# A Psychometric Evaluation of the Climate Change Anxiety Scale

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Clayton and Karazsia (2020) developed the Climate Change Anxiety Scale (CCAS) to measure anxiety associated with perceptions of climate change. The purpose of this study was to evaluate the psychometric properties of the CCAS with a conceptual replication of Clayton and Karazsia's study 2. This study had preregistered inferential criteria and used a sample of 401 Australian and New Zealand residents. The results showed some support for the construct validity of the scale, with weak-moderate positive correlations between CCAS scores and ecocentrism ($r$ = .14) generalised anxiety ($r$ = .37), non-specific distress ($r$ = .36) and concern about climate change ($r$ = .36), and a weak negative correlation with climate change denial ($r$ = -.13). Confirmatory factor analyses indicated that the two-factor model specified by Clayton and Karazsia had reasonable global fit, but neither a one- nor two- factor model met the preregistered criteria for a good fit. Reliability estimates indicated that the CCAS had good to excellent internal consistency ($\alpha$ = .90; $\omega t$ = .91) and good test-retest reliability ($r$ = .87). Suggestions for improvement are provided.

**Key words:** Climate Change Anxiety, Eco-Anxiety, Scale, Validation, Evaluation.

## INTRODUCTION

Anthropogenic climate change refers to rapid and observable global atmospheric changes and ecological degradation that can be attributed, either directly or indirectly, to human activity (IPCC, 2012). It is now commonly accepted that anthropogenic climate change is happening, and could lead to total ecological collapse (IPCC, 2018).

Psychological organisations from countries around the world, including the American Psychological Association (APA; Swim et al., 2010), the Australian Psychological Society (APS; 2019) and the New Zealand Psychological Society (NZPsS; 2018) have declared that anthropogenic climate change is an issue to be addressed by the psychology field. The potential mental health impacts are diverse (see Hayes et al., 2018) and can occur via various pathways (Berry et al., 2010). Some examples of how climate change may affect mental health include more frequent or intense extreme weather events and fires causing incidents of post-traumatic stress disorder, negative agricultural and economic events impacting human wellbeing (Palinkas & Wong, 2020), and increasing temperatures precipitating increases in civil conflict (Hsiang et al., 2011), self-harm (Williams et al., 2015a), and suicide (Williams et al., 2015b).

### *Defining Climate Change Anxiety*

Another potential impact of note is the phenomenon of *climate change anxiety*—"anxiety associated with perceptions about climate change" (Clayton, 2020, p. 2). Climate change anxiety is distinctive from some of the other mental health impacts discussed above in that *consciousness* of climate change is both necessary and sufficient for climate change anxiety to occur. Consequently, a person may experience climate change anxiety even if their health or livelihood has not yet been directly negatively affected by climate change.

Climate change anxiety is related to, but distinct from the broader concept of *eco-anxiety*, which pertains to anxiety about environmental or ecological crises (see Clayton et al., 2017; Ingle & Mikulewicz, 2020). While these terms are often used interchangeably, climate change anxiety is best regarded as distinct due to its specific focus on climate change (see Pihkala, 2020).

For the same reason, climate change anxiety can be considered as conceptually related to, but distinct from, ecological grief (Cunsolo & Ellis, 2018), solastalgia (Albrecht 2005), and habitual ecological worrying (Verplanken & Roy, 2013).

### *Climate Change Anxiety in the Research*

In the last few years there has been a proliferation of media articles and opinion pieces about climate change anxiety and its associated mental health impacts (e.g. Daalder, 2019; Kuipers, 2019; Marks, 2019). National surveys are beginning to detect the emotional toll of climate change on a large scale. In the APA's (2018) "Stress in America" survey, 51% of participants listed climate change as a "somewhat or significant source of stress". A landmark study with 10,000 young people aged between 16 and 25 across 10 different countries found that 84% of young people are at least moderately worried about climate change while 42% report experiencing negative effects in their daily lives as a result of this worry.

The very real threat presented by climate change means that anxiety about it is neither unwarranted nor inappropriate (Clayton, 2020; Hayes et al., 2018; Pihkala, 2020). However, climate change anxiety may nevertheless be an important focus for psychological research. Some people experience climate change anxiety of sufficient severity to cause genuine functional impairment, prompting individuals to seek mental health care (Clayton, 2020; Hayes et al., 2018; Pihkala, 2020). While it is generally accepted by mental health practitioners that some clients are displaying anxiety associated with climate change, there is little consensus in the literature about how (or *whether*) it should be treated therapeutically

(see Clayton & Manning, 2018; Hayes et al., 2018; Verplanken & Roy, 2013). These questions require empirical research to resolve. In addition, while it has been hypothesised that climate change anxiety can be adaptive, there remains considerable uncertainty about when (and how strongly) climate change anxiety affects sustainable behaviour. Such uncertainty again requires empirical research to address.

### *The Climate Change Anxiety Scale*

If researchers are to determine the features and consequences of climate change anxiety, it is essential to identify a valid and reliable measure of climate change anxiety. A measure of climate change anxiety was recently proposed by Clayton and Karazsia in 2020). The Climate Change Anxiety Scale (CCAS; Clayton & Karazsia, 2020) is a 13-item scale that consists of self-report items such as "Thinking about climate change makes it difficult for me to concentrate", and "My concerns about climate change undermine my ability to work to my potential" which are responded to on a 5-point frequency rating scale (1 = *Never* to 5 = *Almost always*).

Clayton and Karazsia conducted both exploratory (Study 1) and confirmatory (Study 2) factor analyses of their scale. They included a set of items intended to measure personal experiences of climate change and sustainable behaviour in their questionnaire and factor analysis. Clayton and Karazsia did not regard these items as forming part of their climate change anxiety scale.

Their factor analyses produced four factors. Two of these were "behavioural engagement" and "personal experiences of climate change", being primarily made up of the items intended to measure these constructs and not representing climate change anxiety per se. The climate change anxiety items loaded on just two factors: Cognitive-emotional impairment (items 1 to 8 in their final 13-item scale), and functional impairment (items 9 to 13). Reliability was measured using Cronbach's alpha and was >.80 for all factors.

Clayton and Karazsia found that scores on both emotional-cognitive impairment and functional impairment correlated positively with environmental identity, negative emotionality and anxiety and depression. They interpreted these correlations as pertaining to concurrent and discriminant validity. However, hypotheses were not stated (or preregistered) for the direction of relationships, so it is difficult to interpret them as constituting a severe test of the validity of the scale.

### *The Present Study*

Clayton and Karazsia (2020) made a significant contribution to psychology in developing the CCAS. Replicating and extending their findings is crucial to improve the credibility of the scale, particularly with psychology's "replication crisis" in mind (see Tackett et al., 2019). Replication is a cornerstone of open science and research transparency, along with preregistration of hypotheses as a best practice recommendation for reproducible science (Tackett et al., 2019). Preregistration can provide readers with greater confidence that a claim or hypothesis has been tested *severely*—i.e., via a method that carried genuine risk of the claim being falsified (see Lakens, 2019). It is a practice of significant potential value in psychometric validation research, where meta-psychological work has suggested that evidence of the invalidity of scales may often end up inadvertently hidden (Hussey & Hughes, 2018). Clayton and Karazsia's analyses were not preregistered, warranting a study of this nature. Additionally, Clayton and Karazsia exclusively recruited participants from the United States, so use of their scale in Australia and New zealand requires testing and validation with local participants.

In this study, we conducted a preregistered conceptual replication of Clayton and Karazsia's (2020) study with participants from Australia and New Zealand. A conceptual replication was chosen over a direct replication to facilitate the testing of falsifiable hypotheses with clear theoretical explanations for how these relate to the validity and reliability of the scale, rather than focusing on literally repeating the procedures used by Clayton and Karazsia. This study and the hypotheses were preregistered with the Open Science Framework (OSF; https://osf.io/zy5bm/).

While Clayton and Karaszia (2020) did validity checks using the subscale scores, we created a total score by averaging participants' responses across the thirteen climate change anxiety items. This allowed us to assess how and whether the CCAS performed as a complete scale, which was important since we expected that future researchers might find it preferable and more parsimonious to use a single scale score rather than subscale scores in applied work with the scale. It also allowed us to produce a parsimonious analysis plan and inferential criteria in our preregistration. We have nevertheless provided supplementary analyses in which we use subscale scores for emotional-cognitive impairment and functional impairment.

In line with the objective of a conceptual replication, we used different measures to assess concurrent and discriminant validity than those used by Clayton and Karazsia. The rationale for these choices are demonstrated in the hypotheses below.

#### *Hypotheses.*

1. The CCAS will be positively correlated with psychological distress, measured by the Kessler Distress scale (K10; Kessler et al., 2002). This was used instead of the PHQ-4 (Kroenke et al., 2009) used by Clayton and Karazsia (2020), which contains four items specifically pertaining to depression and anxiety. While both the K10 and the PHQ-4 are widely used to screen for depression and anxiety, the K10 can measure non-specific distress as well as predict the presence of other disorders such as post-traumatic stress disorder (PTSD; Mughal et al., 2020). This was included with the intention of detecting elevated distress not specific to depression and anxiety.
2. The CCAS will be positively correlated with the new environmental paradigm endorsement ("ecocentrism"), measured by the New Ecological Paradigm Scale (NEP; Dunlap et al., 2000). The NEP has been subjected to rigorous psychometric evaluation and undergone three revisions since 1978 (Dunlap, 2010). The NEP has items which measure both eco-centric attitudes and anthropocentric attitudes. This was used instead of the Environmental Identity Scale (Clayton, 2003) which

only contains pro-environmental items and has not had the same uptake in the literature.
3. The CCAS will be negatively correlated with climate change denial, measured by the total scores on a recently consolidated measure of climate change denial (CCD; Loram et al., 2019). This provided us with a measure of discriminant validity.
4. The CCAS will be positively correlated with generalised anxiety disorder, measured with the common screening tool GAD-7 (Spitzer et al., 2006). As well as detecting a relationship between general distress and climate change anxiety, we wanted to determine whether there was a notable relationship between clinically significant anxiety and climate change anxiety.
5. The CCAS will be positively correlated with concern about climate change, measured with a single item from the New Zealand Attitudes and Values Survey which asks participants to agree or disagree with the statement "I am deeply concerned about climate change" (NZAVS; Sibley, 2020). While concern about climate change and climate change anxiety are not identical constructs, it is reasonable to hypothesise that—if the CCAS is a valid measure of climate change anxiety—it will be positively correlated with concern about climate change.
6. The CCAS will fit a two-factor model. In Clayton and Karazsia's analyses, items 1-8 loaded onto a cognitive-emotional impairment factor and items 9-13 loaded onto a functional impairment factor. This model was assessed for goodness of fit to establish factorial validity of the scale.
7. The CCAS will fit a one-factor model. This hypothesis was specified as a competing hypothesis to H6. We specified this hypothesis for two reasons. First, Clayton and Karazsia seemingly intended their scale to be a measure of climate change anxiety as an overarching construct. Second, support for a single factor would lend support to future researchers who might prefer to calculate a single score for the scale for use in applied analyses (whereas use of subscale scores necessarily adds complexity to analyses). Third, there is a well-established positive relationship between number of items and reliability (Spearman, 1910; Brown, 1910), meaning that total scales (if psychometrically justifiable) would have higher reliability than subscale scores.

## METHOD

### *Design*

This was an observational (non-experimental) cross-sectional survey design conducted through Prolific (Palan & Schitter, 2018). A follow-up study was done 6 weeks later to investigate test-retest reliability. The follow-up was not included in the hypotheses as it was planned only after preregistration and completion of the first study.

### *Participants*

The final sample had 401 participants. Three-hundred and thirty-three were from Australia (83%) and 68 were from New Zealand (17%). Two-hundred and twenty-seven were male (56.5%), 168 were female (41.9%), 5 self-described as non-binary (1.2%) and one preferred not to say. Ages ranged from 18 to 74 with the majority (56.1%) under 44. One-hundred and twenty-five had high-school education or less (31%) and the remainder were university educated.

### *Materials*

**The Climate Change Anxiety Scale (CCAS).** This scale is purported to measure climate change anxiety with 13 items, each using a 5-point frequency rating scale from 1 = Never to 5 = Almost always (Clayton & Karazsia, 2020). Items 1 to 8 relate to cognitive-emotional impairment e.g., "Thinking about climate change makes it difficult for me to concentrate." while items 9 to 13 relate to functional impairment e.g., "My concerns about climate change interfere with my ability to get work or school assignments done." We created both a total score on the scale for each participant by taking the mean of their responses to the 13 items (CCAS-total) as well as subscale scores for cognitive emotional and functional impairment.

**The Climate Change Denial Scale (CCD-7).** The consolidated CCD (Loram et al., 2019) has 7 items, each using a 5-point Likert agreement format from 1 = Strongly disagree to 5 = Strongly agree. Item 5 'Do you think global warming should be a high priority for the government?' was changed to 'Climate change should be a high priority for the government' to keep with the Likert agreement format and wording of the rest of the questions.

**The New Ecological Paradigm Scale (NEP-16).** The revised NEP (Dunlap et al., 2000) has 16 items, each using the same 5-point Likert agreement format as the CCD. This scale measures ecocentric attitudes, e.g., "We are approaching the limit of the number of people the Earth can support" and anthropocentric attitudes, e.g., "Humans have the right to modify the natural environment to suit their needs." We reverse-coded the anthropocentric items and then took the mean of each participants' responses to the 16 items to create an overall score for ecocentrism.

The Kessler Distress Scale (K-10). This measure of psychological distress has 10 items, each using a frequency rating scale from 1 = none of the time to 5 = all of the time (Kessler et al., 2002). Participants are asked to think about their experience in the past four weeks, e.g., "In the past 4 weeks, about how often did you feel tired out for no good reason?".

**The Generalised Anxiety Disorder (GAD-7).** The 7-item GAD-7 measures generalised anxiety on a 4-point frequency rating scale from 0 = Not at all to 3 = Nearly every day (Spitzer et al., 2006). Participants are asked how often they've been bothered by the problem described by each item in the past 2 weeks, e.g. "Not being able to stop or control worrying".

**The NZAVS climate concern item (NZAVS).** The single item from the NZAVS, "I am deeply concerned about climate change" is measured on a 7-point agreement format from 1 = Strongly disagree to 7 = Strongly agree.

### *Procedure*

Study 1 participants were recruited from Prolific. They had to be aged 18 years or over and currently living in Australia or New Zealand, which were specified in the pre-screening criteria. This meant the sample was drawn from a different population than Clayton and Karazsia (2020), who used a sample from the United States through Amazon's Mechanical Turk. The intention of this was to test the scale on a different demographic to contribute to

the assessment of external validity. A stopping rule determined that data collection would cease when 400 responses were returned. This is approximately twice the sample size used by Clayton and Karazsia (2020) and just over the recommended sample size from a power analysis conducted in G*Power before pre-registering the study (for 80% power, an N of 348 would be required to detect a correlation of .15 or higher if the alpha = .05; see supplementary materials on OSF project page). This also exceeded the recommended sample size for a simple CFA model which is around N = 150 (Muthén & Muthén, 2002) or 20 participants for each parameter (scale item) in the model (Kline, 2015), which would have been 260 for the two-factor model of the 13-item CCAS. The final dataset had 404 responses, which was due to a feature in Prolific which does not count some responses toward the final tally when they do not enter completion codes. Once the remaining exclusion criteria were applied, the final sample was 401.

### Exclusion criteria

Five exclusion criteria were applied. Only participants who answered "Yes" to the study consent question were permitted to participate. Prolific only advertised this study to those who had specified that they were 18 years or over who currently lived in Australia or New Zealand (as per pre-screening criteria). If a participant indicated that they did not meet these demographic criteria in response to the demographic questions early in the survey, they were directed out of the survey and their response discarded. The data was checked in SPSS for any participants who responded to less than 75% of the questions (8 items) but none were found.

As a quality check, an attention check was included at the end of the CCAS that read: "Please indicate that you are paying attention by ticking Often". Participants who gave any other response were excluded during data processing (three total). Seven participants provided an unrecognisable Prolific ID (i.e., they were unable to be matched with an ID in Prolific). However these were retained as it was plausible that they were genuine participants who entered incorrect information. Duplicate participants were checked in SPSS and none were detected. The quality of the Prolific process also meant there was only one missing data point. Missing data was handled by pairwise deletion in the correlation analyses and full information maximum likelihood in the CFAs.

### Data analysis and inferential criteria

Most statistical analyses were performed in jamovi, an interface for R (The jamovi project, 2020), with some analyses in SPSS. All raw data and output can be retrieved from the OSF project page (link in introduction). Concurrent and discriminant validity were assessed with Pearson's correlation coefficient (two-tailed). Reliability was assessed with Cronbach's alpha α (1951) and McDonald's (1999) omega total, ωt. Cronbach's α is an estimate of reliability based on the essentially tau-equivalent measurement model, which assumes that the factor loadings for all items are identical. Congeneric estimates like MacDonald's omega, on the other hand, can estimate reliability when the assumptions of essential tau-equivalence are violated (Graham, 2006; Peters, 2014). The congeneric model assumes that each item measures the same latent construct but with potentially different factor loadings and amounts of error (Raykov, 1997).

Factorial validity was assessed with CFA, comparing one and two-factor models via multiple fit indices. In addition to the three global fit statistics reported by Clayton and Karazsia (2020), the Standardised Root Mean Square Residual (SRMR) and the Bayesian Information Criterion (BIC) were reported. The preregistered criteria included the following thresholds (in parentheses) for the fit indices based on recommendations by Hu & Bentler (1999): Root Mean Square Error of Approximation (RMSEA < 0.06), SRMR (< 0.09), Tucker Lewis Index (TLI > .95), and Comparative Fit Index (CFI > .95). The confidence interval for the RMSEA and the Chi-squared test statistic are also reported, accompanied by a p-value with an alpha level of .05. The preregistered inferential criteria required that all the indices would be met in order for the model to fit. If none of the indices were met, the model would be rejected. If some indices were met, but not others, the model would be considered ambiguous. If both models met all the indices, the one with the lower Bayesian Information Criterion (BIC) would be considered the better fit for the data.

## RESULTS

### Descriptive statistics

Table 1 shows the mean scale score, standard deviation and range of scores for each individual scale. Most notably, only 7 participants (2%) scored above the midpoint (3) on the CCAS. For descriptive statistics pertaining to the individual items of the CCAS, please see the supplementary materials at the link in the introduction.

### Hypotheses 1-5

Pearson's correlations between each scale are presented in Table 2. A strong positive relationship was found between the CCAS and the NZAVS climate change concern item ($r$ = .36, 95% CI [.27, .44], $p$ < .001) and weak-moderate positive relationships were found between the CCAS and the K10 ($r$ = .36, 95% CI [.27, .45], $p$ < .01) and GAD7 ($r$ = .37, 95% CI [.28, .45], $p$ < .001) along with a very weak positive relationship with the NEP ($r$ = .14, 95% CI [.02, .21], $p$ = .022). A very weak negative correlation was found between the CCAS and CCD ($r$ = -.13, 95% CI, [-.22, -.02]), $p$ = .012). These correlations

**Table 1.** Descriptive Statistics of Scale Scores

| Scale | *M* | Range | *SD* |
|---|---|---|---|
| CCAS | 1.47 | 1.00-4.85 | 0.54 |
| CCD | 1.78 | 1.00-5.00 | 0.87 |
| NEP | 3.32 | 1.40-5.00 | 0.57 |
| K10 | 2.04 | 1.00-4.60 | 0.75 |
| GAD7 | 1.83 | 1.00-4.00 | 0.67 |
| NZAVS | 5.31 | 1.00-7.00 | 1.58 |

*Note:* The NZAVS item was measured on a 1-7 scale while the rest of the scale items were measured on scales of 1-5.

**Table 2.** Correlations between Scales and Subscales

| | Cog-emo impairment | Functional impairment | CCAS | K10 | NEP | CCD | GAD7 | NZAVS |
|---|---|---|---|---|---|---|---|---|
| Cog-emo impairment | — | | | | | | | |
| Functional impairment | .77** | — | | | | | | |
| CCAS | .96** | .91** | — | | | | | |
| K10 | .36** | .31** | .36** | — | | | | |
| NEP | .09 | .13* | .11* | .16* | — | | | |
| CCD | -.11* | -.13* | -.13* | -.14* | -.67** | — | | |
| GAD7 | .35** | .33** | .37** | .83** | .14* | -.11* | — | |
| NZAVS | .33** | .34** | .36** | .21** | .60** | -.75** | .19** | — |

*Note:* *significant at the $p < .05$ level, **significant at the $p < .001$ level.

13, 95% CI, [-.22, -.02]), $p = .012$). These correlations were all significant and in the predicted direction, indicating that hypotheses 1-5 are supported.

Although our preregistered hypotheses pertained to total scores on the CCAS, it is also possible to examine the degree to which the results accord hypotheses 1 to 5 when the cognitive-emotional impairment and functional impairment subscales were scored separately (as displayed in Table 2). Both subscales were significantly positively correlated with the K-10 (H1), the GAD-7 (H4), and the NZAVS item (H5), and significantly negatively correlated with the CCD (H3). However, only the functional impairment subscale was significantly positively correlated with the NEP (H2). As such, hypotheses 1, 3, 4 and 5 were also supported when using subscale scores for the CCAS, and hypothesis 2 was partially supported.

### *Hypotheses 6-7*

The four indices of global fit for each CFA model are presented in Table 3. Both models met the preregistered inferential criteria of the Standardised Root Mean Square of the Residual (SRMR < 0.09). The two-factor model also met the criteria for the Comparative Fit Index (CFI > 0.95) and the Tucker Lewis Index was only just below the recommended cut-off (TLI > 0.95). Path diagrams with estimates for the measurement models are presented in Figures 1 and 2.

**Table 3.** Global Fit Statistics for the One- and Two-Factor Models of the CCAS

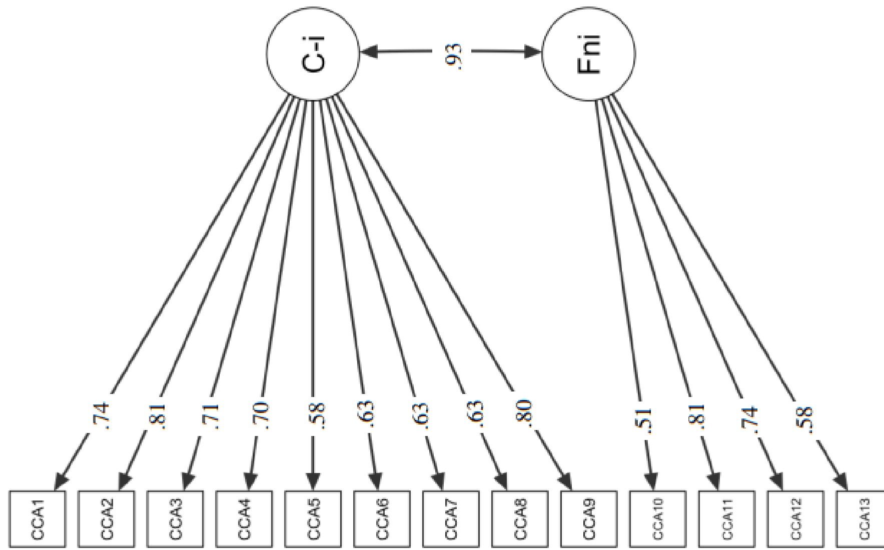
| | CFI | TLI | SRMR | RMSEA [90% CI] | BIC |
|---|---|---|---|---|---|
| Criteria | >0.95 | >0.95 | <0.09 | <0.06 | Lower BIC preferred |
| one-factor model | 0.93 | 0.91 | 0.04 | 0.08 [0.07,0.09] | 10137 |
| two-factor model | 0.95 | 0.94 | 0.04 | 0.06 [0.06,0.08] | 10096 |

**Table 4.** Reliability Coefficients for Each Scale and Subscale

| Scale | α | $\omega_t$ |
|---|---|---|
| CCAS total scale | .89 | .90 |
| CCAS cognitive-emotional impairment subscale | .87 | .87 |
| CCAS functional impairment subscale | .78 | .82 |
| CCD | .91 | .92 |
| NEP | .84 | .85 |
| K10 | .91 | .92 |
| GAD7 | .91 | .91 |

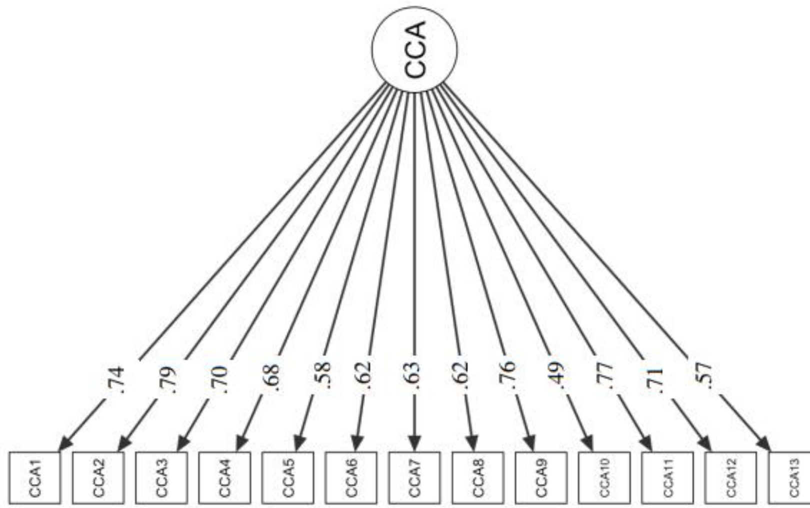
*Note:* The NZAVS is not included because it is a single item.

**Figure 1.** Two-Factor Model Including Standardised Path Estimates




*Note:* C-I = cognitive impairment; Fni = functional impairment. Error variances excluded for brevity.

**Figure 2.** One-Factor Model Including Standardised Path Estimates




*Note.* Error variances excluded for brevity.

We also compared the fit of the two models using the Bayesian Information Criterion (BIC), which includes a penalty for model complexity. This comparison favoured the two-factor model, $BIC_{diff} = 41$, which includes a penalty for model complexity. A chi-square difference test likewise confirmed that the two-factor model demonstrated better fit, $c^2_{diff}(1) = 47$, $p < .001$.

In both the one- and two-factor models, all items had significant positive loadings on their intended factors. The item with the lowest loadings was item 10, "I have problems balancing my concerns about sustainability with the needs of my family". However, even this item had loadings well over 0.4 in both models.

### *Reliability analyses*

Cronbach's α and McDonald's $\omega_t$ were calculated to assess the reliability of each scale (Table 4). The CCAS total scale had good to excellent reliability with an α of .89 and an $\omega_t$ of .90. The CCAS subscales demonstrated slightly lower reliability: α of .87 and $\omega_t$ of .87 for the cognitive-emotional impairment subscale, and α of .78 and $\omega_t$ of .82 for the functional impairment subscale.

The internal consistency for the remaining scales (CCD, K-10, GAD-7, NEP) was also good to excellent according to George and Mallery's (2003) tiered approach to interpreting the α ("≥ .9 – Excellent, ≥ .8 – Good, ≥ .7 – Acceptable, ≥ .6 – Questionable, ≥ .5 – Poor, and ≤ .5 – Unacceptable"; p. 231).

### *Test-retest results*

A test-retest analysis was conducted on a sample of 115 of the original participants, which was more than three times the suggested sample size from a power analysis conducted in G*Power (see extra materials on OSF project page). The test-retest reliability coefficient was found by calculating Pearson's *r* between the CCAS scores at time 1 and time 2 ($r = .87$, 95% CI [.82, .91], $p < .001$). This indicates that the scale has good test-retest reliability according to Cohen's (1988) conventions for interpreting the correlation coefficient. Average scores on the CCAS were higher (with a mean difference of 0.9) the second time the participants took this test.

## DISCUSSION

This study aimed to evaluate the psychometric properties of the CCAS with a conceptual replication of Clayton & Karazsia's (2020) Study 2. The validity of the scale was assessed with concurrent and discriminant validity checks and two CFAs to assess the comparative fit of one- and two-factor models. Reliability was evaluated with Cronbach's α and McDonald's ωt and the test-retest reliability coefficient. Test-retest reliability was calculated in a follow-up study six weeks later. The hypotheses and inferential criteria for validity were preregistered.

### *Convergent and discriminant validity*

The five hypotheses for the direction of each correlation were supported, however, the coefficients were of a weak-moderate size according to Cohen's (1988) conventions. Climate change anxiety scale scores were most strongly correlated with general anxiety (GAD7), psychological distress (K10), and concern about climate change (NZAVS item). Climate change anxiety was less strongly correlated with ecocentrism (NEP) and climate change denial (CCD).

While we did not include preregistered criteria for the size of the relationships, there are some rules of thumb for interpreting the Pearson's r (e.g. Cohen, 1988). A correlation of < .3 is generally considered weak, but it is still a positive correlation. This meant our hypotheses were supported, but perhaps not to the degree that we would have expected. The strength of relationship should be determined in light of the theoretical implications and along with the confidence interval (Schober et al., 2018). Future research should include more explicit criteria in the preregistration for the strength of the relationships. This would give a stronger benchmark for assessing the validity of the scale, where particularly strong relationships between variables would be expected (e.g., climate change denial should be strongly uncorrelated with climate change anxiety).

The intention of including the NZAVS item was to estimate the relationship between concern about climate change and climate change anxiety. This item ("I am deeply concerned about climate change") is a very straightforward measure of concern, though not necessarily of distress or impairment. The relationship between the item and the CCAS was moderate according to Cohen's (1988) conventions (r = .36) suggesting that these measures are detecting something similar, but not strong enough to say they are interchangeable. Again, if we had preregistered the size of the coefficient that we wanted to see here, we could be more clear-cut in our interpretation.

### *Factorial validity*

Two factor structures were evaluated with CFA; a one-factor and a two-factor model (Figures 1 and 2). Four global fit statistics were preregistered with inferential criteria for good fit based on the thresholds recommended by Hu and Bentler (1999). Both models met the criteria for one statistic (SRMR) and the two-factor model met the criteria for the CFI and RMSEA. It was specified in the preregistration that all the indices had to meet their recommended thresholds. Thus, the hypotheses that the models would be a good fit for the data were not entirely supported, but the two-factor model was clearly a better fit for the data.

This has two main implications for future use of the scale. First, there is no strong basis for a particular mapping of items to subscale or scale scores—albeit that we did find a better fit for the two-factor (two subscale) model. Second, to the extent that factor analyses bear on validity as a whole, these findings do not support the validity of the scale. That said, from a validity perspective, the key question is whether the latent factors of interest do in fact have causal effects on item responses (see Borsboom et al. 2004), whereas factor analyses test whether the hypothesised latent variables fully account for all covariances between items. It is possible that responses to CCAS are causally affected by a latent variable of climate change anxiety (i.e., that the scale is valid in the Borsboom et al. [2004] sense) even if there are other contributors to the relationships between items (such as network effects between items [Christensen et al., 2020] or other third variables). As such, this negative finding for

the scale does not conclusively demonstrate that the scale is invalid.

### Reliability

Cronbach's α and McDonald's ωt were calculated to assess the reliability of each scale. The α and ωt of the CCAS were almost identical at just over .89, but histograms of each items' univariate distribution show they are non-normal (being right-skewed with most responses at the bottom of the scale), violating an assumption required for both reliability estimates (Peters, 2014). This said, simulations by Xiao and Hau (2022) suggest the magnitude of bias to Cronbach's α and McDonald's ωt caused by non-normality is reasonably small when using Likert data with at least 4 points. Nevertheless, this assumption violation means the reliability of the CCAS comes with some additional uncertainty attached.

The subscales had slightly slower α and ωt which is unsurprising given their shorter length. While almost all items contributed positively to reliability, item 10 ("I have problems balancing my concerns about sustainability with the needs of my family") contributed slightly negatively to reliability of the functional impairment scale, with α improving slightly to .81 if this item was excluded. However, this item also had the highest mean by some margin. It is possible that respondents agreed with this item not as a reflection of their functional impairment per se, but more as a justification for not doing more about climate change. The ambiguity of this item suggests it may need to be excluded or reworded in future iterations.

The test-retest reliability of the CCAS was relatively strong. Interestingly, the average scores on the CCAS were slightly higher the second time the participants took this test. This could have been due to any number of factors such as increased awareness of issues or more stress due to the pressures of COVID-19 during the second wave of lockdowns across Australia and New Zealand around the time of the test-retest study (September, 2020).

Finally, despite finding some evidence for the validity of the scale using the total scale score, it was not possible to establish norms, cut-offs or alternative ways of interpreting the individual scores as the data was non-normative and so few participants scored above the midpoint.

### Further limitations and future directions

A notable limitation of the present study is that it did not replicate Clayton and Karazsia's Study 2 exactly. This implies that any discrepancies in the present results could be due to procedural differences (Kunert, 2016). Additionally, as previously mentioned, there were no preregistered criteria for the strength of the relationships between the theoretically associated constructs for concurrent and discriminant validity, and this reduced confidence for supporting the hypotheses, despite finding the expected direction in each relationship.

Another notable limitation is in the sample characteristics. The final sample was predominantly male and Australian. Ethnicity was not asked but this information could have been important as climate change concern has been found to be higher in indigenous cultures such as Māori (Tassell-Matamua et al., 2020). Furthermore, males, who made up the majority of the sample, have been found to be less sensitive to climate change anxiety than women (and people of colour) along with those who endorse an anthropocentric worldview (McCright & Dunlap, 2011; Milfont et al., 2021). The mean climate change anxiety score in our sample was also quite low, with positive skew and only a very small number of participants scoring above the midpoint of the scale. As such, our findings with respect to reliability and validity may not generalise to populations with higher levels of climate change anxiety. Future research could investigate the reliability and validity of the scale in groups that may display higher levels of climate change anxiety (e.g., activists, younger samples).

Future research should look at either continuing to investigate the validity of the CCAS as it is, or trialling adapting or even dropping items that do not add value to the scale. One suggested practice in the development of scales is testing face and content validity through a small pilot and/or consulting with experts in the field in question (Boateng et al., 2013). Clayton and Karazsia (2020) do not indicate whether such consultation was conducted, however, some items have poor face validity in our opinion. In particular, items 5 – 8, which were based on the Ruminative Response scale (Treynor et al., 2003), do not seem well-adapted for the CCAS (CCA5: "I think, 'why can't I handle climate change better?'"; CCA6: "I go away by myself and think about why I feel this way about climate change"; CCA7; "I write down my thoughts about climate change and analyze them"; CCA8; "I think, 'why do I react to climate change this way?'"). It appears that these were added based on a theory that rumination is a key feature of climate change anxiety, but the items themselves are not reflective of the first author's own experience of climate change anxiety or her climate activist colleagues'. Consultation with experts and people who identify with having climate change anxiety might make for a more theoretically sound scale. In fact, Clayton has since been involved in a project that developed a survey using this approach (Hickman et al., 2021). More research could also be done to establish a theory of climate change anxiety to inform the development of a new scale. The authors of this paper will be using the data from Hickman et al. (2021) to develop such a theory using a network framework (Borsboom et al., 2021).

While Clayton and Karazsia (2020) specified that the CCAS was not intended to be diagnostic, a diagnostic measure that could be used by clinicians as well as researchers would be useful to aid the development and evaluation of clinical interventions for managing climate change anxiety. Interviews with clinicians about both what they are observing in their clients and what they would need from a measure would be a good way to inform the development of a clinically relevant scale.

### Relevance to Māori

This project addresses the relationship between Te Taiao (the environment) and hauora hinengaro (mental health). Climate change has been found to have a greater impact on the wellbeing of indigenous peoples who are often more connected to place than their colonial counterparts (Middleton et al., 2020). Taonga of great importance to Māori (e.g., freshwater resources, the beach

and ocean, bush and forests, economic interests and investments) are particularly threatened by climate change (King et al., 2010). Anxiety about climate change may therefore have a particularly important impact on Māori. This study did not empirically examine such ethnic differences, but it may be useful for future studies to specifically examine climate change anxiety among tangata whenua and other indigenous populations (including Aboriginal Australians; see also Petheram et al., 2010).

### *Conclusion*

Overall, our study found mixed evidence with respect to the validity and reliability of the scores produced by the CCAS. The concurrent and discriminant validity checks with related constructs were supported, but the relationships were not strong. The test-retest showed good reliability over a 6-week period and the Cronbach's α and McDonald's ωt were good to excellent. Neither the one-factor nor the two-factor model met all the preregistered thresholds for a "good fit", but the two-factor model as specified by Clayton and Karazsia was a better fit for the data. The results of the present study call for continued investigation of the validity, reliability and factor structure of the CCAS. More work may be required to improve the alidity of the current scale, or a fresh attempt based on a stronger theoretical framework may be called for, including to obtain clinical relevance. It would be desirable for future replications to have preregistered inferential criteria in the interest of both validating the scale and furthering the ongoing "credibility revolution" (Vazire, 2018) in psychological research.

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## SUPPLEMENTARY MATERIALS

**Supplementary Table 1.** Descriptive statistics for items in the Climate Change Anxiety Scale

| Abbrev. | Item | Mean | Median | SD | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| CCA1 | Thinking about climate change makes it difficult for me to concentrate. | 1.52 | 1.00 | 0.81 | 1.61 | 2.27 |
| CCA2 | Thinking about climate change makes it difficult for me to sleep. | 1.44 | 1.00 | 0.79 | 1.88 | 3.19 |
| CCA3 | I have nightmares about climate change. | 1.29 | 1.00 | 0.66 | 2.64 | 7.64 |
| CCA4 | I find myself crying because of climate change. | 1.23 | 1.00 | 0.60 | 2.93 | 9.23 |
| CCA5 | I think, “why can't I handle climate change better?” | 1.80 | 1.00 | 1.01 | 1.04 | 0.22 |
| CCA6 | I go away by myself and think about why I feel this way about climate change. | 1.54 | 1.00 | 0.86 | 1.48 | 1.44 |
| CCA7 | I write down my thoughts about climate change and analyze them. | 1.29 | 1.00 | 0.69 | 2.70 | 7.54 |
| CCA8 | I think, “why do I react to climate change this way?” | 1.57 | 1.00 | 0.85 | 1.41 | 1.35 |
| CCA9 | My concerns about climate change make it hard for me to have fun with my family or friends. | 1.36 | 1.00 | 0.68 | 2.06 | 4.29 |
| CCA10 | I have problems balancing my concerns about sustainability with the needs of my family. | 2.06 | 2.00 | 1.09 | 0.65 | -0.59 |
| CCA11 | My concerns about climate change interfere with my ability to get work or school assignments done. | 1.29 | 1.00 | 0.65 | 2.57 | 7.34 |
| CCA12 | My concerns about climate change undermine my ability to work to my potential. | 1.41 | 1.00 | 0.77 | 2.20 | 4.60 |
| CCA13 | My friends say I think about climate change too much. | 1.31 | 1.00 | 0.76 | 2.86 | 8.25 |

*Note.* N = 401