



From negative feelings to impairments: A longitudinal study on the development of climate change anxiety

Hoi-Wing Chan ^{a,*}, Li Lin ^{b,2}, Kim-Pong Tam ^{c,3}, Ying-yi Hong ^{d,4}

^a The Hong Kong Polytechnic University, Hong Kong, China

^b Lingnan University, Hong Kong, China

^c The Hong Kong University of Science and Technology, Hong Kong, China

^d The Chinese University of Hong Kong, Hong Kong, China

ARTICLE INFO

Keywords:

Climate change anxiety
Negative emotions
Impairment
Generalized anxiety
Longitudinal study
Path analysis

ABSTRACT

People may experience anxiety and related distress when they come in contact with climate change (i.e., climate change anxiety). Climate change anxiety can be conceptualized as either emotional-based response (the experience of anxiety-related emotions) or impairment-based response (the experience of impairment in daily functioning). To date, it remains uncertain how these distinct manifestations of climate change anxiety are related. Conceptually, the experience of climate change anxiety may transform from an adaptive and healthy emotional response to an impairment in daily functioning. We conducted two two-wave longitudinal studies to examine the possible bidirectional relationships between three manifestations of climate change anxiety. We recruited 942 adults (mean age = 43.1) and 683 parents (mean age = 46.2) in Studies 1 and 2, respectively. We found that Time 1 emotion-based response was positively linked to Time 2 cognitive-emotional impairment, while Time 1 cognitive-emotional impairment was positively related to Time 2 functional impairment. In Study 2, we also found a bidirectional positive relationship between generalized anxiety and emotion-based climate change anxiety over time. Overall, our findings provide initial support to the temporal relationships between different manifestations of climate change anxiety, corroborating that climate change anxiety may develop from emotional responses to impairment in functioning.

1. Introduction

Climate change poses threats to the physical and mental well-being of individuals. Previous studies have documented that while some people can cope with their experience of extreme weather events (e.g., floods, hurricanes, and droughts), others may suffer severe psychological distress and anxiety-related problems (e.g., post-traumatic stress disorder) (for reviews, see Charlson et al., 2021; Chen et al., 2020). A growing body of research suggests that people can experience anxiety, fear, and even distress when they come in contact with climate change (e.g., Clayton & Karazsia, 2020; Hickman et al., 2021; Tam et al., 2023). This phenomenon is known as “climate change anxiety,” or

“eco-anxiety” when such an anxiety experience originates from people’s worry about broader environmental issues (Clayton, 2020; Pihkala, 2020). Although researchers generally propose that climate change anxiety is a normal and healthy response to climate change threats, it can still pose a risk to people’s well-being, especially when such anxiety is manifested in terms of impairment (Clayton & Karazsia, 2020; Cunsolo et al., 2020; Heeren et al., 2023). Indeed, studies have found that climate change anxiety is related to both adaptive outcomes (e.g., engagement in climate actions; e.g., Tam et al., 2023; Whitmarsh et al., 2022) and maladaptive outcomes (e.g., sleep problems; Ogunbode et al., 2021) (for a review, see Boluda-Verdu et al., 2022). As such, the literature is just beginning to understand the adaptive and maladaptive

* Correspondence to: Department of Applied Social Sciences, Mental Health Research Centre, The Hong Kong Polytechnic University, Hung Hom, Hong Kong, China.

E-mail address: william-hw.chan@polyu.edu.hk (H.-W. Chan).

¹ ORCID: 0000-0002-6884-394X

² ORCID: 0000-0003-4265-9789

³ ORCID: 0000-0003-1485-1343

⁴ ORCID: 0000-0003-3172-9243

<https://doi.org/10.1016/j.janxdis.2024.102917>

Received 4 December 2023; Received in revised form 13 August 2024; Accepted 20 August 2024

Available online 25 August 2024

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implications of climate change anxiety.

1.1. The two conceptualizations of climate change anxiety

Climate change anxiety can be manifested in either affective responses (i.e., the feeling of anxiety and worry about climate change; Hickman et al., 2021; Ogunbode et al., 2022) or clinically significant symptoms (i.e., the experience of impairment in cognitive-emotional and daily functioning; Clayton and Karazsia, 2020). We refer to the former as the emotion-based conceptualization of climate change anxiety and the latter as the impairment-based conceptualization of climate change anxiety. While the emotion-based conceptualization represents the purely emotional aspects of climate change anxiety, the impairment-based conceptualization inherently includes pathological or unconstructive aspects of such anxiety (e.g., rumination) (Ojala et al., 2021). In particular, Clayton and Karazsia, 2020 developed the climate change anxiety scale to capture the impairment associated with climate change anxiety. This scale is created based on clinical symptoms that are relevant to unhealthy worry and anxiety (Clayton & Karazsia, 2020). There are two subcomponents: cognitive-emotional impairment and functional impairment. Cognitive-emotional impairment reflects symptoms associated with rumination about climate change, including repeatedly thinking and analyzing one's response to climate change, difficulty concentrating and sleeping, having nightmares about climate change, and crying. Functional impairment reflects the impact of heightened worry and anxiety on one's ability to function in everyday life, including reduced ability to have fun with or satisfy the needs of family or friends, get important work done, and work to one's full potential. It follows that cognitive-emotional impairment and functional impairment represent two distinct but related manifestations of climate change anxiety.

To date, it is uncertain how these different manifestations of climate change anxiety are related to each other, as existing studies often operationalize climate change anxiety in one way or another but not both. Importantly, Heeren et al.'s (2023) psycho-network analysis suggests the possibility that cognitive-emotional impairment plays a central role in linking general worry, adaptive outcomes (i.e., climate actions), and maladaptive outcomes (i.e., impaired functioning). It follows that one feature of climate change anxiety could be an antecedent of the other feature, and people may develop different climate change anxiety responses over time. Accordingly, studying the relationships between different manifestations of climate change anxiety longitudinally can advance our understanding of how climate change anxiety may become a risk for mental health (Heeren & Asmundson, 2023). The present research thus aims to examine the potential bidirectional relationships between emotion-based and impairment-based responses to climate change anxiety with a two-wave longitudinal design.

1.2. Hypotheses

As no prior study has examined the relationship between these responses of climate change anxiety over time, we derive our hypotheses based on the general function of anxiety, the clinical understanding of pathological anxiety, and Heeren et al.'s (2023) psycho-network analysis.

Anxiety and related negative emotions are triggered by anticipatory threats to a future goal, which motivate people to avoid future danger (Barlow et al., 2018). Anxiety can also serve as a warning for people to deal with uncertain situations (Schwarz & Clore, 2003). Although anxiety is a normal experience, it can become pathological when it is disproportionate to the actual danger faced by individuals (i.e., excessive and irrational) and hampers people's ability to function in their daily lives (American Psychiatric Association, 2022). As climate change is an existential threat to humanity with high uncertainty, it is normal and rational for people to experience anxiety and related emotions when they come into contact with it (Ojala et al., 2021; Pihkala, 2020). It is

thus possible that people may first experience anxiety and related emotions as a normal and healthy response to climate change threat, without necessarily also experiencing disturbances in cognitive-emotional (e.g., ruminating about climate change) and functional (e.g., having difficulties in enjoying life) domains. It follows that the experience of anxiety-related emotions may precede the experience of cognitive and functional impairments and represent an antecedent of such impairments. This notion is consistent with previous studies that found a positive correlation between climate change anxiety (measured in terms of anxiety-related emotional states) and sleep disturbance (Ogunbode et al., 2021). We thus expect that emotion-based climate change anxiety would predict an increase in impairment-based climate change anxiety over time.

Furthermore, Heeren et al. (2023) conducted a series of network analyses based on cognitive-emotional impairment, functional impairment, general worry, experience of climate change, and pro-environmental behavior. The authors found that cognitive-emotional impairment was the most central node in the network, bridging the nodes between general worry, the experience of climate change, and functional impairment. Their directed acyclic graph model further revealed that cognitive-emotional impairment was a parent node of functional impairment, suggesting the possibility that cognitive-emotional impairment can precede functional impairment. Accordingly, we consider the two forms of impairments as separate manifested features of climate change anxiety and explore if cognitive-emotional impairment would predict an increase in functional impairment over time.

In a recent study (Chan, Tam, & Clayton, 2024), we measured both types of climate change anxiety among both Chinese and American participants. With the latent profile analysis, we identified four distinct groups of individuals. All four groups exhibited similarly moderate to high levels of emotion-based climate change anxiety; however, they differed substantially in terms of levels of cognitive-emotional impairment and functional impairment. In other words, we were able to identify groups of individuals who experienced negative emotions associated with climate change anxiety intensely with or without impairments at the same time, but we could not identify any group of individuals who reported impairments but did not experience negative emotions associated with climate change. Put differently, it is possible for an individual to experience emotion-based climate change anxiety but not develop impairment symptoms as a result, but it seems improbable for a person to have impairment symptoms without experiencing emotion-based climate change anxiety at the same time. This pattern converges with our hypothesis that emotion-based responses associated with climate change precede impairment-based responses over time. Supporting this notion, in a recent cross-sectional study, Parmentier et al. (2024) found that climate change risk perception related to more eco-worry and, in turn, related to more impairment responses to climate change. The authors suggested the possibility that the feeling of worry could precede the development of impairment-based anxiety response to climate change.

1.3. Exploratory question: the role of generalized anxiety

Previous studies have commonly suggested that generalized anxiety is a risk factor for experiencing climate change anxiety (e.g., Asgarizadeh et al., 2023; Whitmarsh et al., 2022). Such a suggestion is based on cross-sectional correlational observations, however. It seems equally sensible to expect that the experience of climate change anxiety translates into heightened generalized anxiety in daily life (Sampaio & Sequeira, 2022). Such a bidirectional relationship can only be tested with a longitudinal design. In sum, we explore how the distinct manifestations of climate change anxiety relate to generalized anxiety simultaneously without making any prior predictions.

1.4. The present research

In brief, the present study aims to understand the longitudinal relationships between emotion-based climate change anxiety, the two impairment-based components of climate change anxiety, and generalized anxiety. We conducted two two-wave longitudinal studies with American adult participants. In particular, Study 1 was conducted between September 2022 and January 2023, with a four-month separation in the data collection. Study 1 provides the initial longitudinal findings on the relationship between emotion-based climate change anxiety, cognitive-emotional impairment, and functional impairment. Study 2 advances Study 1 by testing the longitudinal associations between generalized anxiety and the three manifestations of climate change anxiety. Study 2 was conducted between March 2023 and September 2023, with a six-month separation in data collection. Our findings can shed light on the conceptual understanding of climate change anxiety and how it becomes a risk for mental health over time. Data from both studies were from larger survey projects that aim to study human responses to climate change. The present research is exploratory and aims at providing initial insights into understanding the temporal relationship between different manifestations of climate change anxiety, and thus is not pre-registered.

2. Study 1

2.1. Method

2.1.1. Participants

In total, 1003 U.S. adults participated in the Time 1 survey. We recruited our participants from the Amazon Mechanical Turk (MTurk) through the CloudResearch panel (Litman et al., 2017). We invited all participants from Time 1 to complete the Time 2 survey four months later. To ensure the quality of the data, we included attention-check questions that require participants to answer a question by selecting a specific choice (Curran, 2016). In total, 946 and 663 participants completed the survey and passed the attention check at Time 1 and Time 2, respectively. The attrition rate was 30%.¹ The initial sample size was pre-determined to fulfill the purpose of the larger project. Our sensitivity analysis suggested that the final sample size was sufficient to detect a small concurrent effect and a medium to large cross-lagged effect (Orth et al., 2022) ($r = .10$) with .80 statistical power and at a .05 alpha level. Supplementary Table S1 summarizes the demographic information of the participants.

2.1.2. Procedures and measures

At each time point, participants completed an online survey about their climate change experience and opinions. The data collection procedure has been approved by the research ethics committee of the university affiliated with the first author. We present the full items of the measures used in this study in Supplementary Information. Table 1 summarizes the mean, standard deviation, and Cronbach's α of the measures at each time point.

Emotion-based climate change anxiety. We measured emotion-based climate change anxiety by four anxiety-related emotions, including fear, worry, anxious, and tense. Specifically, participants reported the extent to which they feel these emotions when thinking about climate change (1 = not at all to 5 = very strongly).

Impairment-based climate change anxiety. We adopted the climate change anxiety scale (13 items; CCAS; Clayton & Karazsia, 2020) to measure impairment-based climate change anxiety. In their original study, Clayton and Karazsia (2020) identified two dimensions of climate change anxiety – cognitive-emotional impairment (8 items; e.g., “Thinking about climate change makes it difficult for me to concentrate.”) and functional impairment (5 items; e.g., “My concerns about climate change interfere with my ability to get work or school assignments done.”). Participants reported on a five-point scale to indicate

Table 1

Mean, standard deviation, and reliability of the key constructs.

Construct	Study 1		Study 2	
	Mean (SD)	Cronbach's α	Mean (SD)	Cronbach's α
<i>Time 1 variables</i>				
Emotion-based climate change anxiety	2.71 (1.28)	.94	2.68 (1.09)	.94
Cognitive-emotional impairment	1.47 (.77)	.95	1.27 (.51)	.92
Functional impairment	1.38 (.77)	.94	1.19 (.44)	.85
Generalized anxiety	-	-	1.71 (.75)	.93
<i>Time 2 variables</i>				
Emotion-based climate change anxiety	2.54 (1.27)	.94	2.70 (1.07)	.94
Cognitive-emotional impairment	1.40 (.68)	.95	1.25 (.48)	.90
Functional impairment	1.34 (.71)	.94	1.19 (.47)	.86
Generalized anxiety	-	-	1.67 (.74)	.93

how frequently they experienced each anxiety-related symptom (1 = never to 5 = almost always). Although some studies did not successfully replicate the two-factor structure (e.g., Cruz & High, 2022), Tam et al. (2023) demonstrated the measurement invariance of the two-factor solution among China, India, Japan, and the U.S. As we aim to test the longitudinal associations between two components and emotion-based climate change anxiety, we thus consider the two components as separate manifestations of climate change anxiety.²

Demographic covariates. Participants also reported their gender, age, highest education attained, annual household income, and political orientation (1 = strong Republican to 7 = strong Democrat). As previous studies found that demographic variables were correlated with climate change anxiety (e.g., Tam et al., 2023), we included these variables as the covariate.

2.2. Results

We conducted cross-lagged panel path analyses to examine the cross-temporal associations between emotion-based climate change anxiety, cognitive-emotional impairment, and functional impairment. In particular, we estimated both the $t-1$ autoregressive effects and $t-1$ cross-lagged effects by regressing all the Time 1 climate change anxiety variables on the Time 2 climate change anxiety variables. We also included the Time 1 demographic covariate variables in predicting both Time 1 and Time 2 climate change anxiety variables, in order to control for the influence of demographic variables on the initial level and the change in climate change anxiety. All Time 1 predictors were allowed to be correlated. Missing data was handled by the full information maximum likelihood. As cognitive-emotional impairment and functional impairment were not normally distributed, we used maximum likelihood estimation with robust standard error in our analyses (Finney & DiStefano, 2013). All the analyses were conducted using the “lavaan” package of R (Rosseel, 2012).

We found preliminary support for the longitudinal associations between the three climate change anxiety variables. Table 2 shows the results. We observed that emotion-based climate change anxiety at Time 1 was related to an increase in cognitive-emotional impairment at Time 2 ($b = .06$, $SE = .07$, $p = .001$, 95% CI = [.02, .10], standardized beta = .11). Functional impairment at Time 1 was unrelated to a change in cognitive-emotional impairment at Time 2, however ($b = .09$, $SE = .07$, $p = .155$, 95% CI = [−.04, .22], standardized beta = .10). Cognitive-emotional impairment at Time 1 was related to an increase in functional impairment at Time 2 ($b = .24$, $SE = .10$, $p = .020$, 95% CI = [.04, .44], standardized beta = .25), while emotion-based climate change anxiety at Time 1 was positive but non-significant in predicting an

Table 2
Results of cross-lagged path analysis (Study 1).

	Time 2 Emotion-based climate change anxiety			Time 2 Cognitive-emotional impairment			Time 2 Functional impairment		
	b (SE)	p-value	95% CI	b (SE)	p-value	95% CI	b (SE)	p-value	95% CI
Autoregressive effects									
Time 1 Emotion-based climate change anxiety	.72 (.03)	< .001	[.66, .78]	-	-	-	-	-	-
Time 1 Cognitive-emotional impairment	-	-	-	.61 (.07)	< .001	[.47, .75]	-	-	-
Time 1 Functional impairment	-	-	-	-	-	-	.46 (.10)	< .001	[.27, .64]
Cross-lagged effects									
Time 1 Emotion-based climate change anxiety	-	-	-	.06 (.02)	.001	[.02, .10]	.04 (.02)	.053	[-.00, .08]
Time 1 Cognitive-emotional impairment	.17 (.11)	.118	[-.04, .39]	-	-	-	.24 (.10)	.020	[.04, .44]
Time 1 Functional impairment	-.01 (.10)	.897	[-.21, .19]	.09 (.07)	.155	[-.04, .22]	-	-	-
Covariate variables									
Gender	.20 (.06)	< .001	[.09, .32]	-.03 (.04)	.450	[-.09, .04]	-.05 (.04)	.207	[-.13, .03]
Age	-.00 (.00)	.877	[-.01, .00]	-.00 (.00)	.002	[-.01, -.001]	-.00 (.00)	.010	[-.01, -.001]
Education	.04 (.03)	.247	[-.03, .11]	.02 (.02)	.242	[-.01, .05]	.03 (.02)	.105	[-.01, .06]
Income	.01 (.03)	.647	[-.04, .07]	-.01 (.02)	.648	[-.04, .02]	-.03 (.02)	.069	[-.06, .00]
Political orientation	.06 (.02)	.001	[.02, .09]	-.02 (.01)	.033	[-.04, -.002]	-.02 (.01)	.143	[-.04, .01]

Note. We allowed the residuals of the Time 2 variables to be correlated. Time 1 predictors were allowed to be correlated. The path model was just identified. Supplementary Table S3 shows the effect of Time 1 demographic variables on Time 1 predictors and the covariance estimates of the Time 1 variables in the model.

increase in functional impairment at Time 2 ($b = .04, SE = .02, p = .053, 95\% CI = [-.000, .08]$, standardized beta = .07). Lastly, both Time 1 cognitive-emotional impairment ($b = .17, SE = .11, p = .118, 95\% CI = [-.04, .39]$, standardized beta = .10) and Time 1 functional impairment ($b = -.01, SE = .10, p = .897, 95\% CI = [-.22, .19]$, standardized beta = $-.01$) were unrelated to the change in Time 2 emotion-based climate change anxiety. Our results remained consistent when we did not control for the effects of the covariate variables and did not use the full maximum likelihood to handle the missing data.

Overall, we observed some interesting patterns of associations. First, none of the impairment-based climate change anxiety predicted the change in emotion-based climate change anxiety over time, while emotion-based climate change anxiety predicted more cognitive-emotional impairment four months later. These patterns of association support the possibility that the experience of climate change anxiety as an emotional state would develop into cognitive-emotional impairment over time. Second, we observed that cognitive-emotional impairment predicted more functional impairment four months later, while functional impairment did not predict the change in cognitive-emotional impairment over time. This pattern is consistent with Heeren et al. (2023), in which the authors suggested that cognitive-emotional impairment might precede the experience of functional impairment.

3. Study 2

3.1. Methods

3.1.1. Participants

In total, 700 U.S. adults participated in the Time 1 survey. We recruited the Time 1 participants from Prolific Academic. In particular, as the larger project aims to understand how parents with adolescent children respond to climate change, Study 2 only involved parent participants. At Time 2 (six months later), we invited all participants to complete the survey. As in Study 1, we included attention-check questions. In total, 683 and 543 participants completed the Time 1 and Time 2 surveys and passed the attention check questions respectively. The attrition rate is about 22%.¹ Sensitivity analysis suggests that the final sample size is sufficient to obtain a small concurrent effect and a large cross-lagged effect (Orth et al., 2022) ($r = .12$) with a statistical power of .80 at .05 alpha level. Supplementary Table S1 shows the demographic characteristics of these parent participants.

3.1.2. Procedures and measures

As in Study 1, participants completed an online survey at both time points. They completed questions on emotion-based climate change

anxiety, the climate change anxiety scale, and generalized anxiety. They also answered questions on demographic information. The data collection procedure has been reviewed and approved by the research ethics committee of the university affiliated with the first author. Table 1 shows the mean, standard deviation, and Cronbach’s α of the key constructs.

Emotion-based climate change anxiety. We measured emotion-based climate change anxiety with the seven-item state-anxiety inventory used by Ogunbode et al. (2022). Specifically, the measure was based on the state anxiety of the state-trait anxiety inventory (Spielberger, 1983), which asked participants how much they felt calm, tense, relaxed, anxious, peaceful, worried, or terrified when they thought about climate change at the moment.³ Participants reported on a five-point scale (1 = not at all to 5 = extremely) to indicate their momentarily affect on climate change. Following Ogunbode et al. (2022), we reversed the scores of the three positive affect items (i.e., calm, relaxed, and peaceful) when computing the average score of the measure.

Impairment-based climate change anxiety. As in Study 1, we used the climate change anxiety scale (CCAS) to capture cognitive-emotional impairment and functional impairment.²

Generalized anxiety. We adopted the brief measure for generalized anxiety disorder (GAD-7; Spitzer et al., 2006) to capture generalized anxiety. Participants reported on a four-point scale (1 = not at all to 4 = nearly every day) to indicate how frequently they experienced seven anxiety-related problems in the last two weeks (e.g., “not being able to stop or control worrying”).

Demographic covariates. As in Study 1, participants reported their gender, age, highest education level attained, annual household income, and political orientation.

3.2. Results

Similar to Study 1, we conducted cross-lagged path analyses to examine the longitudinal associations between emotion-based climate change anxiety, cognitive-emotional impairment, functional impairment, and generalized anxiety. We included both the $t-1$ autoregressive effects and $t-1$ cross-lagged effects in the analyses. We also controlled for the effects of the demographic covariates by including these variables as predictors of Time 1 and Time 2 variables. Time 1 climate change anxiety variables and generalized anxiety were allowed to be correlated. The missing data was handled using the full information maximum likelihood. We also used the maximum likelihood with robust standard error in our analyses as cognitive-emotional impairment and functional impairment were not normally distributed. Table 3 shows the results.

Table 3
Results of cross-lagged path analysis (Study 2).

	Time 2 Emotion-based climate change anxiety			Time 2 Cognitive-emotional impairment			Time 2 Functional impairment			Time 2 Generalized anxiety		
	b (SE)	p-value	95% CI	b (SE)	p-value	95% CI	b (SE)	p-value	95% CI	b (SE)	p-value	95% CI
Autoregressive effects												
Time 1 Emotion-based climate change anxiety	.59 (.04)	< .001	[.51, .66]	-	-	-	-	-	-	-	-	-
Time 1 Cognitive-emotional impairment	-	-	-	.59 (.09)	< .001	[.42, .76]	-	-	-	-	-	-
Time 1 Functional impairment	-	-	-	-	-	-	.36 (.11)	.002	[.14, .58]	-	-	-
Time 1 Generalized anxiety	-	-	-	-	-	-	-	-	-	.80 (.03)	< .001	[.74, .87]
Cross-lagged effects												
Time 1 Emotion-based climate change anxiety	-	-	-	.04 (.02)	.042	[.00, .08]	.00 (.02)	.908	[-.04, .05]	.07 (.02)	.002	[.02, .11]
Time 1 Cognitive-emotional impairment	.13 (.11)	.235	[-.08, .34]	-	-	-	.27 (.11)	.013	[.06, .49]	-.08 (.07)	.255	[-.21, .05]
Time 1 Functional impairment	-.04 (.12)	.754	[-.27, .20]	.06 (.08)	.442	[-.10, .22]	-	-	-	-.04 (.08)	.570	[-.19, .11]
Time 1 Generalized anxiety	.12 (.05)	.012	[.03, .21]	.01 (.02)	.751	[-.04, .05]	.01 (.02)	.605	[-.03, .06]	-	-	-
Covariates												
Gender	-.14 (.07)	.048	[-.29, .00]	.03 (.03)	.362	[-.04, .10]	.05 (.04)	.183	[-.02, .12]	-.04 (.04)	.325	[-.11, .04]
Age	.00 (.00)	.803	[-.01, .01]	.00 (.00)	.904	[.00, .01]	.00 (.00)	.923	[-.01, .00]	.00 (.00)	.987	[-.01, .01]
Education	.00 (.04)	.933	[-.07, .07]	.01 (.02)	.655	[-.02, .04]	.03 (.02)	.083	[.00, .06]	-.01 (.02)	.705	[-.05, .03]
Income	-.02 (.03)	.482	[-.08, .04]	.00 (.01)	.802	[-.03, .03]	-.01 (.02)	.427	[-.04, .02]	.00 (.02)	.916	[-.04, .03]
Political orientation	.07 (.02)	< .001	[.03, .11]	.01 (.01)	.138	[.00, .03]	.01 (.01)	.530	[-.01, .02]	-.01 (.01)	.545	[-.03, .01]

Note. We allowed the residuals of the Time 2 variables to be correlated. Time 1 predictors were allowed to be correlated. The path model was just identified. Supplementary Table S4 shows the effect of Time 1 demographic variables on Time 1 predictors and the covariance estimates of the Time 1 variables in the model.

Consistent with Study 1, we found that emotion-based climate change anxiety at Time 1 was related to an increase in cognitive-emotional impairment at Time 2 ($b = .04$, $SE = .02$, $p = .039$, 95% CI = [.002, .08], standardized beta = .09). Yet, Time 1 generalized anxiety ($b = .01$, $SE = .02$, $p = .818$, 95% CI = [-.04, .05], standardized beta = .01) and Time 1 functional impairment ($b = .06$, $SE = .08$, $p = .459$, 95% CI = [-.10, .22], standardized beta = .05) were unrelated to it. Also, cognitive-emotional impairment at Time 1 was related to an increase in functional impairment at Time 2 ($b = .29$, $SE = .11$, $p = .009$, 95% CI = [.07, .50], standardized beta = .31), while Time 1 emotion-based climate change anxiety ($b = .003$, $SE = .02$, $p = .898$, 95% CI = [-.04, .05], standardized beta = .01) and Time 1 generalized anxiety ($b = .01$, $SE = .02$, $p = .604$, 95% CI = [-.03, .05], standardized beta = .02) were unrelated to it. Furthermore, cognitive-emotional impairment at Time 1 ($b = .13$, $SE = .11$, $p = .228$, 95% CI = [-.08, .35], standardized beta = -.06) and functional impairment at Time 1 ($b = -.04$, $SE = .12$, $p = .752$, 95% CI = [-.27, .20], standardized beta = -.02) were unrelated to the change in emotion-based climate change anxiety at Time 2. These patterns were consistent with those found in Study 1. Interestingly, we observed a reciprocal relationship between emotion-based climate change anxiety and generalized anxiety over time. Generalized anxiety at Time 1 was related to an increase in emotion-based climate change anxiety at Time 2 ($b = .12$, $SE = .05$, $p = .012$, 95% CI = [.03, .21], standardized beta = .08), and emotion-based climate change anxiety at Time 1 was related to an increase in generalized anxiety at Time 2 ($b = .07$, $SE = .02$, $p = .002$, 95% CI = [.02, .11], standardized beta = .10). Again, Time 1 cognitive-emotional impairment ($b = -.08$, $SE = .07$, $p = .257$, 95% CI = [-.21, .06], standardized beta = -.05) and Time 1 functional impairment ($b = -.04$, $SE = .08$, $p = .570$, 95% CI = [-.19, .11], standardized beta = -.03) were unrelated to the change in Time 2 generalized anxiety. Our results remained consistent when we did not control for the effects of the demographic covariates and did not use the full maximum likelihood

information to handle the missing data.

In brief, we replicated the findings of Study 1 with a sample of U.S. parent participants and with a longer time frame (i.e., a six-month separation). Furthermore, we extended the understanding of the relationship between generalized anxiety and different manifestations of climate change anxiety by showing that this relationship was positive and reciprocal.

4. General discussion

The present research examines how different manifestations of climate change anxiety relate to each other over time. We found that emotion-based climate change anxiety at Time 1 predicted a more frequent experience of cognitive-emotional impairment four months later (Study 1) and six months later (Study 2); the experience of cognitive-emotional impairment at Time 1 also predicted a more frequent experience of functional impairment four months later (Study 1) and six months later (Study 2). By contrast, the two impairment-based climate change anxiety responses did not predict the change in emotion-based climate change anxiety over time in both studies. In Study 2, we also observed a positive bidirectional longitudinal relationship between emotion-based climate change anxiety and generalized anxiety. Overall, our findings provide the initial support for the temporal relationships between different manifestations of climate change anxiety, corroborating that climate change anxiety is a complex emotional, cognitive, and behavioral phenomenon.

4.1. Theoretical implications

The significance of our findings for the understanding of climate change anxiety is threefold. First, the longitudinal associations between emotion-based climate change anxiety, cognitive-emotional impairment, and functional impairment suggest the possibility that some

features of climate change anxiety can precede the other features. In both studies, we observed a temporal sequence from anxiety-related emotions to cognitive-emotional impairment and another sequence from cognitive-emotional impairment to functional impairment. The experience of functional impairment implies that climate change anxiety could hamper people's daily functioning and ability to obtain well-being (Heeren & Asmundson, 2023). As such, the temporal sequences observed reveal how climate change anxiety may transform from an emotional response to maladaptive and unconstructive impairments in functioning over time. Consistent with Heeren et al.'s (2023) psycho-network analysis, our findings also suggest that cognitive-emotional impairment could play a central role in bridging anxiety-related emotional responses to functional impairment. Heeren et al. (2023) suggested that cognitive-emotional impairment could be a tipping point in whether anxiety responses to climate change would lead to adaptive responses (e.g., engagement in climate actions) or maladaptive responses (e.g., experience functional impairment). To our knowledge, a theoretical explanation for this transition in climate change anxiety is currently lacking. Our interpretation of the transition from cognitive-emotional impairment to functional impairment is derived from previous studies on mental health. Cognitive-emotional impairment involves repeatedly thinking and analyzing the source of stress (i.e., climate change). Such repetitive thinking and analyses can make people experience more stress and negativity and distract them from engaging in important daily activities. Indeed, studies found a longitudinal effect of repetitive negative thinking (e.g., worry) on pathological anxiety (e.g., Spinhoven et al., 2018). Furthermore, cognitive-emotional impairment involves difficulty sleeping and having nightmares. It is well-documented that suffering from sleeping problems predicts mental health symptoms longitudinally (Biddle et al., 2019). Together, cognitive-emotional impairment can bear negative consequences on people's daily function, reflected in functional impairment. Given that our findings are based on observations from two-time points, we could not fully examine the dynamics between the three manifestations of climate change anxiety. Future studies would benefit from using a longitudinal design with more waves of observations. Such studies can offer insights into when interventions are needed to prevent climate change anxiety from becoming a risk to mental health.

Second, our findings contribute to the debate on whether there is a one-factor or two-factor structure in the climate change anxiety scale. While previous studies have shown supporting evidence for both the one-factor solution (e.g., Cruz & High, 2022; Innocenti et al., 2021) and the two-factor solution (e.g., Clayton & Karazsia, 2020; Tam et al., 2023) based on psychometric theories and analyses, the current research demonstrates that the two components could have distinct associations with each other and emotion-based climate change anxiety longitudinally. That is, cognitive-emotional impairment could precede functional impairment while functional impairment did not predict cognitive-emotional impairment over time. Accordingly, our findings suggest that cognitive-emotional impairment and functional impairment could be distinct responses to climate change anxiety and serve different functions over time. This observation is not singular. For example, Tam et al. (2023) observed that the relationship between climate change anxiety and climate actions was mainly driven by cognitive-emotional impairment. Their findings thus also point to the need to differentiate the functional roles of the two types of impairment. Together, our findings suggest the potential benefits of using a two-factor model in future studies when the research goal is to understand the function of climate change anxiety.

Lastly, our findings contribute to addressing the crucial question linking generalized anxiety and climate change anxiety. Previous studies have mainly shown the cross-sectional correlation between climate change anxiety and generalized anxiety (e.g., Asgarizadeh et al., 2023; Whitmarsh et al., 2022). It follows that it is uncertain whether generalized anxiety is an antecedent or consequence of climate change anxiety. Our findings suggest that there is a reciprocal association between

emotion-based climate change anxiety and generalized anxiety over time. That is, while feeling anxious about climate change emotionally could make people experience more generalized anxiety disorder symptoms over time, the experience of more generalized anxiety symptoms could also trigger more climate change-related anxiety-related emotions. This notion is consistent with Contreras et al. (2024). They found that momentarily experiencing climate-related emotions (in this case, climate change anxiety) was related to the experience of non-climate-related daily emotions (in this case, anxiety). Their findings corroborate that the experience of climate-related emotions has its experiential basis in daily emotions. Our findings further suggest that a prolonged experience of climate change anxiety can accompany a prolonged experience of daily anxiety, reflecting generalized and persistent anxiety. It is noteworthy that we did not find a direct association between generalized anxiety and cognitive-emotional or functional impairment over time. This finding suggests that even if generalized anxiety predisposes people to experience climate change anxiety, it may start with anxiety-related emotions rather than impairment. Alternatively, emotion-based climate change anxiety may contribute to the experience of anxiety symptoms that can be tied or untied (i.e., generalized anxiety) to climate change. Consistent with this notion, McBride et al. (2021) also observed that concern about climate change predicted an increase in psychological distress one year later, suggesting that worrying about climate change bears negative implications for the general well-being of individuals. These possibilities require future studies with a longitudinal design with three or more waves of observations.

Interpreting the above findings also needs to be cautious, considering the potential influence of unmeasured dispositional factors. Some individuals may be more prone to experience anxiety and be sensitive to threats such as climate change. It follows that they are likely to experience both generalized anxiety and climate change anxiety simultaneously. One such trait factor is neuroticism (or emotional instability), which was found to be associated with vulnerability to suffering pathological anxiety (e.g., Kotov et al., 2010) and climate change anxiety (e.g., Zacher & Rudolph, 2023). Indeed, neuroticism can also be an antecedent of emotion-based climate change anxiety and, in turn, translate into the experience of generalized anxiety. For example, as people with high neuroticism are more prone to experience anxiety and distress when facing threats, they are more likely to experience climate change anxiety when they personally experience, are exposed to, or think about climate change (e.g., Chen et al., 2020). This possibility has not been tested in the current study, as a cross-lagged panel model cannot tackle the influence of unmeasured dispositional factors. Future studies would benefit from considering the role of dispositional factors (e.g., neuroticism) in understanding the associations between climate change experience, climate change anxiety, and generalized anxiety.

4.2. Limitations

Our discussion above has to be taken with cautious attention to the following two limitations. First, although we measured climate change anxiety both in terms of emotional responses and impairments, we may still have failed to capture the full range of climate change anxiety responses. van Valkengoed et al. (2023) proposed that climate change anxiety could be expressed emotionally, cognitively, physiologically, and behaviorally. It is crucial for future studies to consider how these four domains of responses may relate to each other over time. Furthermore, the current study only conceptualizes worry as an anxiety-related emotional response to climate change. The cognitive process of climate change-related worry has yet to be included in understanding the development of climate change anxiety over time. It is noteworthy that recent studies have proposed to distinguish eco-worry from eco-anxiety (e.g., Parmentier et al., 2024). Future studies would benefit from incorporating the non-pathological cognitive component of climate change-related worry into understanding the course of climate change

anxiety. Second, as we included only participants from the U.S. in the present research, it is uncertain to what extent the current findings are generalizable to other countries. As the prevalence of climate change anxiety is generally low in the U.S., most of our participants still experience more anxiety-related emotions and fewer impairments. Our data thus allows us to detect whether such emotional response would trigger more impairment-based climate change anxiety over time. Such changes could be more difficult to observe among populations already experiencing higher levels of impairment-based climate change anxiety. It is thus crucial for future studies to replicate and extend these findings with participants from countries with a higher prevalence of impairment-based climate change anxiety. Such endeavors would represent a timely response to recent calls by scholars for expansion of geographic representation of research samples in climate change and environmental studies (Tam et al., 2021; Tam & Milfont, 2020).

4.3. Conclusion

With a longitudinal design, our two studies successfully exposed how climate change anxiety develops over time. Overall, people seem to experience negative feelings in association with climate change first and then develop impairments in their cognitive-emotional and everyday functioning. Additionally, generalized anxiety serves as both a risk factor and a consequence of the experience of anxiety-related emotions about climate change. It is our hope that this research will stimulate more future studies regarding the course of development of both adaptive and maladaptive responses to climate change among individuals, and inform recommendations on how to protect people's mental well-being from the threats posed by climate change.

Endnotes

1. We conducted attrition analyses to compare how participants completed both waves of surveys with those who completed only the Time 1 survey. We presented the details of the results in Supplementary Materials. In Study 1, we observed that participants who completed both surveys reported less emotion-based and impairment-based climate change anxiety at Time 1 compared with participants who completed the Time 1 survey only, with small effect sizes (Hedge's g ranged from .19 to .24). They did not differ in other demographic variables, except for age. Those retained in the study were older than those who dropped the study, with a very small effect size (Hedge's $g = .14$). In Study 2, we observed that participants who completed both surveys were not significantly different from those who completed only the Time 1 survey in all key measures and demographic variables. As we observed a consistent pattern of findings across the two studies, it appears that the attribution of participants who reported higher levels of climate change anxiety initially did not significantly influence our results.
2. We conducted confirmatory factor analyses (CFA) to compare a one-factor solution against a two-factor solution. In both studies, our data supported a two-factor solution over a one-factor solution. We reported the detailed results of the CFA in the Supplementary Materials. Furthermore, as recommended by the reviewer, we conducted an exploratory analysis by considering a three-factor solution, which was also supported by our data. We conducted an additional exploratory set of cross-lagged panel analyses based on the three-factor solution. We reported these findings in the Supplementary Materials. We opted to report results based on a two-factor model for two reasons. First, a two-factor model allows us to compare and connect our findings with previous studies based on the US samples (e.g., Clayton & Karazsia, 2020; Tam et al., 2023), which also revealed a two-factor model. Second, it enables us to test the temporal associations between cognitive-emotional impairment and functional impairment, as proposed by Heeren et al. (2023).

3. The original STAI did not include the feeling of "terrified." Such feeling was included in other validated measures of anxiety (e.g., the Beck Anxiety Inventory; Beck & Steer, 1990; STAI for Children or STAI-C: Spielberger et al., 1973). We thus consider Ogunbode et al.'s (2022) instrument a valid measure of emotion-based climate change anxiety.

CRediT authorship contribution statement

Ying-yi Hong: Writing – review & editing, Investigation. **Kim-Pong Tam:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Li Lin:** Writing – review & editing, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Hoi-Wing Chan:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of Competing Interest

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

Data Availability

Data will be made available on request.

Acknowledgments

This research is partially funded by a Departmental Research Fund (P0046089) by the Department of Applied Social Sciences, The Hong Kong Polytechnic University, and an MHRC mini-seed fund scheme (P0041569) by the Mental Health Research Centre, The Hong Kong Polytechnic University conferred to H.-W. Chan.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.janxdis.2024.102917.

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