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The 7-items version of the connectedness to nature scale: A study of its validity and reliability with Brazilians

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Electronic supplementary material

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Introduction

Human actions are largely responsible for environmental problems such as climate change, deforestation, and biodiversity loss (Steffen et al. 2015). Hence, several authors have highlighted the importance of a better understanding of the drivers of pro-environmental behaviors (PEB) (Collado et al. 2015; Whitburn et al. 2019). Connectedness to nature (CN) has been defined as a latent construct that represents the connection between individuals and nature and is related to individuals' emotions, beliefs and behaviors toward nature (Mayer and Frantz 2004; Tam 2013; Pasca et al. 2017; Whitburn et al. 2019). CN is thought to be one of the main factors leading to PEB (Tam 2013; Frantz and Mayer 2014; Gkargkavouzi et al. 2018) and, as such, there is a growing interest on the factors leading to CN (Di Fabio and Kenny 2018; Rosa and Collado 2019). For example, experiences in nature (e.g., nature-based recreation) are seen as a relevant determinant of CN (Duron-Ramos et al. 2020; Rosa and Collado 2019).

Considering its importance in predicting PEB, and the relevance of valid and reliable measures, efforts have been put to develop valid and reliable tools to assess CN (Tam 2013). Tam's (2013) reviewed the instruments used to register CN. He found seven different measures of CN, being the Connectedness to Nature Scale (CNS) the most popular one. This author concluded that the unique predictive power of these different measures is irrelevant. In the current study, we focus on the CNS. The original scale is formed by 14 items (Mayer and Frantz 2004) and has been adapted to be used in different countries such as Brazil (Pessoa et al. 2016) and Spain (Pasca et al. 2017). The CNS assesses both the affective and cognitive dimensions of an individual's CN (Whitburn et al. 2019).

In one of its latest adaptations, Pasca et al. (2017) proposed a 7-items version of the scale (hereafter CNS 7-items). The goal was to develop a shorter instrument, which would potentially reduce participants' fatigue when filling in long questionnaires, as well as eliminate items that had poor psychometric properties. This effort fits well into the current framework of psychometric measures where shorter versions are preferable to reduce participants' fatigue and to provide more effective tools. Shorter tools can capture participants' thoughts and feelings in a proper time window without important consequences regarding psychometric properties (Cederberg et al. 2018). More specifically, Pasca et al. (2017) analyzed two measurement properties of the CNS 7-items scale, internal consistency and convergent validity, and found both of them to be sound. Convergent validity was assessed by checking the correlation between the CNS 7-items and two other measures of connectedness to nature (Pasca et al. 2017). In light of these results, the authors encourage the use of the CNS 7-items.

However, relevant measurement properties of the CNS 7-items remain unchecked, precluding the extended use of the scale. First, one of the most relevant aspects of construct validity (i.e., structural validity) was not assessed by Pasca et al. (2017). Structural validity refers to the degree to which the scores obtained by using a certain instrument are an adequate reflection of the dimensionality of the construct to be measured (Mokkink et al. 2018). Second, Pasca et al. (2017) did not check other relevant psychometric properties such as known-group validity - the expected difference in the scale's scores between groups -, and predictive validity - the ability of the scale to predict a criterion. The latter two aspects can also be seen in the context of nomological validity or hypotheses testing (i.e. if the measure correlates with theoretically related constructs in the expected direction) (Mokkink et al. 2018).

To get a more nuanced idea of the validity and reliability of the CNS-7 items, in the current study we checked the scale's structural validity, known-group validity, and predictive validity when administered to a sample of Brazilians. We also checked its internal consistency and compared the psychometric properties of this version of the CNS with the psychometric properties of its longer version. We expected that the CNS-7 items to hold adequate structural validity and high internal consistency (Mayer and Frantz 2004; Pessoa et al. 2016). We also expected a positive and moderate correlation between CN and PEB (i.e. predictivity validity, Whitburn et al. 2019), and medium effect size for the difference in CN between NBR groups (i.e. known-group validity, Nisbet et al. 2009). In Box 1, we briefly describe what is already known and what the present study adds to the topic.

Box 1 What is already known and what the present study adds to the topic

What is already known about this topic?

- Connectedness to nature is a relevant predictor of pro-environmental behaviors and the Connectedness to Nature Scale (CNS) is the most popular measure of this construct.
- A shortened 7-items version of the CNS was created by eliminating items with poor psychometric properties.
- This shortened version holds high internal consistency and convergent validity.

What does this topic add?

- The present study shows that the CNS 7-items version holds adequate structural validity, predictive validity, and known-group validity.
- The shortened and the original versions of the CNS correlate similarly with theoretically related constructs, and the shortened version holds a stronger internal structure.
- In line with a previous study, our results indicate that, compared to the original version, the CNS 7-items is a better option to assess individuals' connectedness to nature.

Method

Participants

Participants were 224 students (140 women; $M_{age} = 23.6$ years old; $SD = 5.96$) from a University in Brazil, enrolled in different courses including pedagogy, biology, law, physical education, and economics. Students should be 18 years old or older to be eligible to participate. We expected a moderate correlation between CN and PEB and a medium effect size for the difference in CN between NBR groups. Thus, a minimum sample size of 85 and 64 was needed, respectively, to find statically significant results ($p < .05$, power = .80, Cohen 1992). Nevertheless, we recruited as many participants as possible during the time available for data collection because larger sample sizes provide more precise estimates.

Measures

Data were collected through an online survey including questions about demographic information, environmental attitudes and behaviors, leisure preferences, and frequency of participation in leisure activities. Some of these variables are part of a larger study (Rosa et al. 2018, 2019~~masked for review~~) and therefore not described here. In the current study, the following measures were used:

Nature-based recreation (NBR): Following previous studies (Larson et al. 2011), NBR was registered by one-item: Do you regularly practice any leisure activities that involve contact with nature?. Answers were registered as 1 = no; 2 = yes.

Connectedness to nature (CN): CN was registered by the CNS 13-items (Pessoa et al. 2016), and its shorter version (CNS 7-items; Pasca et al. (2017)). To facilitate comparison across studies, when presenting the data for the CNS 7-items, we kept the items' numbers used by Pasca et al. (2017) (i.e., 2, 5, 6, 7, 9, 10, 11). Participants rated items on a 5-point Likert scale: 1 = strongly disagree to 5 = strongly agree.

Self-Reported Pro-Environmental Behaviour (PEB): The PEB scale developed by Larson et al. (2015) was used. Three items referring to land stewardship were removed from this study because they refer to behaviors that our participants would not normally engage in (e.g., made my yard or my land more desirable for wildlife). The remaining 10 were translated into Portuguese-BR following a back-translation procedure. All items were reported on a scale from 1 = never to 5 = very often. This scale was found to be unidimensional according to Timmerman and Lorenzo-Seva (2011) implementation of parallel analysis (Appendix Table 3), and its $\alpha = .82$.

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Procedure

The study was approved by the ethical committee of the State University of Santa Cruz (No. 2.055.100). Participants gave their informed consent and completed an online non-probabilistic survey administered via Google Forms. Participation was voluntary and incentives for participation were not provided.

Analyses

To assess the CNS 7-items' structural validity, we first explored its factorial structure and then analyzed the most appropriate solution through confirmatory factor analysis (CFA). The known-group validity was checked by analyzing if individuals who regularly engaged in nature-based recreation (NBR) hold distinct CN (assessed by the CNS 7-items) than individuals with less frequent NBR. Besides, we checked the CNS 7-items' predictive validity by examining its ability to predict PEB. Similar to Pasca et al. (2017), we checked this scale's internal consistency and, in addition to the Cronbach's alpha reported by these authors, we also report the Revelle's omega coefficient. An $\alpha \geq .70$ is considered adequate (Mokkink et al. 2018). Last, we compared the psychometric properties of the CNS 7-items with its longer (Brazilian) version formed by 13 items (Pessoa et al. 2016). Thus, three variables were analyzed, namely: NBR, CN (assessed by the CNS 7-items and the CNS 13-items) and PEB.

After a visual inspection of the data, two participants were left out of the analyses because they had non-random missing values. The few missing values (0.13%) were imputed with the sample mean value for each variable (Tabachnick and Fidell 1996). Before conducting a factorial analysis of the structure of the CNS 7-items, we checked for multivariate outliers. The criteria for multivariate outliers was a value of the Mahalanobis' distance that corresponds to a $p < .001$ according to Tabachnick and Fidell (1996). Data from five participants were discarded because they were deemed multivariate outliers.

Next, the dimensionality of the CNS 7-items was explored according to Timmerman and Lorenzo-Seva (2011) recommendations for parallel analysis, which involves a polychoric-based approach with a 95% threshold for the simulated data. Data can be reduced as long as sample eigenvalues produce more explained variance when compared to simulated data. Following CFA was done. The model was estimated using the diagonally weighted least squares (WLSMV), which performs more accurately with ordinal data (Brown 2006). The criteria for fitting the structure of the CNS 7-items (structural validity) were: $\chi^2/df < 5$, CFI $> .90$, TLI $> .90$ and RMSEA $< .08$ (Brown 2006).

Following, we analyzed the CNS 7-items' known-group validity and predictive validity by using the Student's *t* test (difference in CN between NBR groups), and Linear Regression (CN as a predictor of PEB), respectively (Dancey and Reidy 2006). In addition, the above-mentioned analyses were repeated with the CNS 13-items to compare the psychometric properties of the original and shortened versions of the scale. The data is available as a Supplementary Material.

Results

Participants hold moderate to high connectedness to nature ($M = 3.81$, $SD = 0.62$) and report medium-low frequency of PEB ($M = 2.26$, $SD = 0.64$). Almost half of the participants regularly engage in NBR ($M = 1.47$, $SD = 0.50$).

Structural Validity

An analysis of the dimensionality supported a one factor solution for the CNS 7-items scale (Appendix Table 4). The unidimensional structure of the CNS 7-items fitted well to the data $\chi^2(14) = 48.71$, $\chi^2/df = 3.48$ ($N = 217$, $p = .001$), CFI = .97, TLI = .96 and RMSEA = .107. High RMSEA was a product of the dependency between errors of item 5 with item 7 ($r = .51$, $p < .001$), and 10 ($r = .24$, $p < .001$). Once this was controlled, the fit indexes improved $\chi^2(12) = 25.88$, $\chi^2/df = 2.16$ ($N = 217$, $p = .011$), CFI = .99, TLI = .98 and RMSEA = 0.073. Moreover, all paths included in the CFA were statically significant ($p < .001$) with standardized regression coefficients $\geq .50$ (Table 1). Internal consistency for the unidimensional solution resulted in $\omega = .87$, and $\alpha = .81$.

Table 1

Standardized regression coefficients (λ) of the confirmatory factor analysis of the CNS 7-items ($N = 217$)

Items	λ
(C7) I feel as though I belong to the Earth as equally as it belongs to me.	.86
(C2) I think of the natural world as a community to which I belong.	.78
(C9) I often feel part of the web of life.	.76
(C11) Like a tree can be part of a forest, I feel embedded within the broader natural world.	.63
(C10) I feel that all inhabitants of Earth, human, and nonhuman, share a common 'life force'.	.58
(C5) When I think of my life, I imagine myself to be part of a larger cyclical process of living.	.57

Items	λ
(C6) I often feel a kinship with animals and plants.	.50
C5 \Leftrightarrow C7	.51
C5 \Leftrightarrow C10	.24

Known-Group Validity and Predictive Validity: Hypotheses Testing for Construct Validity

As expected the CNS 7-items hold a moderate and positive correlation with PEB, explaining 17% of its variance ($F(1, 216) = 42.86, p < .001, R^2 = .17$). Also, the participants who engaged regularly in NBR ($M = 4.02, SD = 0.51$) have a higher score in the CNS 7-items than participants who not engaged regularly in NBR ($M = 3.63, SD = 0.66$); the effect size is medium ($t(215) = -4.78, p < .001, \text{Mean Difference} = -0.38, d = 0.66$).

Comparison between the CNS 7-Items and CNS 13-Items

The CNS 13-items was also found to be unidimensional (Appendix Table 5) and internally consistent. Nonetheless, the CNS 7-items holds better structural validity than the longer version. Similar results for the hypotheses testing were found for both scales. These results are shown in Table 2. The correlation between the mean scores of these two scales is $r = .93, p < .001$.

Table 2

Psychometric properties of the CNS 7-items and the longer version (CNS13-items)

Psychometric properties	CNS 7-items	CNS 13-items
Structural ^a validity	$\chi^2(14) = 48.71, \chi^2/df = 3.48, CFI = .97, TLI = .96$ and $RMSEA = .107$	$\chi^2(65) = 225.80, \chi^2/df = 3.47, CFI = .92, TLI = .91$ and $RMSEA = 0.108$
Known-group validity ^b	Mean difference = $-.38$ (95% $CI = [-.54, -.23], d = 0.66$)	Mean difference = $-.30$ (95% $CI = [-.43, -.17], d = 0.61$)

As suggested by Cumming (2014), Cohen's d and confidence intervals for R^2 were calculated using the Free Statistics Calculator version 4.0 available at <https://www.danielsoper.com/statcalc/default.aspx>

^aConfirmatory factor analysis of the scale

^bMean difference in CN between individuals who engaged regularly in NBR and individuals who not engaged regularly in NBR. A negative mean difference indicates that individuals who engaged regularly in NBR had a higher CN

^cPEB were regressed on CN

Psychometric properties	CNS 7-items	CNS 13-items
Predictive validity ^c	$R^2 = .17$ ([95% $CI = [.8, .26]$)	$R^2 = .17$ ([95% $CI = [.8, .26]$)
Internal consistency	$\omega = .87, \alpha = .81$	$\omega = .83, \alpha = .82$
As suggested by Cumming (2014), Cohen's d and confidence intervals for R^2 were calculated using the Free Statistics Calculator version 4.0 available at https://www.danielsoper.com/statcalc/default.aspx		
^a Confirmatory factor analysis of the scale		
^b Mean difference in CN between individuals who engaged regularly in NBR and individuals who not engaged regularly in NBR. A negative mean difference indicates that individuals who engaged regularly in NBR had a higher CN		
^c PEB were regressed on CN		

Discussion

Extending from Pasca et al.'s (2017) study, we checked the CNS 7-items' structural validity, known-group validity, and predictive validity with a sample of Brazilians. In addition, we compared the psychometric properties of the original (Brazilian) version of the CNS (i.e., 13-items version) with the psychometric properties of the recently developed 7-items version of the scale. Our results indicate that the scale holds a unidimensional structure, with adequate structural validity, known-group validity, and predictive validity. The CNS 7-items scale's unidimensional structure was supported by the results of the CFA. Regarding the CFA's results, the fit indices for the unidimensional structure of the CNS 7-items were better than those of its longer version, suggesting that the use of the CNS 7-items as unidimensional is more appropriate than the use of the CNS 13-items. In line with previous studies, CN was positively and moderately correlated with PEB (Whitburn et al. 2019), and the individuals who engaged regularly in NBR hold higher CN (Nisbet et al. 2009). These results support the CNS 7-items' predictive validity and known-group validity, respectively.

Some limitations should be noticed. First, large variance of PEB remains unexplained. Other factors such as barriers for behaving in a pro-environmental way may influence PEB (Hines et al. 1987). For example, even if a person is inclined to cycle to work, s/he may prefer driving because of a lack of cycling lanes (Rosa and Collado 2020). Similarly, NBR participation is probably not the only factor related to CN, and other factors, such as environmental education

might come into play (Otto and Pensini 2017). Thus, future studies should include other variables when the focus of the research is to explain PEB and CN.

Second, our sample is a non-probabilistic one and our design is cross-sectional, hindering the generalization of our results as well as causal inferences. Thus, future studies should check whether our findings hold with a probabilistic larger sample of university students as well as with a non-student sample. Longitudinal studies could also help to establish causality.

Third, our research design did not account for common method biases (e.g. consistency motif, and item demand characteristics), which may have inflated the correlation between our measures (Podsakoff et al. 2003). Also, the reliability of the NBR item is unknown and self-reported PEB may not assess the observable PEB very accurately. Thus, future studies can check whether our findings hold when accounting for common method biases (see Podsakoff et al. 2003 for instructions) and observe NBR and PEB directly.

To conclude, the CNS 7-items holds adequate structural validity (and internal consistency), convergent validity (Pasca et al. 2017), known-group validity, and predictive validity. Our results and those of Pasca et al. (2017) suggest that the CNS 7-items can be used to estimate connectedness to nature and to examine its correlates with Brazilians. A cross-cultural analysis of the CNS 13-items (Spanish version) was performed, but the samples used to calculate the invariance of the measure were quite different (Pasca et al. 2018). As a result, it is difficult to assert if differences observed in the CNS 13-items across countries were due to true differences in the items or due to differences between the samples. Nonetheless, the unidimensionality of the CNS 13-items was supported, independent of sample differences (Pasca et al. 2018). Thus, we encourage a cross-cultural examination of the CNS 7-items with more similar samples. We also encourage future studies to check the test-retest reliability of this scale using longitudinal designs.

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The Statement of Individual Author's Contributions

CR and CP conceived the study. CR and PP analysed the data. CR, PP and SC interpreted the data. CR wrote drafts of the paper. SC reviewed critically the drafts and did substantial contributions to its content.

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Compliance with Ethical Standards

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual adult participants included in the study.

Appendix

Table 3

Parallel Analysis of the Pro-environmental Behaviour (PEB) scale ($N = 217$)

PEB parallel analysis			
Variable	Real-data	Mean of random	95 percentile of random
	% of variance	% of variance	% of variance
1	51.9581	20.4924	24.1974
2	12.9264	17.5218	19.9909
3	10.3473	15.1762	17.1826
4	6.7658	13.0499	14.6954
5	6.0279	10.9788	12.4104
6	5.0379	8.8791	10.5407
7	3.8936	6.7412	8.6273
8	2.3589	4.6913	6.5841
9	0.6841	2.4694	4.5598

Table 4

Parallel Analysis of the 7-items Connectedness to Nature Scale (CNS 7-items); $N = 217$

CNS 7-ITEMS PARALLEL ANALYSIS			
Variable	Real-data	Mean of random	95 percentile of random
	% of variance	% of variance	% of variance
1	58.6863	29.2029	35.5259
2	13.9087	23.6352	27.5828
3	10.8056	18.6375	21.9138
4	6.6424	14.0705	17.2022
5	5.5151	9.5052	13.0027
6	4.442	4.9486	8.9204

Table 5

Parallel analysis of the CNS 13-items (N = 217)

CNS13 PARALLEL ANALYSIS			
Variable	Real-data	Mean of random	95 percentile of random
	% of variance	% of variance	% of variance
1	43.9474	15.7316	17.8157
2	11.3375	14.0481	15.7506
3	7.8609	12.5953	13.9752
4	7.746	11.2537	12.2971
5	6.5075	10.0068	11.0051
6	5.4456	8.8061	9.63
7	4.8569	7.6542	8.5551
8	4.1966	6.4585	7.5171
9	3.171	5.2165	6.345
10	2.4844	4.0352	5.1804
11	1.6988	2.7311	3.8659
12	0.7474	1.463	2.5654

Electronic supplementary material

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(XLSX 32 kb)

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