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Research article

# Psychometric properties of the Italian version of the climate change worry scale

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ABSTRACT

*Introduction:* Assessing the psychological impact of climate change is of crucial importance as it is widely recognized that human mental health is negatively affected by changing weather patterns. Worry about climate change is commonly used as a measure of risk perception, and includes concepts such as concern, perceived seriousness, and perceived risk. In order to better evaluate the levels of climate change worry, Alan E. Stewart developed the Climate Change Worry Scale (CCWS).
*Methods:* The aim of the present study was to validate Stewart's CCWS in Italy. To this purpose, CCWS was translated into Italian and its psychometric properties were tested on a sample of 130 Italian adults who were required to complete the CCWS, as well as other standards of measurement, such as the Depression Anxiety Stress Scales (DASS), Penn State Worry Questionnaire (PSWQ), New Ecological Paradigm (NEP), Pro-Environmental Behaviours Scale (PEBS) and Climate Change Anxiety Scale (CCAS). Patients were retested after three months. In this study, Stewart's original single-factor scale was used. Additionally, internal consistency, test-retest reliability, and discriminant validity were specifically analysed.
*Results:* Factor structure of CCWS was investigated, and a Confirmatory Factor Analysis (CFA) showed a good fit for the single-factor model. Climate Change Worry Scale items exhibited excellent internal consistency. Test-retest reliability at a three-month evaluation proved to be good. Climate change worry was associated with concern, climate change anxiety, pro-environmental behaviors and political orientation.
*Conclusions:* The Italian version of the Climate Change Worry Scale is a valid and reliable tool to assess climate change worry in the general population.


## 1. Introduction

Extreme weather events due to climate change are occurring all over the planet with serious direct and indirect consequences on the environment [1] and on mental [2,3,4] and general human health [5]. The American Psychological Association (APA) recognizes that climate change can lead to mental health issues such as an increase in the incidence of stress, depression, and anxiety [6]. Climate change, perceived as an aversive stimulus, may also enhance strongly negative emotional experiences [6,7].

Anxiety is activated whenever potential future events are perceived as threats. It determines a high degree of somatic activation which is useful for generating an adaptive response to the threatening stimuli [8]. Anxiety is usually associated with somatic alterations, autonomic arousal, and modification of cognitive processes, such as worry [8]. Worry is a common cognitive effect of climate change and is a common symptom of most of the emotional disorders associated with climate change, such as depression, anxiety, and post-traumatic stress disorder (PTSD) [6,9]. Worry is defined as "a chain of thoughts and images, negatively affect-laden and relatively uncontrollable." However it also can trigger an "attempt to engage in mental problem-solving on an issue whose outcome is uncertain", and healthy people can feel worried without experiencing associated anxiety or depression [10].

Worry can be classified in two ways: adaptive and maladaptive. Adaptive worry is defined as a functional cognitive process, as a chain of thoughts directed at solving a potential problem or threat, while maladaptive worry is when the process becomes excessive, persistent, and ineffective in solving the problem for which it has been activated [11,12]. Extreme levels of worry are associated with poorer mental and physical health [13].

Worry about climate change generally may be intended as an adaptive process, because it drives finding a strategy to act against the consequences of climate change, but whether climate change

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worry is adaptive depends on its intensity and if it activates excessive negative emotions [14]. Solutions for climate change are hard to develop and implement, and evidently, they are slow to be put into practice and their use is often hindered by political and economic interests. Due to the lack of implementation of large-scale climate change solutions, worry about climate change may therefore become chronic and maladaptive, thus leading to anxiety and/or depression [14]. It is important to note that climate change anxiety differs from general anxiety in that it is not defined as a mental disorder and is not included in DSM-V. Stewart's CCWS does not take into consideration Clayton's climate change anxiety scale (CCAS), which had not yet been developed when Stewart started his work on CCWS. In the absence of this specific measure, Stewart used DASS, the Fear of Weather Scale (FOWS) and the Storm Fear Questionnaire (SFQ) to validate his scale. In this study CCAS, a measure of anxiety specifically associated with climate change, was used alongside DASS, a general anxiety measure, to form our hypothesis. The concept of worry is also closely connected to the personal goals, preferences and behaviors of different individuals [14]. Moreover, personal feelings of worry about climate change are associated with higher levels of support for public actions on global warming [15]. It is well known that political orientation is highly predictive of climate change worry [16,17]. Several studies have confirmed this view and highlighted the necessity of promoting climate change mitigation and adaptation policies [18,19]. Bouman and colleagues [14] stated that "worry about climate change can play an important role in motivating individuals to support specific climate policies and to undertake personal behaviours to mitigate climate change." Therefore, worry about climate change is the preferred indicator if the goal is to understand the association between environmental emotions and behavior and/or policy support [20].

In light of these considerations, measuring worry is extremely useful in assessing the emotional response to climate change, which is why it is fundamental for this study to use a standard measure of Climate Change Worry. Alan E. Stewart [21] validated a specific self-report questionnaire for measuring worry related to climate change: the Climate Change Worry Scale (CCWS). Given the lack of an Italian validation of the CCWS, the aim of this study was, in addition to translating the scale into Italian, to verify the psychometric properties of the Italian version of the CCWS in a healthy sample of 130 individuals. Internal consistency, test-retest reliability, and discriminant validity were specifically addressed.

## 2. Materials and methods

### 2.1. Participants and procedure

#### 2.1.1. Italian adaptation of the CCWS

Two English native speakers independently translated the original English CCWS items into Italian and resolved any potential disagreements in discussion. Two Italian native speakers with proficient knowledge of English checked the translation. All items of the Italian version were then back-translated into English by two additional researchers who were not aware of the original scale. After the three stages of translations, corrections, and adjustments, the final wording of the Italian adaptation of the CCSW was determined.

In the translation of the scale, excessively complicated terms have been replaced by simpler syntax. No adaptations were made for specific Italian dialects because, although there are many different dialects in Italy, the Italian language is well understood by the majority of the population.

The questions of the original CCSW were clear and simple; therefore, minimal adjustments were made during translation. For example, with regard to question number seven, "I worry that I might not be able to cope with climate change", the correct translation of the verb "to cope" in Italian corresponds to an extremely specific term, which may not be understood by the general population. Therefore, the Italian verb meaning "to face" was used instead, in order to make the question easier for everyone to understand.

#### 2.1.2. Sample size

In his validation scale study, Stewart relied on a sample of 600 participants. We opted to follow Nunnally, who recommends an ideal ratio of ten respondents per scale item [22]. As a result, our *a priori* targeted sample size was at least 130 participants [23].

#### 2.1.3. Participants

Participants were recruited using convenience and snowball sampling methods, provided they met the following inclusion criteria: age between 18-80 years, Italian nationality, and Italian residency. The exclusion criteria included: illiteracy, inability to provide consent, or inability to complete the survey online. On the basis of the methodology adopted, a set of 45 participants was initially selected to reduce selection bias associated with the non-probabilistic sampling method. The first subjects were selected by sharing the research protocol in university social spaces. Each participant was then asked to choose five individuals and send them the questionnaire. This recruitment procedure was carried out until data saturation was achieved.

In total, 174 Italian adults (65.3% female, 34.7% male, aged 18-77 years) were recruited after providing informed consent. The following demographic and socio-economic data were collected: age, gender, marital status, education, profession. 130 participants correctly completed the survey, 30 participants did not complete the survey, and 14 missed at least one response and were excluded from the study. Another 60 participants who had correctly completed the survey were retested after three months in order to verify the stability of the construct of climate change worry over time. A long-term retest interval was chosen to avoid bias due to short term retest interval (e.g., participants remembering the answers, motivational factors). The final sample consisted of 130 participants. Data were collected from January to June 2021. The Google Forms platform was used for data collection. The study protocol was approved by the local Institution Ethics Committee.

### 2.2. Current study

For the purpose of this study, Stewart's Climate Change Worry Scale was translated into Italian, and its psychometric properties were tested on a sample of Italian individuals in order to validate its use in Italy. Currently, Clayton's Climate Change Anxiety Scale, the only validated measure of climate change distress in Italy, is the most commonly used measure to evaluate the psychological effects of climate change. However, it is crucial also to evaluate levels of climate change worry, as literature shows a positive relationship between constructive climate worry and environmentally friendly behavior. The results of previous studies revealed that, while anxiety is generally correlated with negative emotional responses, worry triggers behavioral responses and a potential increase in pro-environmental attitudes [14,24].

#### 2.2.1. Summary of hypotheses

The study assessed the following hypotheses:

1. It was hypothesised that climate change worry could be positively correlated with anxiety about climate change, measured through the Climate Change Anxiety Scale (CCAS), because existing literature demonstrates that worry is the cognitive correlate of anxiety [25]. As stated by Verplanken, "When worrying becomes a dominant feature of the mind, and occurs repetitively and persistently, it may become dysfunctional, and may be a symptom of deeper-

seated pathological conditions, such as generalised anxiety disorder" [24,26,27].

2. No correlation was hypothesised between CCWS and anxiety and depression symptoms, measured through the DASS-21 subscales. This was based on Stewart's validation study which examined all of the DASS-21 subscales and showed that "only the DASS stress subscale exhibited the most robust correlation with climate change worry" [21,28]. In fact, even though Stewart found a correlation between CCWS and both the DASS-21 anxiety and depression subscales, control for the DASS-21 stress subscale was not statistically significant. By contrast, the correlation between the CCWS and DASS-21 stress subscale remained significant even after controlling for the DASS-21 anxiety subscale and DASS-21 depression subscale [21].
3. It was hypothesised that subjects with higher levels of Climate Change Worry might be better informed about climate change issues based on evidence provided by relevant literature of a positive correlation between information about climate change and climate-change-related psychopathology [31].
4. It was hypothesised that Climate Change Worry would positively correlate with Pro-Environmental Behaviours (measured using the Pro-Environmental Behaviours Scale, PEBS) and with an environmentally sustainable lifestyle (measured using the New Environmental Paradigm - New Social Paradigm subscale, NEP-NSP), as it has been demonstrated that individuals with worry related to climate change are more prone to implement pro-environmental behaviors and to behave in an eco-friendly manner [24,29,30].
5. Based on hypothesis 4, it was hypothesised that Climate Change Worry would negatively correlate with a measure of an environmentally unsustainable lifestyle (measured using the New Environmental Paradigm – Dominant Social Paradigm subscale, NEP-DSP).
6. It was hypothesised that Climate Change Worry would have a positive correlation with political orientation based on the findings of previous literature, according to which individuals with psychopathological conditions related to climate change, and with worry about climate change, are more likely to support political policies that address climate change-related issues [32,33].
7. It was hypothesised that participants with higher levels of Climate Change Worry might be better informed about climate change issues, as a positive correlation between information about climate change and climate change-related psychopathology has been found in the literature [31].

### 2.3. Instruments

#### 2.3.1. Penn State Worry Questionnaire

The Penn State Worry Questionnaire (PSWQ) [34] is a self-report questionnaire, created with the purpose of measuring worry. It is widely used for assessing generalised anxiety disorder (GAD) and other disorders affected by worry, and it is composed of 16 items rated from 1 (= "not at all typical of me") to 5 (= "very typical of me"). The PSWQ shows a high level of internal consistency ($\alpha$ = .95) and high level of test-retest reliability (r = .93) [34].

The scale has been validated in Italian with similar psychometric characteristics [35].

#### 2.3.2. The New Ecological Paradigm Scale-Revised

The New Ecological Paradigm Scale-Revised (NEP-R) [36] is an updated version of the New Ecological Paradigm Survey [37] used to measure personal attitude, beliefs and values about environmental protection [36].

The NEP-R consists of 15 Likert items presented as statements with which respondents must express their degree of agreement from 1 (= "strongly agree") to 6 (= "strongly disagree").

The NEP-R presents a good internal consistency ($\alpha$ = .83) [36].

The scale has been validated in Italian and shows similar psychometric characteristics [38].

#### 2.3.3. Pro-environmental Behaviours Scale

The Pro-Environmental Behaviours Scale (PEBS) [39] is a self-report questionnaire, created for measuring attitudes related to eco-friendly behaviors. The PEBS is composed of 19 Likert items rated from 1 (= "never") to 5 (= "always"). The PEBS is structured into four factors: conservation (attitude to reduce daily consumption), environmental citizenship (tendency to take part in eco-friendly activities), food (disposition to reduce beef consumption), and transportation (attitude about eco-friendly transport).

The PEBS presents good internal consistency ($\alpha$ = .80) and good test-retest reliability (r = .85) [39].

The Italian version of the PEBS shares similar psychometric characteristics to the original [40].

#### 2.4.4. Depression Anxiety Stress Scales (DASS)

The Depression Anxiety Stress Scales (DASS) [41] is a self-report questionnaire that concerns three dimensions: depression (example of item: "I felt like I had nothing to look forward to"), anxiety (example of item: "I feel close to a panic attack"), and stress (example item: "I found it difficult to relax").

Respondents are asked to indicate how much each statement applies to them on a four-point Likert scale (0 = "It doesn't apply to me at all" to 3 = "It applies a lot or most of the time to myself") in the context of the previous week.

The DASS presents a high level of internal consistency ($\alpha$ = .93) [41].

The Italian version of the DASS is a valid and reliable questionnaire to investigate depression, anxiety and stress in both community and clinical settings [40].

#### 2.4.5. Climate Change Anxiety Scale (CCAS)

The Climate Change Anxiety Scale (CCAS) [42] is a self-report scale that investigates self-perceived anxiety in relation to climate change. The first version of the CCAS consisted of 22 items with a four-factor structure, but it was noted that the first 13 items and two factors were most useful for defining climate change anxiety [42,43]. Therefore, a 13-item version containing only the first two factors was used in the German validation study [43]. The scale consists of 13 statements in which the interviewee evaluates the frequency with which he/she experiences the phenomenon described by the item using a Likert scale from one to five, where 1 = Never; 2 = Rarely; 3 = Sometimes; 4 = Often; 5 = Almost always. The CCAS is divided into two subscales: cognitive and functional impairment. The Italian version of the scale showed a good internal consistency ($\alpha$ = 0.78 for Cognitive Impairment subscale, and $\alpha$ = 0.73 for Functional Impairment subscale) [44].

#### 2.4.6. Information about degree of information about climate change and political orientation

To better assess the reciprocal relationship between information about climate change and Climate Change Worry, subjects were asked to estimate their level of information on climate change, as well as the time spent acquiring information about climate change using a Visual Analogue Scale ranging from 0 to 5. Subjects were then asked to answer four questions regarding the role played by climate change in their political orientation. Answers were rated using a Likert scale ranging from 0 ("totally disagree") to 5 ("totally agree") and then total score was acquired by adding each item.

### 2.5. Data analysis

Reliability was assessed by estimating Cronbach's alpha coefficients for each subscale. Convergent validity was assessed by evaluating correlation between CCWS total scores and CCAS subscales scores. A direct correlation was hypothesised between these two measures of climate change-related distress.

Divergent validity was assessed by evaluating correlation between CCWS total scores and PSWQ, and CCWS total scores and DASS-21 stress and anxiety subscales. No correlation was hypothesised between these measures of psychopathology and CCWS.

Concurrent validity was assessed by evaluating correlation between CCWS total scores and political engagement, CCWS total scores and NEPS subscales, and CCWS total scores and PEBS total scores. Higher levels of political engagement, information about climate change, and pro-environmental behaviors were hypothesised in subjects with higher levels of Climate Change Worry.

Test-retest reliability was estimated by evaluating absolute agreement between two measures taken in three months' time via estimation of intraclass correlation coefficient, two ways, mixed, for mean values for each subscale.

The factor structure of the Italian version of the CCWS was first investigated through Exploratory Factor Analysis (EFA), then confirmed via Confirmatory Factor Analysis (CFA). In the EFA, a scree test was used to select the number of factors. A scree test consists of a graph representing the decreasing curve of the eigenvalues and allows the selection of the factors that precede the flattening of the curve [45]. This method has shown good reliability in identifying the strongest eigenvalues, despite the subjectivity of the method [46]. Factors with an eigenvalue greater than 1 were not selected, since this method has been shown to select an excessive number of factors [47]. In CFA, in line with literature recommendations, it was decided to use multiple fitness indexes [48]. Root Mean Square Error of Approximation (RMSEA) was not calculated, as some authors suggest that it tends to refuse correctly estimated models for small sample sizes and recommend avoiding its use for sample sizes below 200 [47]. Therefore, Standardised Root Mean Square Residual (SRMR), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI) were calculated. Indices of acceptable fitness are values below 0.08 for SRMR, values above 0.9 for CFI, and 0.95 for TLI [49].

Statistical analyses were performed using IBM SPSS 25.0 and AMOS 24 [50], with p values < .05 indicating statistical significance.

## 3. Results

The final sample was composed of 130 participants, 69 (53.1%) were female and 61 (46.9%) were male. Of the total sample, 40 subjects (30%) were in a stable relationship, 91 (70%) were not engaged in a relationship. Regarding education levels, eight subjects (6.2%) completed junior high school, 12 subjects (9.2%) completed high school, 100 subjects graduated college (76.6%), and 10 subjects had postgraduate degrees (7.7%). Regarding occupational status, five subjects were students (3.8%), four subjects were unemployed (3.1%), and 121 subjects were employed (93.1%). The mean age of participants was 35.02±10.68 years. The mean result of the Likert scale evaluating information about climate change was 2.35±1.29, mean time spent informing was 2.19±1.36, and mean political engagement against climate change was 40.74±13.02.

Descriptive analysis for the psychometric indexes used in the study are reported in Table 1.

An exploratory factor analysis was conducted to evaluate the factor structure of the Italian version of the CCWS. Only one factor showed an eigenvalue > 1 (Table 2) and the scree test confirmed that the better option was a single-factor model (Figure 1).

Communalities and loadings with the factor are reported in Table 3.

**Table 1**
Descriptive analysis for the sample.

| | Males (N=61) | | Females (N=69) | | Total sample (N=130) | |
|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD |
| Climate Change Worry Scale | 15.91 | 11.55 | 19.55 | 9.36 | 17.84 | 10.56 |
| Penn State Worry Questionnaire | 37.45 | 7.87 | 39.52 | 7.26 | 38.55 | 7.59 |
| CCAS cognitive impairment | 13.37 | 6.81 | **18.20**** | **8.10** | 15.93 | 7.87 |
| CCAS functional impairment | 7.14 | 2.91 | **9.24**** | **5.31** | 8.26 | 4.46 |
| DASS-21 stress | 5.08 | 4.61 | 6.52 | 4.83 | 5.84 | 4.76 |
| DASS-21 anxiety | 5.54 | 6.39 | 5.65 | 5.29 | 5.60 | 5.81 |
| DASS-21 depression | 6.91 | 5.78 | **8.82*** | **4.82** | 7.93 | 5.36 |
| PEBS total score | 54.32 | 20.40 | 59.31 | 19.22 | 56.97 | 19.86 |
| NEP-NSP | 32.79 | 7.24 | 33.56 | 7.39 | 33.21 | 7.31 |
| NEP-DSP | 16.72 | 4.83 | **14.63*** | **5.14** | 15.61 | 5.09 |

Significant differences between female and male subjects, assessed via t-test for independent samples, are bolded (*p<0.05, **p<0.01, ***p<0.001).
(M: male, F: female, CCAS: Climate Change Anxiety Scale, DASS: Depression Anxiety Stress Scale, PEBS: Pro-Environmental Behaviours Scale, NEP-NSP: New Ecological Paradigm – New Social Paradigm subscale, NEP-DSP: New Ecological Paradigm – Dominant Social Paradigm subscale)

**Table 2**
Eigenvalues for factors in Exploratory Factor Analysis.

| Factor | Eigenvalue | Percentage of variance |
|---|---|---|
| 1 | 8.106 | 81.05 |
| 2 | 0.778 | 7.77 |
| 3 | 0.362 | 3.62 |
| 4 | 0.213 | 2.13 |
| 5 | 0.175 | 1.75 |
| 6 | 0.116 | 1.16 |
| 7 | 0.110 | 1.10 |
| 8 | 0.067 | 0.66 |
| 9 | 0.042 | 0.42 |
| 10 | 0.031 | 0.31 |

Items six and seven were removed due to factor loading <0.7 following the suggestion of Beavers [51] that the ideal communality value should be above 0.7.

The single factor model for the eight items scale was then tested with Confirmatory Factor Analysis. SRMR was 0.06 and CFI was 0.91, suggesting that the single factor model had a good fitness to data. However, TLI was 0.88, below the cut-off for acceptable fitness.

Descriptive analysis for the 8-item scale is reported in Table 4.

Internal consistency for the 8-item scale was estimated via calculation of Cronbach's alpha: Cronbach's alpha was 0.975, therefore it was excellent [52].

Correlations between CCWS and the other measures used in the analysis are reported in Table 5. A positive, significant correlation was detected between CCWS and CCAS subscales, between CCWS and measures of Pro-Environmental Behaviours (NEPS-NEP, PEBS), and between CCWS and information and political engagement on climate change-related topics. A significant negative correlation was detected with NEPS-DSP. No correlation was detected between CCWS and PSWQ or DASS-21 anxiety and depression subscales. A negative correlation was detected between CCWS and DASS-21 stress subscale.

After three months, 60 subjects were retested. Intraclass correlation coefficient, two ways, mixed, for mean values was 0.987 ($F(59,59)=76.24$, $p<0.001$).

## 4. Discussion

The present study provides support for the psychometric properties of the Italian version of the Climate Change Worry Scale. Since

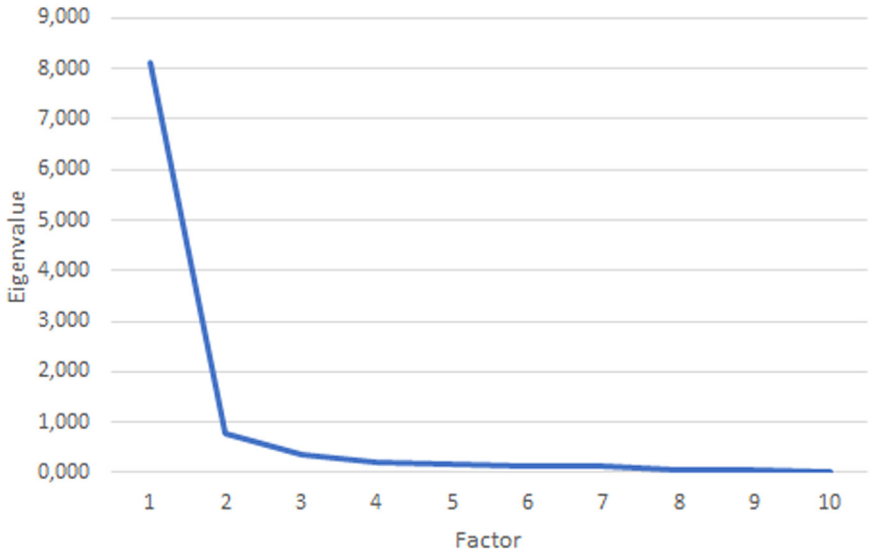


**Figure 1.** Scree test used for the Exploratory factor analysis

**Table 3**
Communalities and loadings for the single-factor model.

| Item | Communality | Loading |
|---|---|---|
| 1 | 0.780 | 0.883 |
| 2 | 0.886 | 0.941 |
| 3 | 0.848 | 0.921 |
| 4 | 0.923 | 0.960 |
| 5 | 0.750 | 0.866 |
| 6 | 0.660 | 0.812 |
| 7 | 0.688 | 0.830 |
| 8 | 0.949 | 0.974 |
| 9 | 0.718 | 0.847 |
| 10 | 0.904 | 0.951 |

**Table 4**
Descriptive analysis for the 8-item scale.

| Item | Mean ± Standard Deviation | Item-total correlation |
|---|---|---|
| 1 | 2.34±1.29 | 0.874 |
| 2 | 2.30±1.39 | 0.929 |
| 3 | 2.14±1.48 | 0.921 |
| 4 | 2.42±1.44 | 0.961 |
| 5 | 2.74±1.26 | 0.850 |
| 8 | 2.24±1.45 | 0.963 |
| 9 | 1.44±1.54 | 0.774 |
| 10 | 2.18±1.55 | 0.925 |

**Table 5**
Pearson's correlations between CCWS and the other measures used in the study.

| | n | M | SD | CCWS |
|---|---|---|---|---|
| 1.PSWQ | 130 | 38.55 | 7.59 | −0.005 |
| 2. CCAS cognitive impairment | 130 | 15.93 | 7.87 | 0.782** |
| 3.CCAS functional impairment | 130 | 8.26 | 4.46 | 0.560** |
| DASS-21 stress | 130 | 5.84 | 4.76 | −0.244* |
| DASS-21 anxiety | 130 | 5.60 | 5.81 | −0.071 |
| DASS-21 depression | 130 | 7.93 | 5.36 | −0.091 |
| PEBS total score | 130 | 56.97 | 19.86 | 0.790** |
| NEPS-NSP | 130 | 33.21 | 7.31 | 0.704** |
| NEPS-DSP | 130 | 15.61 | 5.09 | −0.661** |
| Information | 130 | 2.35 | 1.29 | 0.659** |
| Political engagement | 130 | 40.74 | 13.02 | 0.755** |

All analyses were adjusted for age and sex. Significant correlations between the mean scores of the scales and Climate Change Worry Scale are bolded (*p<0.05, **p<0.01, ***p<0.001).
(r: Pearson's correlation coefficient, p: p value, PSWQ: Penn State Worry Questionnaire, CCAS: Climate Change Anxiety Scale, DASS: Depression Anxiety Stress Scale, PEBS: Pro-Environmental Behaviours Scale, NEP-NSP: New Ecological Paradigm – New Social Paradigm subscale, NEP-DSP: New Ecological Paradigm – Dominant Social Paradigm subscale)

worry is the cognitive correlate of anxiety, some items on this scale are similar to those on the Climate Change Anxiety Scale and the Hogg Eco-Anxiety Scale [53]. However, the Climate Change Worry Scale does not include questions about health issues deriving from climate change anxiety, such as sleep difficulties, lack of concentration, and the insurgence of nightmares during sleep. This is because the main purpose of the CCWS is to identify and investigate triggers of climate change worry. Along this line, the Italian version of the CCWS maintains a focus on worry rather than anxiety, fear, or depression. For this reason, the term worry is included in every question on the scale except for question three. This is, to the best of our knowledge, the first study which validates an Italian version of the CCWS. Reliability proved to be excellent [21] even if slightly lower than reliability indexes of the original validation study. Climate Change Worry Scale items exhibited excellent internal consistency, and the one-factor model showed adequate fitness to data. Test-retest reliability at a three-months evaluation proved to be good.

The results of this study confirm that there is a relationship between Climate Change Worry and Climate Change Anxiety, which is explained by the fact that worry is a cognitive correlate of anxiety [25]. However, while high levels of Climate Change Worry can lead to an increase in Climate Change Anxiety, which reduces an individual's ability to act against climate change [21], low levels of Climate Change Worry tend to encourage individuals to implement actions to combat climate change.

The absence of correlation between CCWS and PSWQ could be explained by the specificity of Climate Change Worry, which does not necessarily generate worry about other issues [24]. The absence of correlation between the CCWS and DASS-21 Anxiety and Depression subscales could be explained by the mainly adaptive nature of the Climate Change Worry construct, which only under specific circumstances - female, age under 35, pro-environmental orientation, anxious personality traits - may lead to generalised anxiety or clinical depression [54].

The negative correlation between CCWS and DASS-21 Stress subscale was unexpected but could be interpreted as a consequence of

an unconsidered variable, education, which correlated positively with Climate Change Worry and negatively with stress. For instance, since individuals with higher levels of education show higher levels of Climate Change Worry, it can be hypothesised that a coping mechanism is triggered in educated individuals that enables them to transform negative worry/stress into constructive worry [29,43].

The experience of climate change worry proved to be related to pro-environmental behaviors, and degree of knowledge and political engagement regarding climate change-related topics. This is in line with evidence showing a direct relationship between climate change worry and pro-environmental behaviors [55,56] and between climate change worry, level of knowledge and political engagement on climate change-related topics [15,18,19].

While the findings of this study show that climate change worry cannot be considered a measure of serious psychopathology, such as anxiety and fear, investigating it is still of crucial importance, as climate change worry is not only responsible for climate change anxiety; it is also an effective measure to predict the extent to which individuals who worry about climate change and its consequences are likely to adopt pro-environmental behaviors as supported by the hierarchy of concern model [29] and gateway belief model [15,57].

Previous studies also show that whereas pathological worry leads to anxiety, stress and impaired health, constructive worry, including climate change worry, tends to generate positive mental attitudes and functional cognitive operations/behaviors (e.g., generating plans, taking initiatives and problem solving), especially if associated with a sense of responsibility [14]. As recently stressed by the Intergovernmental Panel on Climate Change (IPCC) 2021 [58], it seems critical to raise awareness of issues deriving from climate change and encourage pro-environmental behaviors.

## 5. Limitations

The present study must be considered in light of some limitations. The sample examined was not fully representative of the Italian population, as it was composed of individuals with an average age below that of the general Italian population and did not present an adequate representation of ethnic minorities and non-native speakers. This could lead to a reduction in the possibility of generalising the observed results. Moreover, the meaning of the correlation observed between the CCWS and the DASS-21 stress subscale needs further evaluation in order to be more accurately explained.

## 6. Conclusions

It is of fundamental importance to use a measurement tool to estimate levels of climate change worry in Italy in order to appropriately address the psychological impact of climate change among the general Italian population. Moreover, it is important to assess Climate Change Worry during educational programs aimed at increasing climate change awareness. Worry is also significant since it is a cognitive phenomenon related to anxiety [44] and to the enhancement of pro-environmental behaviors. Therefore, it would be useful to assess the interplay between worry and other cognitive dimensions, in order to understand how worry could lead to psychopathology or to adaptive behaviors. This could be helpful to develop appropriate environmental educational programs and to develop clinical protocols to reduce excessive climate change worry. This study should be followed by more extensive research to evaluate the levels of climate change worry within the Italian population. These results are consistent with the fact that feelings of worry are rapidly increasing among the population, especially in youth populations. Climate change effects and inadequate governmental responses are leading to climate change worry among adults and young people globally. Extreme climate change worry, though it has the potential to make individuals feel personally responsible to take action to mitigate climate change, threatens the health and wellbeing of those who experience it. Given this, there is an urgent need to develop measures to evaluate the mental health effects of climate change.

## Authors' contribution

M.I, G.S. and G.C. conceived and planned the experiments. Data collection was performed by V.R., G.C., G.S., M.I., V.F., F.G., and L.C. Material preparation and statistical analysis were performed by G.S. with the contribution of M.I. A contribution to the interpretation of the results was provided by all the authors. The first draft of the manuscript was written by M.I. and G.S. with the supervision of G.C., F.G. and V.R. All authors provided critical feedback and helped shape the manuscript. All authors read and approved the final version of the manuscript

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## Declaration of competing interest

The authors declare no potential conflict of interest.

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