–0.50]
Pro-environmental policy support	**0.67*** [0.60–0.73]	**-0.63*** [-0.70–-0.55]	**0.40*** [0.30–0.49]	0.16* [0.05–0.26]	**0.47*** [0.38–0.56]	0.38* [0.28–0.48]	**0.58*** [0.50–0.65]	**0.59*** [0.50–0.66]

Note. Shown here is Spearman's *r*. Associations remaining significant after Bonferroni-Holmes correction are marked with an * ($p < .0009$). Associations in boldface are consistent with our hypotheses, those marked with an [a] are inconsistent with our hypotheses (see Table 1). Brackets show the adjusted 95% confidence intervals.

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4 Discussion

The aim of this study was to translate the Inventory of Climate Emotions (Marczak et al., 2023) into German and validate the questionnaire in a German representative sample. Furthermore, we aimed to investigate the association between the distinct climate emotions and other variables, like different forms of pro-environmental behavior and mental health measures.

We could confirm our first hypothesis and replicated the 8-factor structure found in the Polish (Marczak et al., 2023), Norwegian and Irish samples (Marczak et al., 2024). All of the subscales showed acceptable to good internal consistency (Cronbach's $\alpha > .7$), confirming our second hypothesis. Furthermore, all climate emotions met our criterion for discriminant validity and all climate emotions except climate powerlessness met our criterion for convergent validity, which is in line with previous results (Marczak et al., 2023). Additionally, our results (Figure 1, Table 2) show that climate emotions are common among the population in Germany, which is in line with recent reports of the UN (United Nations Development Programme, 2024). The most common climate emotions were climate sorrow (mean = 3.75; 1-5 point-Likert scale), climate anger (mean = 3.59) and climate anxiety (mean = 3.25). We thereby confirm the importance of investigating the effects of distinct climate emotions.

It is important to note that we found very high correlations (all $r > 0.70$) and factor covariances (all $cov > 0.85$) between climate anger, climate sorrow and climate anxiety. This is in line with Marczak et al. (2023). While this makes sense from a conceptual standpoint, it may present a statistical problem (i.e., multicollinearity) for studies which want to investigate the unique effects of emotions. One solution to this problem is to summarize unpleasant climate emotions into one single factor, like climate change distress (Hayes et al., 2018; Hepp et al., 2023; Ogunbode et al., 2023). However, it is conceivable that distinct emotions like anger, sorrow and anxiety as different reactions to different aspects of the underlying threat still have distinct effects on important behaviors, which is information that is lost when summarizing them into one factor. While our first-order model outperformed the second-order model, the overall fit of the second-order model was acceptable. The data could thereby be interpreted within both factorial solutions. Thus, the potential existence of an overarching climate emotion factor remains an open question that will need to be addressed in subsequent work.

Other studies have provided evidence for distinct predictive power of individual climate emotions. Using the same data set as in this study, our group investigated the unique predictive value of climate emotions for collective climate action and social influence using multiple regression analyses (Blumenschein et al., under review). We found that climate enthusiasm, powerlessness, guilt, isolation and anxiety explained unique variance in both PEB outcomes. In a recent study, Contreras et al. (2024) present the first longitudinal ecological momentary assessment study of climate emotions. They found that the experience of one climate emotion (e.g., climate anger) was associated with the experience of the two other measured climate emotions (e.g., climate anxiety and climate sorrow) in the same time frame. Importantly, they also found that the experience of a climate emotion (e.g., climate anger) was associated with the experience of the corresponding climate-unspecific

emotion (e.g., anger) in the same time frame, but not with experiencing other climate-unspecific emotions (e.g., anxiety). This finding highlights that different climate emotions are mostly distinct from each other and that an individual may experience them in different intensities at different points in time. However, the conceptual overlap and simultaneous predictive use of climate anxiety, anger and sorrow is in need of further investigation. As it was an ecological momentary assessment study, Contreras et al. (2024) measured climate and basic emotions with single-item measures. It would be most interesting to use a more differentiated instrument like an adapted ICE in longitudinal studies.

Researchers should carefully weigh up the advantages and disadvantages of summarizing vs. distinctly measuring emotions and make the decision based on their specific research question.

Most of our hypotheses concerning the association of climate emotions and external measures were confirmed. Most notably, all emotions showed significant associations with pro-environmental collective climate action, social influence and policy support. This association was always positive – except for climate contempt, which was negatively associated with the three types of pro-environmental behavior. As this study is cross-sectional, our data cannot make any statement about the directionality of this association, however it provides further evidence for the importance of climate emotions for pro-environmental behavior. It also suggests that there is not one specific climate emotion that can promote pro-environmental behavior, but many different emotions. Investigating the distinct influence of emotions in more intricate analyses (e.g. Blumenschein et al., under review) and longitudinal studies will shed more light onto the specific role of distinct climate emotions.

Another important finding is that climate guilt, isolation, anxiety and powerlessness had a negative association with well-being and a positive association with anxiety and depressive symptoms. Climate anger and sorrow also showed a positive association with anxiety and depressive symptoms. These findings support past research showing that climate emotions are associated with mental health problems (Heinzel et al., 2023; Mouguiama-Daouda et al., 2022; Ogunbode et al., 2023; Whitmarsh et al., 2022). They are also in line with the Australian ICE validation study which showed a negative association of anger, powerlessness, isolation, anxiety, guilt and sorrow with life satisfaction (Rice et al. 2025). Climate emotions as such are not pathological as they represent an appropriate response to an existential threat. Lawrance et al. (2022) describe climate emotions as risk multipliers that do not cause any new types of mental disorders, but may increase the risk to develop e.g. depression or aggravate an existing mental disorder (Brakemeier et al., 2024). Thus, climate emotions can become clinically relevant for individuals. There is a large body of conceptual research on how an intervention for individuals, whose mental health is impacted by climate emotion, could look like (Baudon & Jachens, 2021; Bingley et al., 2022; Pitt et al., 2024; Xue et al., 2024). Reoccurring elements of possible interventions is accepting and validating climate emotions as a healthy response, while also encouraging individuals to take action and helping them to build up resilience and social connections. However, the body of literature empirically testing said interventions is small. Lindhe et al. (2023) tested

an internet-delivered cognitive behavioral therapy for 30 adult participants experiencing psychological distress related to the climate crisis in Sweden. In comparison to the control group, mental health outcomes improved in the experimental group. In an interview study, emotion regulation techniques and the social context were identified as effective means by which an after-school intervention program supported young people in coping with climate anxiety (Eklöf & Klöckner, 2025). Considering the accumulated evidence for a negative association between mental health and climate emotions, advancing the empirical evaluation of these suggested intervention approaches represents an important next step.

Climate powerlessness showed the weakest internal consistency (Cronbach's α = .72), which had also been the case in other studies (Marczak et al., 2024; Marczak et al., 2023). The authors argued that powerlessness might overlap with other negative emotions and might therefore not be as easily distinguishable from e.g., isolation, anxiety or sorrow. Just as in previous studies, climate powerlessness did not meet the threshold for convergent validity (AVE = 0.39). This implies that less than half of the variance in the powerlessness items is due to the underlying construct itself but due to measurement error or other factors. While participants of our pilot study rated the climate powerlessness items as understandable, two rated the scale as being incomplete. Participant 6 criticized that they missed an item that relates to the powerlessness one feels when trying to convince loved ones to change their behavior. They suggested the following item: "I feel sad/powerless that my personal environment is doing so little to combat the climate crisis." Critique by participant 8 was similar, they felt like the scale was incomplete because the two dimensions of being politically powerless and powerless in one's private-sphere were not represented equally. These comments underline the argument made by Marczak et al. (2023) that the climate powerlessness scale might be entangled with other constructs but additionally question if the current climate powerlessness items manage to capture all relevant ways in how individuals can experience climate powerlessness. Our hypothesis concerning the association of climate powerlessness and other constructs were largely confirmed: we found a negative association with well-being and resilience and a positive association with anxiety/depressive symptoms as well as the HEAS affective symptoms scale. Surprisingly, climate powerlessness was not associated with self-efficacy, even though some items of the two scales are rather similar to each other (e.g., "I believe that I can contribute to solving the environmental crisis through my own actions" and "As an individual, I feel powerless with little agency over what happens with the climate"). Marczak et al. (2023) found a significant negative association between the two constructs, but it was small (r = -.12). To explore the lack of association more deeply we calculated the correlation between the two scales on the item level (see OSF analysis report). Here we see that the feeling of being powerless as an individual (ICE powerlessness item 3) was negatively associated with self-efficacy. However, the feeling of helplessness when thinking about how hard a climate friendly life is (ICE powerlessness item 4) was positively associated with some of the efficacy items, though the correlation was small. Thus, one core difference between the scales seems to be that climate powerlessness includes the difficulties of living climate-friendly and by that the negative affect related to having to change or give up aspects of one's live (e.g., flying). These results further strengthen the idea that the climate power-

lessness subscale might be measuring a vast spectrum of different emotions concerning different aspects of dealing with the climate crisis and associated transformational demands. It might have to be revised in future versions of the questionnaire.

Our hypotheses concerning climate enthusiasm were also only partly confirmed. We found a positive association between climate enthusiasm and the HEAS behavioral symptoms subscale and no significant association with dietary CO_2 footprint. A closer look at the item-level correlation between behavioral symptoms and climate enthusiasm (see OSF analysis report) revealed that the association was driven by climate enthusiasm items 1 and 4, which are related to the public discourse of and the mobilization against the climate crisis. A possible explanation is that enthusiastic individuals who are more engaged and aware of the climate crisis are also more likely to feel the psychological strain associated with their commitment and concerns. Thus, civic engagement may mediate or moderate the association of enthusiasm and behavioral symptoms. However, this is just a hypothetical assumption and has to be investigated in future studies. Dietary CO_2 footprint generally showed little to no association with climate emotions. One reason behind this may be that we chose to measure the footprint by calculating CO_2 emissions rather than relying on an averaged self-report behavior scale (Markle, 2013). It is possible that participants believe that they live a low-emission lifestyle, because they are not aware of the actual CO_2 emissions of their behavior (Denton et al., 2020). Therefore, while emotions may be associated with an individual's perceived pro-environmental private-sphere behavior (Contreras et al., 2024; Stanley et al., 2021; Thomson & Roach, 2023), they may not be associated with their actual CO_2 emissions.

In the pilot study, seven of our ten participants marked the climate anger subscale as being incomplete. In the subsequent interviews, they reported that the scale lacked an item measuring the anger people feel towards individuals who are not in a position of power. One participant said, "It's not just the politicians who have let it get this far, but everyone [...], especially the older generation". Another felt "angry not only about politics, but also about the people around you, about ignorance or reckless climate behavior e.g., driving everywhere by car instead of taking the bike." We also asked our participants about suggestions, how an additional item could look like. One participant suggested the following. "I'm angry at people who don't take the issue as seriously as I do". As the aim of this study was to validate the questionnaire, we did not add any items. However, we believe that this is an important issue to keep in mind. The current climate anger items are directed at politicians and the industry. Considering that the solutions to the climate crisis lie in transformative political measures and the termination of the fossil fuel industry (IPCC, 2023), the anger towards those institutions is an important dimension. However, the anger towards one's own social circle (e.g., colleagues, family) might be just as infuriating for an individual and may act as a driving force behind pro-environmental behavior. It is even conceivable, that an individual is very aware of the fact that private-sphere mitigation measures are not an effective way to combat climate change and still feel angry when their social circle behaves in an environmentally harmful manner. The quote above indicates that the anger may not even be directly caused by the emitted CO_2, but rather the feeling that other people don't seem to care about the climate crisis. This line of reasoning would be in line

with Gregersen et al. (2023), who asked participants openly what triggered their climate anger. Here, 57% reported human actions as the cause of their anger, while only 31% reported that agents (like politicians or the rich) made them angry. While this is partly measured in the climate isolation subscale ("I feel like one of the few people who actually understand what climate change entails"), this does not measure the experienced anger an individual may feel. We encourage scientists who are specifically interested in investigating climate anger to consider adding additional items to the climate anger subscale.

4.1 Limitations and future directions

Our study comes with some limitations. Firstly, we performed a cross-sectional study, so our data does not allow for any causal interpretation between climate emotions and mental health or pro-environmental behavior. Future studies should investigate the mechanisms behind climate emotions and mental health and the possibility of pro-environmental behavior moderating this relationship (Schwartz et al., 2022), e.g. via time lagged network models. Furthermore, our study only aimed to translate the ICE into German. Our results indicate, however, that some subscales of the ICE lack construct validity and could be improved (i.e. powerlessness and anger). Furthermore, despite our multi-stage and careful translation process, it is possible that the meaning of individual items may have changed slightly in the German version due to language-specific phrases or words.

Furthermore, while most of our hypotheses were supported by the data, the results indicate that many climate emotions are associated with external variables, even in cases where we did not formulate hypotheses about the existence or direction of such associations. In addition, some emotions showed weaker correlations with the measures they were hypothesized to relate to than with other measures (e.g., climate contempt). While this partly reflects the limited literature on which our hypotheses could be based, it is important to consider when interpreting the results. Conceptual overlap between emotions (e.g. climate anxiety, sorrow, anger), emotions and external variables (e.g. climate anxiety and social identity (Blumenschein et al., under review) or between external variables (e.g. wellbeing and depression and anxiety) may lead to redundancy. Future research would therefore benefit from examining the unique associations between climate emotions and outcomes, as well as their interplay in predicting these outcomes.

4.2 Conclusion

The German version of the ICE was validated in a large, representative sample and the 8-factor (climate anger, contempt, enthusiasm, powerlessness, guilt, isolation, anxiety, and sorrow) structure could be confirmed. We show a negative association between all climate emotions – except contempt and enthusiasm – and mental health. On the other side, we report a positive association between all climate emotions – except contempt – and pro-environmental behaviors.

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5 Open science statement

All data, analysis scripts, analysis reports, supplementary tables, questionnaires, and interview materials can be downloaded at https://osf.io/xtw2p. The pilot study was not preregistered. The main study was preregistered at https://osf.io/d3gyv/. All deviations from the preregistrations – including type, reason, timing, original wording, deviation description, and reader impact – are presented in Supplementary Table 1. We confirm that our paper includes all studies that we have conducted on this research question. We confirm that, for all studies, we have reported all analyzed measures, conditions, data exclusions, and how we determined our sample sizes. All additional measures – which have been measured but were not relevant for the preregistered hypothesis – are described in the preregistration and all items are available in the study questionnaire.

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