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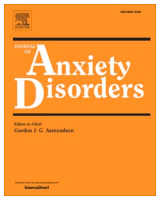

Ecological anxiety and pro-environmental behaviour: The role of attention

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ABSTRACT

Climate change is a serious threat to human health and the awareness of this threat can elicit ecological anxiety (eco-anxiety), which could be considered a rational and potentially adaptive response. However, the experience of eco-anxiety does not always lead to adaptive behaviour. The present study investigated whether differential patterns of selective attention towards climate-related information, and variability in this attention, might explain this inconsistent relationship. Participants completed a dot-probe assessment of attentional bias to images of both climate change mitigation strategies and of climate change causes and consequences, and measures of eco-anxiety, climate change belief, environmental self-efficacy, and general psychological symptoms. Engagement in pro-environmental behaviours was measured using a daily behavioural diary. Eco-anxiety and attentional bias independently predicted behaviour, but did not interact. However, attentional bias variability moderated the relationship between eco-anxiety and behaviour, such that higher eco-anxiety predicted greater behavioural engagement, but only when attentional bias variability was low. This was the first known study to examine the potential moderating effect of attentional bias on the relationship between eco-anxiety and pro-environmental behaviours. This growing field of research can help in identifying how the rational response of eco-anxiety can be better harnessed to motivate an adaptive response to the climate crisis.

1. Introduction

Climate change has become the most prominent threat to human health in the twenty first century (Costello et al., 2009; Ripple et al., 2020). Whilst the physical implications of climate change have been widely investigated, there remains a scarcity of research into the psychological ramifications (Cianconi et al., 2020; Hayes & Poland, 2018; Rocque et al., 2021). This is problematic as two thirds of people worldwide (Flynn et al., 2021; Patrick et al., 2021) report concerns about climate change. Climate-related concerns appear to be most prevalent amongst individuals under the age of 35 (Searle & Gow, 2010), with the prevalence of climate-related anxiety as high as 80% (ReachOut, 2019). Young people and future generations are disproportionately affected by climate change as they will endure the consequences throughout their lifetime (Burke et al., 2018; Philipsborn & Chan, 2018; Sanson et al., 2019). Therefore, distress and anxiety about the current and future state of the planet is understandably common amongst young people.

Ecological anxiety (eco-anxiety) refers to the experience of heightened feelings of distress relating to ecological crises, including anthropogenic climate change (Pihkala, 2020a). Studies have shown that climate-related distress is associated with symptoms of depression and pathological anxiety, insomnia, panic attacks, and obsessive thinking (Jones et al., 2012; Ogunbode et al., 2021; Searle & Gow, 2010; Verplanken et al., 2020). Eco-anxiety is not currently recognised as a clinical disorder. Nevertheless, the American Psychiatric Association has acknowledged the psychological implications of climate change on the human psyche, defining eco-anxiety as the "*chronic fear of environmental doom*" (Clayton et al., 2017, p. 68). However, some argue that such a narrow conceptualisation of eco-anxiety can lead to the inappropriate pathologizing of a largely rational response (Hickman, 2020; Pihkala, 2020b). Given the genuine threat of climate change and ecological degradation, experiencing fear and worry can be considered a rational and reasonable response (Clayton, 2020; Heeren & Asmundson, 2023; Verplanken & Roy, 2013).

Fundamentally, anxiety is a practical emotion that alerts individuals to potential threats. The anticipatory cognitive, affective, and physiological processes involved in the experience of anxiety can serve a protective role in potentially dangerous situations when they result in a heightened state of preparedness and adaptive behavioural responses (Beck & Clark, 1997; Grupe & Nitschke, 2013; Yerkes & Dodson, 1908). Anxiety becomes maladaptive when these processes are dysfunctional or

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disproportionate to the present danger (Barlow, 2004; Rosen & Schulkin, 1998). Considering the real threat of climate change, what constitutes a normal, appropriate, or even adaptive level of eco-anxiety is still in question (Doherty & Clayton, 2011). Therefore, it is essential to differentiate between adaptive and maladaptive forms of eco-anxiety.

Maladaptive eco-anxiety can be defined as the experience of psychological distress coupled with an inability to act appropriately in response to climate change, whereas adaptive eco-anxiety motivates climate activism, such as collective action and individual mitigation behaviours (Taylor, 2020). One specific mitigation strategy is engaging in pro-environmental behaviours, i.e. any action that has a minimal negative impact on, or is actively beneficial to, the environment (Steg & Vlek, 2009). Some examples of pro-environmental behaviours include conserving energy and water, reducing plastic use, composting food waste, recycling, and using sustainable products. Recent research on how eco-anxiety relates to pro-environmental behaviours has yielded inconsistent results. Some studies have shown that anxiety about climate change is positively related to environmental identity and pro-environmental behaviours (Gao et al., 2020; Verplanken et al., 2020; Verplanken & Roy, 2013), whilst others have found no relationship, or a negative relationship, between eco-anxiety and pro-environmental behaviours (Clayton & Karazsia, 2020; Stanley et al., 2021). At present, this limited body of evidence suggests that eco-anxiety may enable some individuals to respond to climate change in a productive manner, whilst leading to maladaptive responses for others. Hence, the question remains: what factors might contribute to whether an individual's eco-anxiety manifests as an adaptive or maladaptive response?

One potential cognitive factor that could influence the degree to which eco-anxiety affects engagement in pro-environmental behaviours is attentional bias. An attentional bias refers to the preferential allocation of attention to certain information, and has been studied extensively in relation to anxiety (Bar-Haim et al., 2007). Attentional processes can become dysfunctional when individuals are overly sensitive to threat, resulting in a negative attentional bias (Bar-Haim et al., 2007; Clark & Beck, 2011; MacLeod et al., 1986). Negative attentional bias contributes to the onset and maintenance of multiple psychopathologies, such as depression and anxiety disorders (Bar-Haim et al., 2007; Barlow, 2004; Mathews & MacLeod, 2005). However, research also suggests that an attentional bias to threat can be adaptive when individuals are confronted with genuine danger, where there is an ability to engage in protective behaviours (Georgiades et al., 2021; Notebaert et al., 2016; Notebaert et al., 2020; Notebaert et al., 2017). For instance, Notebaert et al. (2016) found that the relationship between trait anxiety and bushfire preparedness was moderated by an attentional bias. That is, when individuals with high trait anxiety displayed an attentional bias to bushfire-related threat, this impaired their engagement in preparatory behaviours that would reduce their risk of being endangered by a future bushfire. However, for individuals with low trait anxiety, an attentional bias to bushfire-related threat enhanced their behavioural preparedness. These studies highlight that the degree of anxiety may be a crucial determinant in whether an attentional bias provokes an adaptive or maladaptive response.

There is a small but growing body of research suggesting a relationship between attentional bias and climate-related constructs, such as climate concern (Whitman et al., 2018) and pro-environmental attitudes (Carlson et al., 2019; Meis-Harris et al., 2021). Research has found that individuals tend to have a greater attentional bias toward positive rather than negative climate change-related images (Carlson et al., 2020). However, in another study, whilst viewing images of climate change solutions resulted in positive emotional responses, viewing images of negative climate impacts produced greater behavioural change intentions (Chapman et al., 2016). Overall, these findings indicate that differential attention to climate-related information, as well as the specific content (i.e. solutions or causes and consequences) of such images, may contribute to promoting engagement in pro-environmental behaviours. Given the existing research, it seems plausible that the relationship between eco-anxiety and pro-environmental behaviours may depend on attention to climate-related information, and may differ depending on whether this information is related to climate change mitigation strategies or the causes and consequences of climate change. Yet, to date, no research has considered how attentional processes might relate to eco-anxiety and subsequent engagement in pro-environmental behaviours.

The aim of the present study was to investigate the relationship between young people's experience of eco-anxiety and engagement in pro-environmental behaviours by examining whether this relationship depends on the degree of attentional bias, and variability in this bias, to climate change-related information. Specifically, we were interested in whether an attentional bias towards images of the causes and consequences of climate change or images of mitigation strategies moderates the relationship between eco-anxiety and pro-environmental behaviours assessed through a daily behaviour diary. This is the first known study to examine the role of attentional bias in the relationship between eco-anxiety and pro-environmental behaviours. If differential patterns of selective attention to climate-related information play a moderating role in this relationship, this could explain why some individuals who experience eco-anxiety engage in pro-environmental behaviours, while others do not. The present study adds to the limited existing literature on eco-anxiety by investigating the underlying attentional processes that may influence the adaptive or maladaptive potential of eco-anxiety. By extending the understanding of the cognitive and affective determinants of pro-environmental behaviour, this research has direct practical implications for the development of strategies to motivate individuals to engage in climate action.

2. Method

2.1. Design

The experiment was a two-part prospective study. Part one included a baseline assessment of attentional bias, eco-anxiety, and pro-environmental behaviour administered through Millisecond Inquisit Web (Inquisit 6, 2021) on the participant's computer in their chosen location. Part two involved a week-long diary, measuring daily emotions and engagement in pro-environmental behaviours, completed via the SEMA3 application (Koval et al., 2019) on the participant's phone. This research project received ethical approval from the University of Sydney Human Research Ethics Committee (No. 2021/317). The study was pre-registered on Open Science Framework (see: https://osf.io/9dejv/).

2.2. Participants

This study recruited participants from the community through social media advertisements and undergraduate students from the University of Sydney and the University of Western Australia through psychology student research pools. An a priori power analysis conducted using G*power (Version 3.1, Faul et al., 2009), indicated that a final sample of at least 77 participants would be required to detect medium effects (f =.15) in a moderation model with three predictors, with .80 power using a significance level of .05.

Participants were eligible for inclusion in the study provided they were residing in Australia, aged 18–30, fluent in English, had normal (or corrected to normal) vision, and owned a smartphone. Participants also needed to have some belief in climate change, complete a sufficient amount of the study (i.e. baseline, and at least 5 of 7 diaries), and give a serious attempt (i.e. accuracy $\geq$ 75% on dot-probe, and valid questionnaire responses) for their data to be retained. Of the 130 participants that took part, we excluded 34 as they dropped out (N = 8), completed the diary on < 5 days (N = 15), had < 75% accuracy on the dot-probe task (N = 1), had invariable responses on questionnaires suggesting non-serious attempt (N = 2), or low belief in climate change (N = 8).

This left a final sample of 96 participants between 18 and 31 years old ($M = 20.86$, $SD = 3.44$). One participant indicated they had just turned 31, and their data was retained. Most participants identified as female (70.8%), described their nationality as Australian (58.2%) and their political orientation as either slightly liberal (32.3%) or very liberal (28.1%).

2.3. Measures

2.3.1. Questionnaires

Eco-anxiety was measured with the Hogg Eco-Anxiety Scale (HEAS-13, Hogg et al., 2021). The HEAS-13 is a 13-item questionnaire, which we adapted to a one-week time frame for comparability with other measures. An overall eco-anxiety score was calculated by averaging all items, with higher scores indicating greater eco-anxiety on a scale of 0–3. This scale has demonstrated excellent internal consistency in previous research (Hogg et al., 2021), and in the present study ($\alpha = .92$).

Climate change belief was measured using six items from previous research (Brick et al., 2017). Since belief in climate change was a fundamental premise of this study, this measure was included as a participant screening tool. Items were averaged, and higher indices indicated greater belief in climate change on a scale of 1–7. This measure has demonstrated good internal consistency in previous research ($\alpha = .84$, Brick et al., 2017), and acceptable internal consistency in the present study ($\alpha = .77$).

Environmental self-efficacy was an exploratory measure based on a 5-item scale from previous research (Strzelecka et al., 2018). This measure assessed the degree to which individuals felt their actions can contribute to ameliorating climate change. Items were averaged, where higher indices indicated greater environmental self-efficacy on a scale of 1–5. This scale has demonstrated good internal consistency in previous research ($\alpha = .89$, Strzelecka et al., 2018), and in the present study ($\alpha = .86$).

Depression, anxiety, and stress symptomatology was measured with the Depression, Anxiety, and Stress Scale (DASS-21, Lovibond & Lovibond, 1995). The 21-item version was employed. Raw scores were multiplied by two to create standardised scores. On a scale of 0–42, higher scores on each subscale indicated greater severity of depression, anxiety, or stress symptomatology over the past week. This scale demonstrated good to excellent internal consistency in the present study, with Cronbach's alpha values of.92,.83, and.86 for the subscales of depression, anxiety, and stress respectively.

2.3.2. Dot-probe assessment of attentional bias

Attentional bias was measured using a modified version of the dot-probe task employing images of climate change mitigation strategies, images of climate change causes and consequences, and neutral images. Each trial contained an image pair with a target (i.e. climate relevant) and neutral (i.e. climate irrelevant) image. On each trial, a white fixation cross appeared in the centre of the screen for 500 ms followed by an image pair. Images (9 cm x 6 cm) were presented simultaneously on a plain black background for 500 ms, with one situated above the other on the screen (2 cm apart). The image pair disappeared and a white visual probe ('<' or '>') appeared in the location of one of the images. In congruent trials, the visual probe appeared following the location of the target image. In incongruent trials, the visual probe appeared following the location of the neutral image. Participants were instructed to respond to the probe by pressing the corresponding key on their keyboard, after which the next trial would begin. The word 'incorrect" appeared following an incorrect response to encourage accuracy. Participants' reaction time to respond to the visual probe was measured. Response time to the probe indicates where their visual attention had

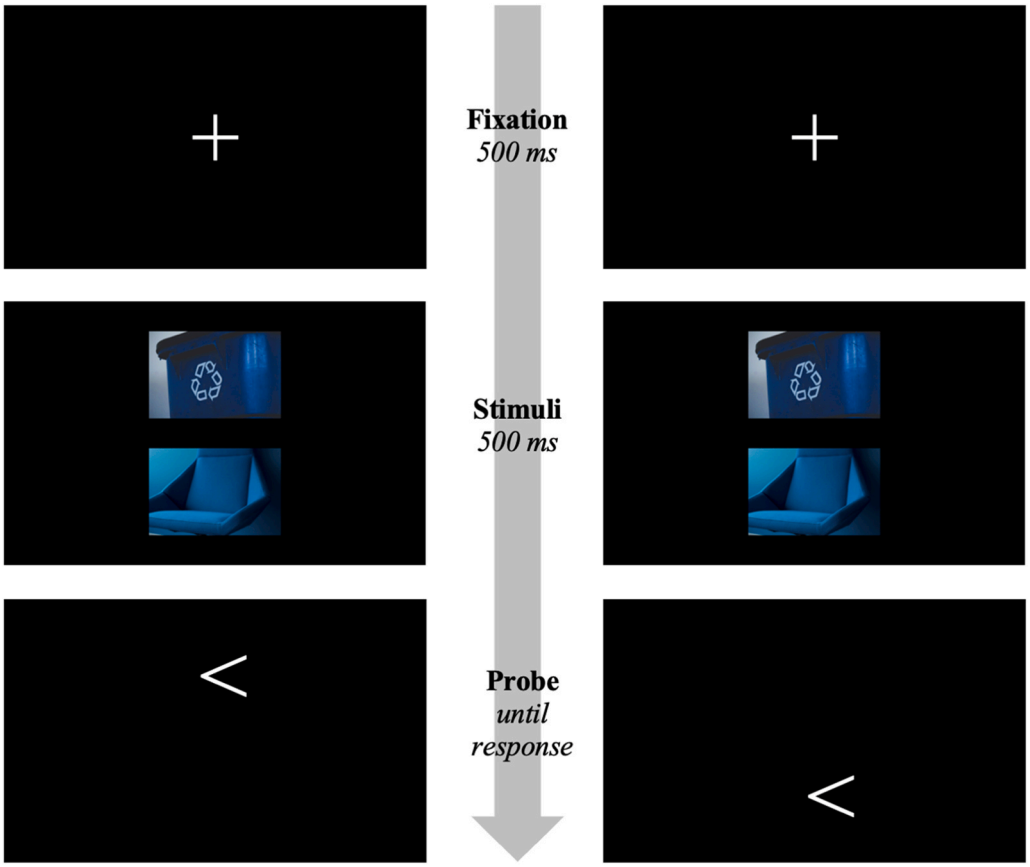

Fig. 1. *Example of a Congruent Trial and Incongruent Trial in the Dot-Probe Task. Note.* Climate change congruent trial (left) and incongruent trial (right). Fixation cross and visual probe enlarged for illustrative purposes.

been allocated, that is a faster response would indicate the allocation of attention to the image located in the same position as the probe. See Fig. 1 for a pictorial representation of the dot-probe task used in the present study.

To assess attentional bias towards climate change-related images, we calculated an attentional bias index (ABI) for each participant for the causes and consequences, and mitigation strategies blocks. The attentional bias indices were calculated by subtracting their mean response time to congruent trials from their mean response time to incongruent trials. A higher positive ABI indicates stronger attentional bias towards climate change-related images relative to neutral images, whereas a more negative ABI indicates greater attentional avoidance of climate change-related images.

To assess attentional bias variability, we calculated a trial-level bias score (TLBS) for each participant separately for the causes and consequences, and mitigation strategies blocks. The TLBS is calculated by first pairing individual trial response times to congruent trials with individual trial response times to incongruent trials based on order of appearance. The congruent trial response time is then subtracted from the incongruent trial response time. The result is a temporal sequence of attentional bias indices for each participant, for each stimuli category (climate change causes/consequences, climate mitigation strategies). A series of difference scores between each index and the subsequent index are then calculated, resulting in an inter-trial bias change score. The absolute (i.e. non-negative) value of these changes scores are used to create a mean attentional bias variability, or TLBS, score. A higher TLBS score indicates greater variability in attention to climate change-related information.

2.3.3. Dot-probe task stimuli

A total of 114 images were initially sourced online from stock photography websites and previous studies (Carlson et al., 2020; Carlson et al., 2019). These images were rated by a group of nine independent raters on climate change relevance, emotional valence, and arousal. Ratings were conducted on a sliding scale from 0 to 100. Based on these ratings, 18 climate change mitigation images with positive valence (valence: $M = 65.17$, $SD = 8.31$) and high relevance to climate change (relevance: $M = 79.42$, $SD = 11.37$), 18 climate causes and consequence images with negative valence (valence: $M = 16.93$, $SD = 8.48$) and high relevance to climate change (relevance: $M = 91.49$, $SD = 3.24$), and 36 neutral images (valence: $M = 51.71$, $SD = 4.55$) with low relevance to climate change (relevance: $M = 18.17$, $SD = 4.40$) were selected. We used a total of 36 image-pairs in the dot-probe task, matched on colour and composition. Images were paired based on dominant colours and configural properties, such as the positioning of the subject matter. An additional 20 neutral images were selected for the practice phase.

To ensure the ecological validity of the dot-probe task, we employed an interpretation check of the dot-probe stimuli. We presented each image individually at the end of the experiment and asked participants to indicate whether they perceived it to be a mitigation strategy, a cause or consequence, or irrelevant to climate change. This interpretation check acted as a measure of the dot-probe task's ecological validity. The average rate of accurate interpretation was high: 96.22% for climate change causes and consequences images, 83.39% for climate change mitigation images, and 81.42% for neutral images. See Fig. 2 for example images.

2.3.4. Behavioural diary

A behavioural diary was used to measure participants' daily self-reported eco-emotions and daily engagement in pro-environmental behaviours over one week. Seventeen items were adapted from three previous studies to develop the pro-environmental behaviour questions (Brick et al., 2017; Casey & Scott, 2006; Whitmarsh & O'Neill, 2010). Items were altered to reflect a daily context (i.e. engagement in behaviour in the past 24 h) and participants responded to these questions with either *yes*, *no*, or *N/A*. Each participant's weekly score was computed by first calculating their proportion of behaviours per day (i.e. yes / yes + no) and then averaging these daily scores across the number of days participants completed the diary. Higher indices indicated greater engagement in pro-environmental behaviours across the week on a scale from 0 to 1.

2.4. Procedure

Participants accessed the study via advertisements on a student research platform or social media. After completing a brief survey assessing eligibility, participants provided informed consent and completed part one of the study on their own computer. A calibration procedure was used to ensure stimuli were presented in a consistent size for all participants, and participants were instructed to sit 60 cm from their computer screen. Participants completed demographic questions, followed by the dot-probe task. Participants were presented with 12 practice trials, followed by 144 trials across two blocks. In one block, the target image depicted a cause or consequence of climate change. In the other block, the target image depicted a climate change mitigation strategy. The presentation of blocks and trials were counterbalanced across participants. Questionnaires were then completed, with questionnaires and items counterbalanced across participants. Participants then completed the dot-probe stimuli interpretation check.

Upon completion of part one, participants were added to the daily behavioural diary and received instructions on how to download, log in, and use the application. The diary was administered via SEMA3, an ecological momentary assessment application, installed on participants' phones. Written instructions about how to use the diary were provided. The week-long diary commenced on the subsequent evening and continued for seven days after the experiment, measuring participants' daily emotion states and engagement in pro-environmental behaviours. Question sets and questions within each set were counterbalanced across participants. Participants received a push notification at 7:00 pm each night to complete the diary and were given up to 3 h to complete the diary. Following the seven-day reporting period, participants were emailed a debrief statement. Participants received course credit (university students) or went into the draw to win one of four AUD $50 gift card vouchers (community members).

Fig. 2. *Example of Images used in the Dot-Probe Task. Note.* Climate change mitigation strategy (left), neutral (middle), and climate change cause or consequence (right).

3. Results

3.1. Data cleaning and statistical analyses

Prior to calculating attentional bias indices, the dot-probe data was filtered to exclude incorrect responses, probe response latencies < 200 ms or > 2000 ms, and outlier responses using a + /- 2.5 median absolute deviation (MAD). This resulted in the removal of 10.2% and 9.8% of trials for the climate change mitigation and causes/consequences blocks, respectively. The cleaned data was then used for the calculation of attentional bias indices and subsequent analyses. Where small amounts of questionnaire data were missing, we employed multiple imputation where possible (i.e. correlation analyses) or otherwise this data was excluded from specific analyses (i.e. moderation analyses).

For statistical analysis of the data, Pearson product-moment correlations were calculated between all baseline variables. A linear mixed-modelling approach was then taken using the jamovi software (The jamovi project, 2021) with the linear models package to test whether the relationship between eco-anxiety and daily pro-environmental behaviour was moderated by a) attentional bias to climate change-related causes and consequences, b) attentional bias to climate change mitigation strategies, c) attentional bias variability towards climate change-related causes and consequences, and d) attentional bias variability to climate change mitigation strategies.

3.2. Descriptive statistics and correlations

Means and correlations between baseline constructs of interest are displayed in Table 1. The sample, on average, had relatively low eco-anxiety (M = 0.43, SD = 0.48), relatively high engagement in pro-environmental behaviours (M = 0.65, SD = 0.15), and relatively high environmental self-efficacy (M = 3.51, SD = 0.74). Notably, eco-anxiety was significantly positively correlated with depression ($r_{(94)}$ = .36, p <.001), anxiety ($r_{(94)}$ = .38, p <.001), and stress ($r_{(94)}$ =.27, p = .008). Environmental self-efficacy was also associated with attentional bias variability for climate mitigation strategies ($r_{(84)}$ = .26, p= .020). No other correlations between attentional bias constructs and questionnaire scores were significant (ps > .05). A paired samples t-test revealed no significant difference between the average ABI for causes and consequences and the average ABI for mitigation strategies, $t_{(94)}$ = 1.35, p = .181, and no significant difference between the TLBS for causes and consequences, and the TLBS for mitigation strategies, $t_{(83)}$ = 0.05, p = .958. However, there was considerable individual variability in the attentional bias and attentional bias variability indices (see Table 1), which is important when examining individual differences.

To ensure that the reaction time data from the dot-probe was reliable, we conducted split-half reliability analyses separately for congruent and incongruent trials, for the cleaned data. Within the climate mitigation and causes/consequences blocks, congruent and incongruent trials were ordered by trial presentation. Every second trial was separated to create two means per congruency and block, per participant. We then compared these means using the Spearman-Brown formula. Reliability was sound across all 4 split-half analyses (rSB = .961 −.972). We then tested split-half reliability on the attentional bias index, calculated using this same odd-even split data. The reliability of the attentional bias index was low for both climate change causes and consequences (α = .398) and for mitigation strategies (α = .349). Finally, we tested the reliability of the TLBS. Given the TLBS relies on proximal trials, we opted to split the data in half (i.e. first half of trials for each block vs second half of trials for each block), and then calculate the split-half reliability from the resulting TLBS indices for these halves. The reliability of the TLBS was good for climate change causes and consequences (α = .887) and poor for climate mitigation strategies (α = .579).

3.3. Attentional bias as a moderator of the relationship between eco-anxiety and pro-environmental behaviour

To test the assumption that eco-anxiety would predict subsequent engagement in pro-environmental behaviours and that attention to climate change-related images would moderate this relationship, we conducted two moderation analyses with linear mixed-modelling. Eco-anxiety was entered as the predictor variable, and daily engagement in pro-environmental behaviours was entered as the outcome variable, clustered by participant. Attentional bias to climate change causes and consequences, and attentional bias to climate change mitigation strategies was entered as the moderator for the first and second model, respectively.

For the first model (see Table 2), eco-anxiety was a significant predictor of greater engagement in pro-environmental behaviour, $t_{(82.4)}$ = 2.60, p = .011. Attentional bias to climate change causes and consequences was a significant negative predictor of engagement in pro-environmental behaviour, $t_{(83.1)}$ = −2.06, p = .043, such that those with greater bias towards negative climate-related information engaged in less pro-environmental behaviour. The interaction between eco-anxiety and pro-environmental behaviour was not significant (p = .128). For the second model (see Table 3), eco-anxiety was again a significant predictor of pro-environmental behaviour, $t_{(82.5)}$ = 2.02, p = .047. However, attentional bias to climate change mitigation strategies (p = .620), and the interaction between eco-anxiety and attentional bias (p = .068), were both not significant.

3.4. Attentional bias variability as a moderator of the relationship between eco-anxiety and pro-environmental behaviour

The attentional bias moderator analyses were repeated, using the TLBS attentional bias variability towards climate change causes and consequences (third model; see Table 4) and towards mitigation

Table 1
Pearson Correlations Between Baseline Climate Change-Related Constructs, Attentional Bias, and Pro-Environmental Behaviours.

Variables	Eco-anx	AB-C	AB-M	TLBS-C	TLBS-M	ESE	Depression	Anxiety	Stress
Eco-Anxiety	–								
AB-C	.102	–							
AB-M	-.011	-.188	–						
TLBS-C	.212	.229 *	.039	–					
TLBS-M	.024	.095	-.121	.586 * **	–				
ESE	.012	-.046	.013	.131	.255 *	–			
Depression	.359 * **	.118	-.151	-.015	-.078	-.222 *	–		
Anxiety	.383 * **	.072	-.111	.080	-.038	-.068	.631 * **	–	
Stress	.271 * *	.034	-.016	.171	.002	-.019	.668 * **	.727 * **	–
M	*0.43*	*5.59*	*-0.10*	*136.95*	*137.08*	*3.51*	*12.30*	*9.33*	*14.96*
SD	*0.48*	*26.73*	*25.99*	*80.34*	*45.77*	*0.74*	*10.49*	*8.26*	*9.49*

Notes. AB-C = attentional bias for climate change causes/consequences. AB-M = attentional bias for climate change mitigation strategies, TLBS-C = trial-level bias score (attentional bias variability) for climate change causes/consequences, TLBS-M = trial-level bias score (attentional bias variability) for climate change mitigation strategies, ESE = environmental self-efficacy. * p < .05. * * p < .01. * ** p < .001. N = 84–96

Table 2
Eco-anxiety and attentional bias to climate change causes and consequences as predictors of pro-environmental behaviour.

			95% Confidence Interval				
Names	Estimate	SE	Lower	Upper	df	t	p
(Intercept)	0.6544	0.0156	0.624	0.685	82.8	41.90	< .001
Eco-anxiety	0.0843	0.0324	0.021	0.148	82.4	2.60	0.011
AB-C	-0.0012	0.0006	-0.002	-0.000	83.1	-2.06	0.043
Eco-anxiety*AB-C	-0.0016	0.0010	-0.004	0.000	82.8	-1.54	0.128

Notes. AB-C = attentional bias for climate change causes/consequences.

Table 3
Eco-anxiety and attentional bias to climate mitigation strategies as predictors of pro-environmental behaviour.

			95% Confidence Interval				
Names	Estimate	SE	Lower	Upper	df	t	p
(Intercept)	0.6512	0.0160	0.620	0.683	82.8	40.68	< .001
Eco-anxiety	0.0669	0.0332	0.001	0.132	82.5	2.02	0.047
AB-M	-0.0003	0.0006	-0.002	0.001	83.0	-0.50	0.620
Eco-anxiety * AB-M	0.0023	0.0013	-0.000	0.005	82.5	1.85	0.068

Notes. AB-M = attentional bias for climate change mitigation strategies.

Table 4
Eco-anxiety and attentional bias variability to climate change causes and consequences as predictors of pro-environmental behaviour.

			95% Confidence Interval				
Names	Estimate	SE	Lower	Upper	df	t	p
(Intercept)	0.6529	0.0160	0.6216	0.6843	71.8	40.79	< .001
Eco-anxiety	0.0918	0.0349	0.0235	0.1602	71.5	2.63	0.010
TLBS-C	0.0006	0.0003	0.0000	0.0012	71.6	2.03	0.046
Eco-anxiety* TLBS-C	-0.0011	0.0003	-0.0017	-0.0005	71.8	-3.64	< .001

Notes. AB-C = attentional bias for climate change causes/consequences.

strategies (fourth model; see Table 5), instead of the traditional attentional bias indices. The significant relationship between eco-anxiety and pro-environmental behaviour remained across both additional models. For the third model, attentional bias variability towards climate change causes and consequences was a significant predictor of pro-environmental behaviour, $t_{(71.8)} = 2.03$, $p = .046$, such that greater attentional bias variability predicted greater engagement in pro-environmental behaviour. This was qualified by an interaction $t_{(71.8)} = -3.64$, $p < .001$, which was probed through simple slopes analysis (see Fig. 3). For high levels of attentional bias variability (+1 SD), there was relatively little variation in engagement in pro-environmental behaviour based on level of eco-anxiety, $F_{(1,71.8)} = 0.14$, $p = .709$. However, for those with lower attentional bias variability (−1 SD), greater eco-anxiety corresponded to greater engagement in pro-environmental behaviours, $F_{(1,71.6)} = 7.34$, $p = .008$.

For the fourth model, attentional bias variability towards mitigation strategies was not a significant predictor of pro-environmental behaviour, $t_{(70.5)} = 0.80$, $p = .425$. However, there was an interaction between eco-anxiety and attentional bias variability towards mitigation strategies, $t_{(70.4)} = -2.72$, $p = .008$, which was probed through simple slopes analysis (see Fig. 4). In the same pattern as the third model, for high levels of attentional bias variability (+1 SD), there was relatively little

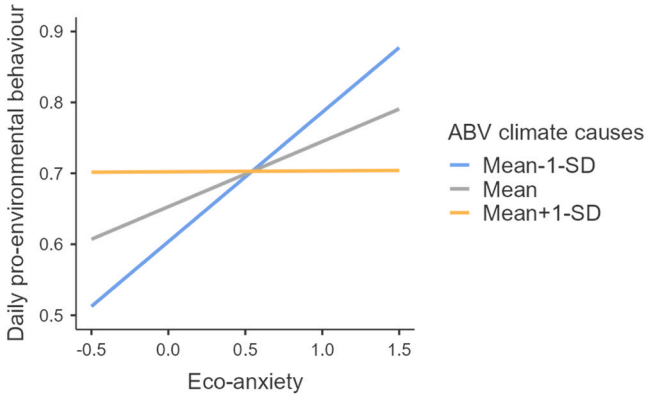

Fig. 3. *Attentional bias variability to images of climate change causes/consequences as a moderator of the relationship between eco-anxiety and pro-environmental behaviour. Note:* ABV = attentional bias variability. Eco-anxiety scale values represent extrapolated rather than true score range.

Table 5
Eco-anxiety and attentional bias variability to climate mitigation strategies as predictors of pro-environmental behaviour.

			95% Confidence Interval				
Names	Estimate	SE	Lower	Upper	df	t	p
(Intercept)	0.6466	0.0165	0.6142	0.6790	70.8	39.081	< .001
Eco-anxiety	0.0908	0.0362	0.0199	0.1620	70.5	2.510	0.014
TLBS-M	0.0003	0.0004	-0.0004	0.0010	70.5	0.802	0.425
Eco-anxiety * TLBS-M	-0.0017	0.0006	-0.0030	-0.0005	70.4	-2.724	0.008

Notes. AB-M = attentional bias for climate change mitigation strategies.

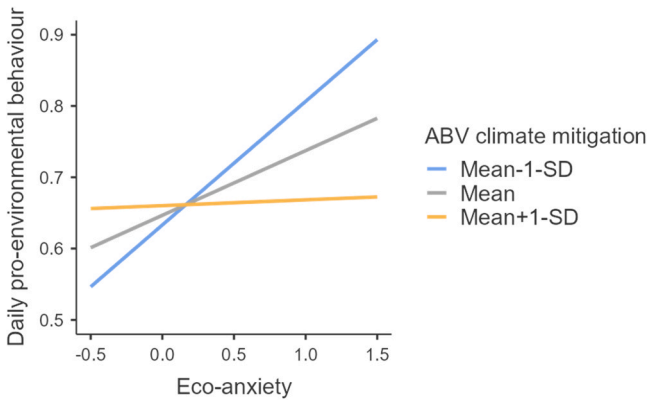

Fig. 4. *Attentional bias variability to images of climate mitigation strategies as a moderator of the relationship between eco-anxiety and pro-environmental behaviour. Note:* ABV = attentional bias variability. Eco-anxiety scale values represent extrapolated rather than true score range.

variation in engagement in pro-environmental behaviour based on level of eco-anxiety, $F_{(1,70.5)} = 1.51$, $p = .223$. However, for those with lower attentional bias variability towards mitigation strategies (−1 SD), greater eco-anxiety corresponded to greater engagement in pro-environmental behaviours, $F_{(1,70.8)} = 5.04$, $p = .028$.

4. Discussion

The aim of the present study was to elucidate the relationship between young adults' experience of eco-anxiety and subsequent engagement in pro-environmental behaviours by investigating whether this relationship depends on attentional bias to climate change-related information. This is the first known study to investigate the role of attentional bias in the relationship between eco-anxiety and daily pro-environmental behaviours. The overarching hypothesis was that the relationship between eco-anxiety and pro-environmental behaviours would depend on the preferential allocation of attention towards climate-related information, and that this pattern would differ depending on whether this information was related to climate change mitigation strategies or the causes and consequences of climate change.

As expected, eco-anxiety was a significant predictor of subsequent engagement in pro-environmental behaviours. We also found that greater attentional bias (and less attentional bias variability) to climate change causes and consequences predicted less behavioural engagement, potentially indicating behavioural avoidance. The relationship between eco-anxiety and pro-environmental behaviours was moderated by attentional bias variability, not attentional bias, to both climate change causes and consequences, and mitigation strategies. That is, eco-anxiety predicted engagement in greater pro-environmental behaviour, but only when attentional bias variability to climate information was low.

Eco-anxiety was found to predict greater engagement in pro-environmental behaviours over the subsequent week, indicating that individuals who experience more eco-anxiety tend to engage in more pro-environmental behaviours. Prior research in this area has produced inconsistent results, with some studies suggesting that eco-anxiety and habitual worrying about climate change can be adaptive and support engagement in mitigation strategies (Gao et al., 2020; Verplanken et al., 2020; Verplanken & Roy, 2013). And yet, other studies have found no relationship, or a negative relationship between eco-anxiety and pro-environmental behaviours (Clayton & Karazsia, 2020; Stanley et al., 2021). The present study supports the line of research suggesting eco-anxiety is an adaptive response to climate change, and contributes ecologically sound evidence, to this nascent field.

The present study distinguished between attentional bias toward images of mitigation strategies, and the causes and consequences, of climate change to examine whether attention toward such images moderated the relationship between eco-anxiety and subsequent engagement in pro-environmental behaviours. Previous research found that an attentional bias towards climate-related stimuli was associated with climate-related concern (Whitman et al., 2018) and pro-environmental tendencies (Carlson et al., 2019; Meis-Harris et al., 2021), although another study found an inverse relationship between this attentional bias and pro-environmental disposition (Carlson et al., 2020). The present study found that attentional bias to climate change causes and consequences predicted engagement in pro-environmental behaviour, but in the opposite direction to expected. That is, consistent with Carlson et al. (2020), greater attentional bias to climate causes and consequences predicted *less* engagement in pro-environmental behaviour. These findings suggest that those who focus more on negative climate change information are less likely to engage in pro-environmental behaviour. Although not tested, engaging with negative climate change-related information may lead to a climatic nihilism which interferes with pro-environmental behaviour. This is consistent with health research, where models such as the protection motivation theory emphasise that negative messaging can backfire, unless accompanied by adequate self-efficacy (Maddux & Rogers, 1983). Given the paucity of research on eco-anxiety, further investigation of possible explanations of this pattern could draw on theories and models from both health and clinical psychology.

We found no role of attentional bias to mitigation strategies in predicting pro-environmental behaviour. Previous research has found that viewing images of climate change impacts leads to greater behavioural change intentions than viewing images of climate change solutions (Chapman et al., 2016). Whilst this previous study did not test attentional bias, and the direction of results oppose the present findings, it does appear that attentional bias to climate change-related causes and consequences is mechanistically important in the engagement of pro-environmental behaviour, whilst attentional bias to climate change solutions appears less important, at least in our sample of young adults.

Contrary to our predictions, we did not find that the relationship between eco-anxiety and pro-environmental behaviour was moderated by the traditional attentional bias index. This differs from the pattern of findings in Notebaert et al.'s (2016) study, where an attentional bias to threat moderated the relationship between trait anxiety and bushfire preparedness. There are several potential explanations for why the current study did not find the predicted moderation effects. On average, participants in this study reported mild eco-anxiety, and it could be that a low level of eco-anxiety is adaptive regardless of where one's attention is directed. Given that climate change is a genuine threat, and that normal and pathological anxiety can be distinguished by response magnitude (Beck & Clark, 1997; Yerkes & Dodson, 1908), then a small amount of eco-anxiety might be necessary to motivate climate action. However, if an individual were to experience greater levels of eco-anxiety it may become a pathological form of anxiety and thus impair behavioural responses (Clayton & Karazsia, 2020), which may be more susceptible to moderation by other constructs such as attentional bias. That is, the relationship between eco-anxiety and pro-environmental behaviours may be non-linear, requiring further investigation of the 'optimal' level of eco-anxiety (phrased as the 'goldilocks zone by other researchers; Heeren & Asmundson, 2023) that promotes behavioural engagement. Future research should examine whether the relationship between eco-anxiety and pro-environmental behaviours depends on attentional bias when eco-anxiety is at severe or clinically significant levels.

We did however find that attentional bias variability moderated the relationship between eco-anxiety and pro-environmental behaviours, and the pattern was the same for climate change-related causes and consequences, and climate mitigation strategies. That is, when attentional bias variability was low, greater eco-anxiety predicted greater engagement in pro-environmental behaviour. In contrast, for those with heightened attentional bias variability, there was no association

between eco-anxiety and pro-environmental behaviour. For those who are unable to maintain a consistent attentional pattern, or who show dysregulation in their attention when engaging with climate change information, anxiety does not appear to prompt behaviour. As such, attentional bias variability may serve as an indicator of who is able to respond adaptively to act in response to eco-anxiety. This represents an important contribution, as the first study to assess attentional bias variability as it relates to eco-anxiety and pro-environmental behaviour. The only other study to assess attentional bias variability in the climate change context (Carlson et al., 2023) only measured its association with pro-environmental disposition, albeit with null findings. Taken together, our findings suggest that attentional bias variability, but not attentional bias, may play a role in the relationship between eco-anxiety and pro-environmental behaviours.

It is worth noting that the attentional bias indices in our present study had low reliability, a concern that has been raised regarding the dot-probe attentional bias index more broadly (McNally, 2019; Price et al., 2015; Schmukle, 2005; MacLeod et al., 2019). In contrast, attentional bias variability had good reliability, suggesting that alternative TLBS indices may be more reliable than the traditional attentional bias index, albeit measuring a different aspect of attention. And yet, attentional bias variability measures also have limitations (Kruijt et al., 2016) such as confounding response time variability with attentional bias variability. Similar concerns have been raised in the only study to date to assess attentional bias variability in the climate change context (Carlson et al., 2023). Measuring and controlling for response time variability through the inclusion of a neutral trial block would therefore help to ensure that the present pattern of results can be attributed to attentional bias variability rather than response time variability.

This study utilised an undergraduate sample, restricting the generalizability of the findings. However, since climate change concerns and eco-anxiety are highly prevalent amongst young adults (ReachOut, 2019; Searle & Gow, 2010), we explicitly wanted to target this demographic, rendering the sample appropriate for the study. Whilst the present study used a prospective design, the causal relationship between eco-anxiety and pro-environmental behaviour was not tested. Experimental manipulations of eco-anxiety are needed to confirm the causal direction between these constructs. Finally, the diary questions used to measure pro-environmental behaviours in this study did not assess participants' motivation for engaging in these behaviours, nor the relativity that is involved in the choice to engage in certain behaviours. Participants may have performed some behaviours for reasons other than mitigating climate change. Therefore, further experimental research that manipulates attention and eco-anxiety and observes the effects on pro-environmental behaviours is needed to disentangle the direct relationship between these variables.

Nonetheless, the present study had many methodological strengths. It was the first to assess the relationship between eco-anxiety, attentional bias, attentional bias variability, and pro-environmental behaviour. The assessment of attentional bias was rigorous, with a high level of accuracy in detecting the visual probes, indicating that participants were adequately engaging with the task. The images in the task were subjected to two forms of stimuli validation, as they were developed based upon the ratings of a group of independent raters, and then rated individually by each participant. Therefore, we can conclude that neither image ambiguity nor idiosyncratic interpretations of the stimuli unduly influenced the results of the present study. We also used a recently validated measure of eco-anxiety (HEAS-13, Hogg et al., 2021), which unlike other measures of eco-anxiety, does not conflate anxiety with behavioural responses and belief in climate change. Moreover, in previous research behaviour has tended to be measured through a proxy such as intentions, or using retrospective self-report, which is prone to error (Gifford, 2014; Lange & Dewitte, 2019). Instead, the present study employed a daily experience sampling approach which is a more accurate and reliable measure of behaviour (Lange & Dewitte, 2019; Shiffman et al., 2008).

The current results can inform clinical practice in acknowledging the existence of eco-anxiety in young adults. However future research is still needed to establish the most optimal ways to deal with this distress. The present study found that eco-anxiety shared a positive relationship with depression and general anxiety. This indicates that people struggling with anxiety generally may also experience eco-anxiety and perhaps strategies used to target other anxiety disorders could serve in eco-anxiety interventions. However, given that common clinical interventions for anxiety involve cognitive reappraisal of anxiety-provoking objects as less threatening, this may not be appropriate given the genuine threat of climate change. Therefore, future research should investigate the most optimal strategies and clinical interventions to help individuals cope with specific climate-related distress and eco-anxiety in a way that does not discount the threat, but instead channels the experience of anxiety into practical and adaptive action. Given that attentional bias variability may be underpinned by poor attentional control (Clarke et al., 2020), attentional control training could help to reduce attentional bias variability, thus enabling individuals to act positively in response to eco-anxiety. Further research could also look more broadly at other adaptive climate change behaviours, beyond engagement in daily pro-environmental behaviours, potentially examining longer-term mitigation behaviours (such as housing and lifestyle choices), engagement in social and political action, community engagement and environmental education, and enhancing connection to nature and the environment.

5. Conclusion

This research was the first known investigation into the potential role of attentional bias in the relationship between eco-anxiety and pro-environmental behaviours. Taken together, our findings suggest that the experience of eco-anxiety in young adults predicts an adaptive behavioural response to climate change particularly when there is low attention dysregulation. This has significant implications for the current understanding of eco-anxiety amongst young adults and its adaptive potential in addressing the issue of climate change. This is not to discount the societal response and more systemic, policy-driven changes needed to address the climate crisis (Mah et al., 2020). However, if greater eco-anxiety is predictive of individual pro-environmental behaviours, then we appear to be faced with a double-edged sword. Whilst eco-anxiety is predictive of pro-environmental behaviours that are helpful for climate change mitigation, it is crucial that the experience of eco-anxiety is manageable and does not develop into a pathological form of anxiety that interferes with an individual's ability to function.

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.

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