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Assessing the Unidimensionality of Clayton's Environmental Identity Scale Using Confirmatory Factor Analysis (CFA) and Bifactor Exploratory Structural Equation Modeling (bifactor-ESEM)

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A relevant intrapersonal characteristic for understanding intentions and behavior toward environmental sustainability is the degree to which nature is important for a person's self-definition. Clayton's Environmental Identity (EID) scale purports to measure this construct. However, a limited number of prior exploratory studies of this measure have supported different factor structures. Hence, our initial aim was to develop an understanding of the dimensionality of Clayton's 24-item EID scale by testing competing latent structures using confirmatory factor analysis. We analyzed self-reported data from 458 adults ($M_{age} = 26.7$ years; 81% female). Four *a priori* models (a first-order model, a second-order model, a unidimensional model, and a bifactor model) did not show satisfactory fit to the data. An ancillary analysis using bifactor exploratory structural equation modeling (bifactor-ESEM) indicated a bifactor model with three specific factors had a good fit to the data. The factor loadings of this model and values for bifactor indices (Omega Hierarchical and Explained Common Variance [ECV]) indicated a single mean score across all EID scale items taps into an essentially unidimensional construct and is therefore appropriate to interpret. In sum, our study provides a critical insight into the dimensionality of Clayton's EID scale that will be valuable when applying this measure for research and intervention purposes.

A pressing challenge facing current society is the need to facilitate development and prosperity while protecting the planet's health for future generations (World Commission on Environment and Development, 1987). To focus and organize efforts toward sustainable development, the United Nations General Assembly (2015) has proposed a series of goals for the year 2030. These include the eradication of poverty, achieving gender equality, fighting climate change, and promoting inclusive and equitable education, among others. While most of these goals are formulated at the societal level, they contain various themes, including those related to environmental sustainability, that should ideally be expressed in individuals' knowledge, attitudes, and behaviors (Gericke et al., 2019; UNESCO, 2006). Understanding the variables that underpin individual differences in pro-environmental knowledge, attitudes and behaviors is an important step for developing and implementing effective policies and interventions that will help empower people to act in an environmentally sustainable way.

One such relevant variable is the degree to which people

experience a subjective sense of connection to the environment via their incorporation of nature into their self-concept. The present study focuses on the specific notion of *environmental identity*, which captures a sense of connection to nature that influences the way people perceive and interact with the world (Clayton, 2003). According to Clayton, non-social objects such as natural objects and geographical places can be an important aspect of many people's self-concept. For these individuals, the environment is an important part of who they are. Environmental identities reflect self-relevant perceptions that result from a person's history of interactions with the natural world (Rosenberg, 1981). From the perspective of the *Theory of Planned Behavior* (Ajzen, 1985), these self-relevant perceptions are important because they serve as a key source of information when forming intentions to act. These intentions, according to the theory, are the most proximal predictors of behavior. Therefore, environmental identity has clear implications for understanding people's intentions and behavior toward environmental sustainability (Nielsen et al., 2021).

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Environmental psychologists have proposed numerous similar constructs to reflect this environment-self connection such as the inclusion of nature in self (Schultz, 2001), connectedness to nature (Mayer & Frantz, 2004), and nature relatedness (Nisbet et al., 2009), among others (see Tam, 2013, for a review). However, while research has shown a large degree of convergence between the various constructs and measures assessing environment-self connection, including environmental identity, they are conceptually and practically distinguishable (Tam, 2013). Indeed, Clayton's Environmental Identity (EID) scale (2003), was found to have stronger correlations with criterion variables such as self-reported ecological behaviors, and some incremental predictive power over and above a common factor linking the various constructs. However, despite these strengths, we will highlight that the small body of psychometric research on the EID scale presents contrasting findings concerning its factorial structure and limited information about other relevant psychometric characteristics.

The EID scale assesses individual differences in the extent to which the natural environment plays a role in one's self-definition. The 24 items of the EID scale were designed to capture salience of environmental identity (extent and importance of a person's interactions with nature), self-identification with and support for environmental ideology, positive emotions associated with the environment, and memories of interacting with nature; in other words, the cognitive and emotional components of people's perceived relationship with the natural world. Internal consistency of the full 24-item EID scale is good (alpha coefficients > 0.80) in various young adult (typically university student) samples, including those from Spain (Olivos & Aragonés, 2011), Singapore (Chew, 2019), Turkey (Clayton & Kilinc, 2013), France (Navarro et al., 2017) and Russia (Clayton et al., 2019). Recent cross-cultural validation has offered evidence that the construct of EID is meaningful across additional cultures (Clayton et al., 2021). Moreover, the convergent validity of the EID scale has been established via the observation of significant correlations with related measures, including pro-environmental behaviors (Kiesling & Manning, 2010; Matsuba et al., 2012; Watson et al., 2017), ecocentric values (Clayton, 2003) and engagement with sustainable development (Moreira et al., 2020).

Although environmental identity is theoretically multidimensional, Clayton (2003) stated "analyses suggest a single factor accounts for most of the variance" (p.53). However, no specific results or methodological details from these analyses were presented. A more recent assessment of the factorial structure of the EID scale in a sample of Singaporean university students confirmed, via exploratory factor analysis (EFA; principal axis factoring extraction method and Promax rotation), that a single latent factor did indeed account for most of the variance in EID scale items (Chew, 2019). However, in contrast with this result, a study by Olivos and Aragonés (2011) using a sample of Spanish undergraduates has identified five factors (EFA using a principal component factoring method and oblimin rotation). The first, accounting for the largest proportion of variance (32.8 %), was labeled environmental identity. Three remaining additional factors, with variances lower than 8%, were labeled as enjoying nature, appreciation of

nature, and environmentalism (the fifth factor was excluded because it comprised one item). Such contrasting findings mean that the dimensionality of the EID scale remains unclear. Put more simply: *Are EID scale items unidimensional or multidimensional?*

Addressing this question is theoretically and practically important because researchers studying environmental identity have, despite some evidence of multidimensionality, often compute and interpret a mean score for all EID scale items (Clayton et al., 2021; Kiesling & Manning, 2010). This approach has the advantage of being simple to understand conceptually and ensures the EID scale has adequate reliability due to a sufficiently large set of items (Chen et al., 2012). However, when using an overall mean EID scale score to predict an outcome, it is unclear whether the outcome is related equally to all subscales across different contexts. This is relevant because if not all subscales predict an outcome, the association with the overall mean score will be weakened, thus risking erroneous conclusions. An alternative approach used by some researchers is to compute and analyze a mean score for each subscale of the EID scale separately (e.g., Olivos & Aragonés, 2011). While this approach addresses some of the disadvantages of computing a mean score across all EID scale items, it is impossible to disentangle the effects of the subscales from the overall construct (Chen et al., 2012). One solution to this issue is to use the bifactor approach. A bifactor model for the EID scale hypothesizes a general environmental identity factor that accounts for relationships between items rather than relationships between first-order factors and orthogonal specific factors that account for unique variance among groups of items beyond the general factor (Chen et al., 2012). Bifactor models can be used to determine whether scale items are essentially unidimensional and, therefore, whether they capture a theoretically unidimensional construct, or sufficiently multidimensional to require an interpretation of subscales. As far as we are aware, no study has yet considered testing a bifactor model for the EID scale despite it being a plausible solution.

In sum, understanding people's level of environmental identity has clear implications for motivation and behavior toward environmental sustainability (Nielsen et al., 2021). The EID scale is accruing evidence as a reliable and valid measure of environmental identity, but it remains unclear what the appropriate factor structure for this measure is. Thus, this study aimed to use confirmatory factor analysis to test several plausible latent structures for the EID scale. Specifically, we aimed to test the four-factor model identified by Olivos and Aragonés (2011), the unidimensional model championed by Chew (2019), and a previously untested bifactor model. By testing these models we hoped to diagnose whether EID scale items are essentially unidimensional or multidimensional, with implications for how researchers score and interpret the EID scale in future research

Method

Participants and Procedure

For this study, we merged two independent samples of adult students from a Portuguese university. The first sam-

ple ($n = 174$) had participated in a study about contact with nature and environmental attitudes. The second sample ($n = 288$) had participated in a study about environmental attitudes and well-being. These samples did not differ significantly in terms of age ($t = .227, p = .820$) or gender ($\chi^2 = .900, p = .343$).

From this merged sample, we excluded four participants for having over 85% missing data for either of the primary study measures, resulting in a final sample of 458. Most of the sample were women (81%) and most were aged between 20 (1st quartile) and 30 (3rd quartile; $M = 26.7, SD = 8.92$), with a smaller number of individuals older than 30 (see [Figure 1](#)).

The two samples of participants completed different batteries of questionnaires. Both sets of questionnaires had a pen-and-paper format. A list of all measures included in these batteries is available on the paper's project page (available at: <https://osf.io/yimb2v/>). Both of these distinct batteries included the two measures included in the present study (see Measures section below). All participants completed the study measures individually while in class. This process was supervised by the class teacher. Class groups ranged from between 15 to 25 individuals. Participants did not receive compensation for their involvement.

Measures

The Environmental Identity (EID) Scale. Participants in both studies completed the 24-item Environmental Identity (EID) scale (Clayton, 2003), translated into European Portuguese (see Appendix for Portuguese and English versions of the items). Forward-translations from English to Portuguese were performed by the authors, two of whom are Portuguese and fluent in both languages. The items of the scale were presented in the form of a statement (example item: "I think of myself as a part of nature, not separate from it") to which participants indicated their agreement on a 5-point Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*).

The Connectedness with Nature Scale (CNS). For the purpose of establishing convergent validity (the extent to which a scale correlates with another scale purportedly measuring the same construct), participants also completed a Portuguese translation of the 14-item CNS (Mayer & Frantz, 2004). This instrument measures individuals' affective, experiential connections to nature (example item: "I often feel a sense of oneness with the natural world around me"), and is thus conceptually similar to the EID scale (Tam, 2013). Indeed, as is evident in the example items given, the EID scale and CNS have several items with very close overlap. The items of the CNS are scored on a Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*). In the study sample, the CNS was reliable, $\omega = .85$.

Data Analysis

We conducted analyses using the statistical environment R (version 3.6.1; R Core Team, 2019). Raw participant data are available on the paper's project page (available at: <https://osf.io/yimb2v/>).

Because we aimed to identify which of several theoret-

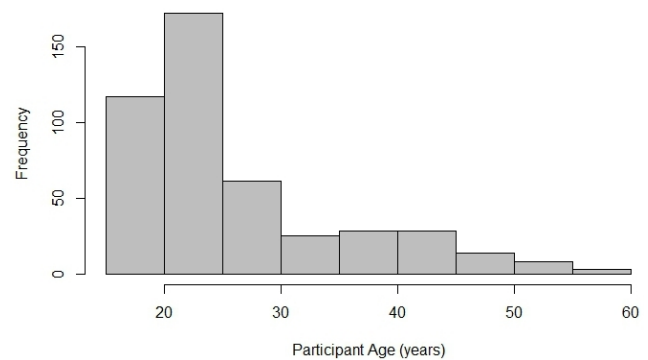


Figure 1. Histogram of participant ages.

ically plausible and empirically identified factor structures best represented our data, we used a confirmatory (CFA) rather than exploratory (EFA) approach to factor analysis. We specifically tested four *a priori* models (see [Figure 2](#)). The first two models were based on the four factors identified by Olivos and Aragonés (2011). To be consistent with the structure identified by Olivos and Aragonés, for these multidimensional models we omitted item 8. Model 1 was a first-order model where the four factors (*environmental identity*, *enjoying nature*, *appreciation of nature*, and *environmentalism*) correspond to distinct-yet-correlated constructs. Model 2 was a second-order model where a global EID factor accounts for the relationship between the first-order factors. Model 3 tested the basic unidimensional structure suggested by Clayton (2003) and supported by Chew (2019). Model 4 was a bifactor model with one general environmental identity factor and four completely orthogonal specific factors reflecting the subsets of items for each of the four factors of Models 1 and 2. Because specific factors are not mathematically or conceptually the same as first-order factors, we do not assign the same labels. Both Model 3 and Model 4 included 24 EID scale items. All CFAs used the robust maximum likelihood estimator (MLR). The fits of these models were assessed using the goodness-of-fit indices and thresholds suggested by Hu and Bentler (1999; CFI $\geq .95$, RMSEA $< .06$, and SRMR $< .08$) as well as the comparative measures of AIC, BIC and SABIC. When comparing multiple models, the model with the lowest values for these indices has the best fit.

Next, we used an Exploratory Structural Equation Modeling (ESEM) approach to test whether an alternative factor structure represents the data better than the four *a priori* models. This analysis was ancillary to our original analytical plan of performing CFAs. ESEM simultaneously addresses the restrictive nature of CFA (which presupposes a simple structure without cross-loadings and thus often inflates factor correlations) and lack of features for model confirmation in EFA (Marsh et al., 2014; Morin et al., 2013). Studies are beginning to suggest that CFA models may be too restrictive to provide acceptable fit for many psychological measures (Marsh et al., 2014). Because we were primarily interested in assessing Clayton's claim of a single underlying construct, we sought to test a bifactor-ESEM model. For this analysis, we used all 24 EID scale items. First, the optimal number of factors to extract was guided by

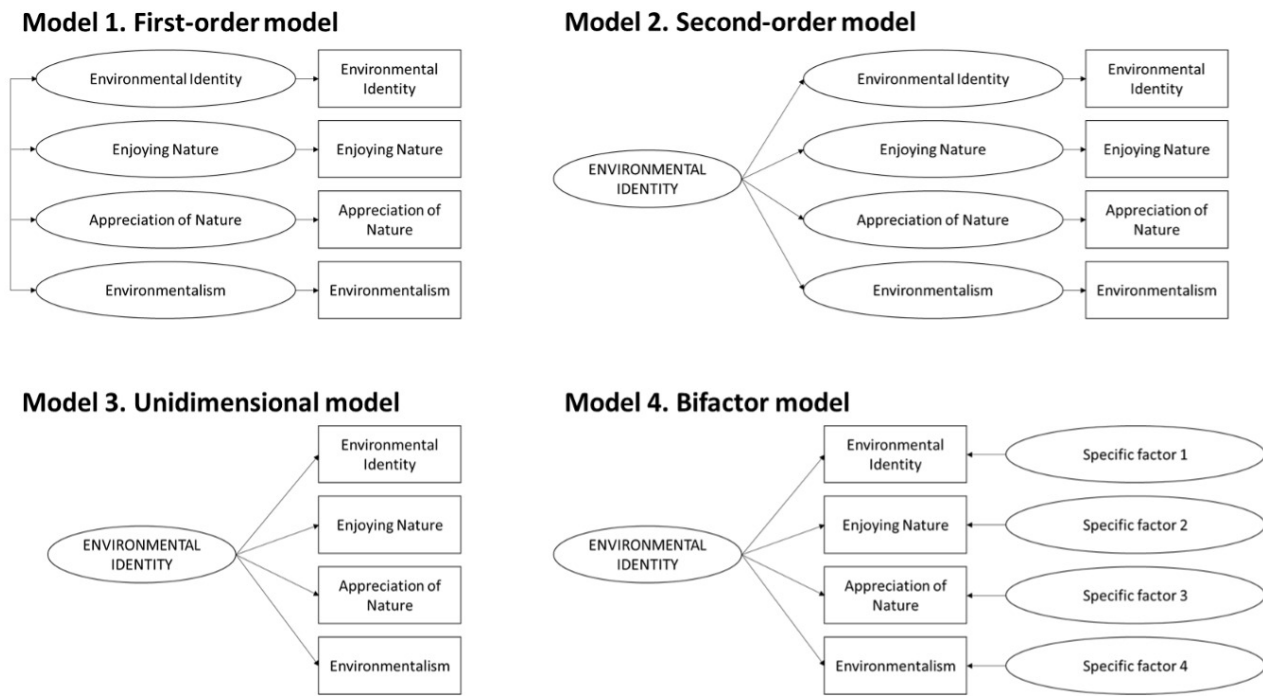


Figure 2. The four *a priori* models tested using CFA.

Ellipses represent latent factors. Rectangles represent item sets. Error terms removed for ease of interpretation.

an initial exploratory factor analysis (EFA) (*omega* function of *psych*) with Schmid-Leiman transformation. This analysis supported three specific factors alongside the general factor. Next, guided by the procedure outlined in Fischer and Karl (2019), we performed a separate EFA using the bifactor rotation of Jennrich and Bentler (2011) (*fa* function of *psych*) to test a four-factor solution (one general factor, three specific factors). Finally, the loading matrix from this EFA was transformed into structural equations and analyzed using CFA (*cfa* function of *lavaan*). In this bifactor-ESEM, items simultaneously load on the general factor and a corresponding specific factor, but unlike for bifactor CFA cross-loadings are freely estimated between specific factors.

To evaluate the interpretability of a mean EID scale score (i.e. mean across *all* EID scale items) and the degree to which this score reflects a single construct, we calculated Omega Hierarchical (ω_H) to evaluate the proportion of variance in mean EID scale scores due to the general factor. ω_H values greater than .75 suggest they are interpretable as a measure of a single construct despite observed multidimensionality (Reise et al., 2013). We also calculated explained common variance (ECV; Reise et al., 2010). ECV estimates the percentage of common variance due to the general factor. Values for ECV greater than .70 indicate that the factor loadings from a unidimensional model are a good approximation of factor loadings on the general factor in a bifactor model (Rodriguez et al., 2016).

Finally, we examined the consequences of adopting alternative models in terms of their relationship with CNS scores. Specifically, we used Structural Equation Modelling

(SEM) to estimate the factor correlations between connectedness with nature and (a) the unidimensional model, and (b) the ESEM-bifactor model. In both models, connectedness with nature was modeled as a latent factor by using a single composite indicator and fixing its error variance. Assuming the unidimensionality of connectedness with nature was appropriate based on an Omega hierarchical value of .74 for the CNS. Following the procedure used by Brown Yost & Finney (2018), the unstandardized error variance of the CNS composite was fixed to .04 based on the equation $(1 - r_{xx}) \times \text{var}(x)$, where r_{xx} was the Cronbach's coefficient alpha for the CNS (.81) and $\text{var}(x)$ was the variance of the CNS composite score (.23). The latent factor representing connectedness with nature was allowed to freely correlate with all factors in each EID model (including general and specific factors in the ESEM-bifactor model).

Results

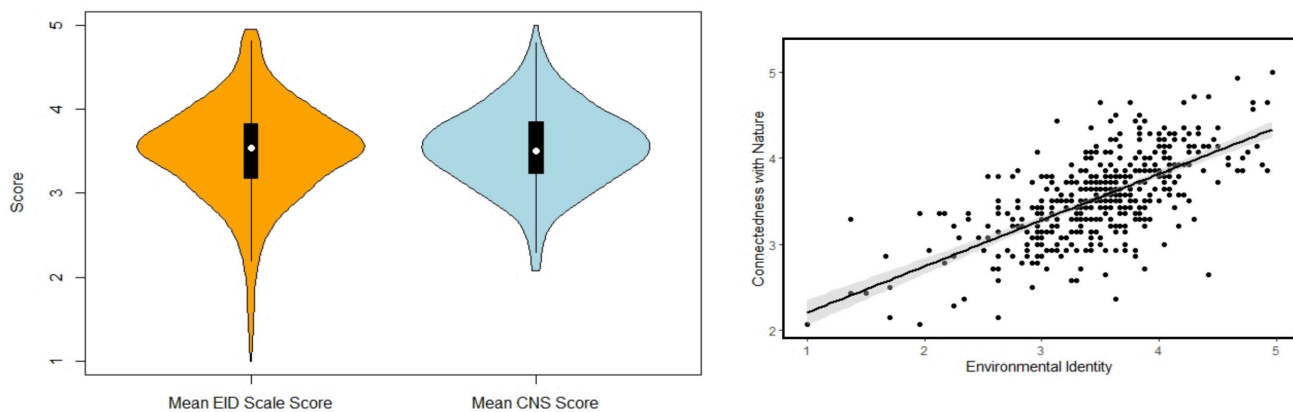
EID scale inter-item correlations are shown in [Table 1](#). Descriptive statistics for the EID scale items are presented in [Table 2](#). To summarize, most items exhibited low levels of skew and kurtosis ($< |1|$), suggesting there were no major issues of non-normality. Note, however, that there was a tendency for mild negative skew. Nonetheless, the mean scores for each item were around the middle response option, which suggests results were probably not influenced by floor or ceiling effects. EID scale descriptive statistics are shown in the left-hand panel of [Figure 3](#).

Table 1. EID-scale inter-item correlations.

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
1	1.00																									
2	.45	1.00																								
3	.35	.60	1.00																							
4	.36	.61	.54	1.00																						
5	.27	.48	.45	.47	1.00																					
6	.36	.42	.36	.43	.50	1.00																				
7	.36	.55	.43	.52	.36	.43	1.00																			
8	.20	.37	.39	.43	.41	.42	.40	1.00																		
9	.21	.37	.49	.34	.28	.32	.40	.31	1.00																	
10	.23	.38	.37	.38	.34	.43	.41	.29	.34	1.00																
11	.27	.49	.59	.43	.36	.31	.41	.39	.52	.41	1.00															
12	.26	.33	.45	.34	.36	.37	.23	.30	.30	.27	.44	1.00														
13	.33	.55	.54	.51	.46	.40	.47	.40	.39	.40	.58	.48	1.00													
14	.24	.46	.56	.48	.45	.36	.39	.45	.37	.37	.51	.46	.59	1.00												
15	.32	.45	.50	.46	.35	.39	.43	.35	.38	.39	.59	.43	.55	.43	1.00											
16	.17	.25	.31	.33	.37	.41	.27	.35	.24	.21	.25	.29	.29	.36	.24	1.00										
17	.33	.39	.33	.31	.32	.38	.30	.26	.21	.30	.29	.27	.29	.29	.26	.29	1.00									
18	.20	.33	.33	.36	.31	.29	.34	.36	.37	.31	.33	.28	.34	.32	.39	.35	.25	1.00								
19	.34	.40	.45	.40	.39	.37	.35	.37	.34	.28	.43	.36	.43	.46	.36	.30	.29	.28	1.00							
20	.26	.23	.21	.26	.21	.23	.28	.27	.14	.19	.25	.19	.26	.24	.30	.27	.31	.24	.27	1.00						
21	.22	.35	.43	.39	.43	.35	.24	.39	.31	.24	.33	.31	.35	.46	.32	.30	.22	.29	.38	.20	1.00					
22	.27	.49	.46	.54	.32	.39	.62	.48	.41	.38	.43	.25	.48	.45	.49	.28	.27	.37	.40	.31	.37	1.00				
23	.29	.44	.43	.43	.47	.46	.44	.42	.41	.38	.43	.28	.45	.39	.50	.34	.29	.48	.43	.27	.42	.55	1.00			
24	.26	.33	.27	.35	.36	.28	.32	.29	.31	.34	.24	.23	.25	.23	.30	.32	.28	.39	.31	.26	.28	.28	.43	1.00		

Table 2. EID scale item descriptive statistics.

Item	Median	Mean	SD	Skew	Kurtosis
1	3	3.05	1.05	-0.31	-0.86
2	4	3.43	0.88	-0.59	0.24
3	4	3.68	0.83	-0.86	1.09
4	3	3.38	0.96	-0.27	-0.27
5	4	3.94	0.88	-0.91	1.22
6	4	3.71	1.01	-0.81	0.30
7	3	2.86	0.93	0.09	0.05
8	4	3.52	0.92	-0.40	-0.09
9	3	3.17	0.92	-0.25	0.08
10	3	3.11	1.08	-0.21	-0.81
11	3	3.40	0.85	-0.50	0.52
12	4	3.63	0.96	-0.69	0.26
13	4	3.65	0.87	-0.65	0.68
14	4	4.09	0.83	-1.11	2.00
15	3	3.37	0.81	-0.38	0.38
16	4	3.77	1.03	-0.67	-0.12
17	4	3.75	0.99	-0.85	0.51
18	3	3.24	0.99	-0.32	-0.20
19	4	3.66	0.91	-0.70	0.56
20	4	3.45	0.94	-0.41	-0.09
21	4	4.05	0.92	-0.93	0.64
22	3	3.25	0.87	-0.18	0.18
23	3	3.29	1.04	-0.29	-0.35
24	4	3.36	1.17	-0.35	-0.77

**Figure 3. Violin plot and scatterplot of participants' mean scores for the EID scale and the CNS.**

The solid line superimposed on the scatterplot is a regression slope. EID = Environmental Identity. CNS = Connectedness with Nature Scale.

A review of the model fit indices presented in [Table 3](#) indicated that none of the a priori solutions had satisfactory fit considering the pre-defined cut-offs (Hu & Bentler, 1999). Moreover, while the values for CFI, RMSEA, and SRMR generally supported the bifactor model (Model 4) as the best fitting solution, the values for AIC, BIC and SABIC suggested that the first-order model (Model 1) was superior. However, an inspection of the factor loadings and error

variances for the bifactor model (see Supplementary Table 1) showed that this model was inadmissible due to a negative error variance for item 23. Moreover, the non-significant loadings for three of the four specific factors indicated that they were redundant in the model. Additionally, the factor correlations observed in the first-order model (M correlation = .89, SD = .05) indicated issues of discriminant validity.

Table 3. Model Fit Indices

	Model Fit							
	<i>df</i>	χ^2	CFI	RMSEA	SRMR	AIC	BIC	SABIC
Model 1. First-order model†	224	598.53	.893	.060	.050	24817.2	25031.8	24866.8
Model 2. Second-order model†	226	620.66	.887	.062	.051	24839.8	25046.2	24887.5
Model 3. Unidimensional model	252	719.57	.872	.064	.052	25960.7	26158.8	26006.5
Model 4. Bifactor model*	229	553.31	.911	.056	.045	25773.1	26066.1	25840.7
Ancillary Model								
Model 5. Bifactor-ESEM	266	346.21	.978	.026	.046	25476.9	25617.3	25509.4

Note. † = Item 8 excluded in accordance with Olivos and Aragonés (2011). *Model inadmissible due to negative error variance.

Because none of the a priori models were fully supported, we used an ESEM approach to test whether an alternative factor structure better represents the data. Because we were primarily interested in assessing Clayton's claim of a single underlying construct, we sought to test a bifactor-ESEM model. The factor loadings of the bifactor-ESEM model are shown in Table 4. The fit of the bifactor-ESEM model was notably better than the a priori models, and indicated good fit for all indices: CFI = .978, RMSEA = .026 [.018, .032], SRMR = .046.

To evaluate the interpretability of a mean EID scale score (i.e. mean across all EID scale items) and the degree to which this score reflects a single construct, we first evaluated the factor loadings shown in Table 4. For all items, factor loadings were stronger for the general environmental identity factor than the specific factors. This indicates that mean EID scale scores are appropriate. Next, we calculated Omega Hierarchical (ω_H) and ECV. The values obtained for these indices were .94 and .82, respectively. Additionally, McDonald's Omega (ω) was .94, indicating that the EID scale items had an excellent internal consistency reliability.

Finally, to evaluate the consequences of adopting different models, we calculated correlations between environmental identity and connectedness with nature using several different approaches. CNS descriptive statistics are shown in the left-hand panel of Figure 3. First, we calculated Pearson's correlations between the observed mean score across all EID scale items and the observed mean across all CNS items. As is shown in the right-hand panel of Figure 3, participants' mean scores for the EID scale and CNS had a strong positive association: $r = .66$, 95% CI [.61, .70], $p < .001$. Next, we computed factor correlations based on the unidimensional model and the ESEM-bifactor model. All correlational results are summarized in Table 5. Regardless of the approach, all produced statistically significant positive correlations of similar magnitudes. As expected, the correlation based on observed means ($r = .66$) was smaller than the latent correlations; that is, measurement error lead to attenuated correlations. It was also noteworthy that the factor correlations for the ESEM-bifactor model ($r = .75$) and the unidimensional model ($r = .77$) were similar.

Discussion

Past evidence about the latent structure of Clayton's EID scale has offered contrasting findings. While some studies supported a multidimensional structure (Olivos & Aragonés, 2011), others identified, or at least assumed, a unidimensional structure (Chew, 2019; Clayton, 2003). Given this confusion in the literature, this study aimed to investigate competing factor models to offer clarity on the dimensionality of the EID scale.

First, we tested several competing models using CFA, including two plausible multidimensional models derived from the results of Olivos and Aragonés (2011), a unidimensional model, and a bifactor model. Our first major finding was that none of these models had a satisfactory fit to the data. While the bifactor model had the strongest fit in terms of CFI, RMSEA and SRMR, it was not interpretable due to a negative error term. The remaining three models did not demonstrate acceptable fit considering our predetermined thresholds (e.g., CFI values were all lower than .95), although the values for AIC, BIC, and SABIC suggested the first-order model (Model 1) had some predictive advantage. However, the very strong factor correlations in this model suggested issues with discriminant validity; that is, the model was likely forcing factors that were not present in the data. To investigate the structure of the EID scale further, we conducted ancillary analyses using a bifactor-ESEM approach. Unlike the predefined models, this bifactor-ESEM model presented excellent fit to the data. This finding suggests that all EID scale items represent a general environmental identity factor, but also that subsets of items share variance (representing nuisance effects) not accounted for by the general factor. Based on this finding, we suggest that past studies identifying multidimensional solutions (e.g., Olivos & Aragonés, 2011) may have done so, not because environmental identity is a multidimensional construct, but because the conceptual breadth of the construct results in diverse item content (Reise et al., 2000).

In addition to supporting the ESEM bifactor structure, we conducted several analyses that provide guidance on the best way to score and use the EID scale. Several findings helped us converge on the conclusion that it is appropriate for researchers to use the mean score across all EID scale

Table 4. Factor loadings for the bifactor-ESEM model.

Item	English translation of item text	g	SF1	SF2	SF3	Error Variance
1	I spend a lot of time in natural setting (woods, mountains, desert, lakes, ocean).	.42	-.09	.03	-.22	.77
2	Engaging in environmental behaviors is important to me.	.76	.00	.09	-.43	.29
3	I think of myself as a part of nature, not separate from it.	.79	.26	-.11	-.18	.37
4	If I had enough time or money, I would certainly devote some of it to working for environmental causes.	.70	-.05	.09	-.18	.47
5	When I am upset or stressed, I can feel better by spending some time outdoors "communing with nature".	.67	-.19	-.23	-.03	.43
6	Living near wildlife is important to me; I would not want to live in a city all the time.	.59	-.22	-.05	.04	.55
7	I have a lot in common with environmentalists as a group.	.66	-.03	.41	-.12	.38
8	I believe that some of today's social problems could be cured by returning to a more rural life-style in which people live in harmony with the land.	.60	-.05	.03	.16	.58
9	I feel that I have a lot in common with other species.	.56	.24	.09	.11	.65
10	I like to garden.	.49	.03	.07	.03	.76
11	Being a part of the ecosystem is an important part of who I am.	.74	.51	-.03	.00	.34
12	I feel that I have roots to a particular geographic location that had a significant impact on my development.	.53	.18	-.29	.01	.64
13	Behaving responsibly toward the Earth – living a sustainable life-style – is part of my moral code.	.76	.24	-.05	-.10	.44
14	Learning about the natural world should be an important part of every child's upbringing.	.73	.18	-.17	.00	.45
15	In general, being part of the natural world is an important part of my self-image.	.72	.29	.09	.07	.45
16	I would rather live in a small room or house with a nice view than a bigger room or house with a view of other buildings.	.45	-.18	-.12	.18	.67
17	I really enjoy camping and hiking outdoors.	.45	-.14	-.06	-.09	.75
18	Sometimes I feel like parts of nature – certain trees, or storms, or mountains – have a personality of their own.	.50	-.03	.07	.23	.66
19	I would feel that an important part of my life was missing if I was not able to get out and enjoy nature from time to time.	.61	.04	-.09	.04	.63
20	I take pride in the fact that I could survive outdoors on my own for a few days.	.38	-.07	.07	.10	.82
21	I have never seen a work of art that is as beautiful as a work of nature, like a sunset or a mountain range.	.56	-.04	-.17	.12	.62
22	My own interests usually seem to coincide with the position advocated by environmentalists.	.70	.05	.41	.07	.33
23	I feel that I receive spiritual sustenance from experience with nature.	.63	-.05	.12	.22	.50
24	I keep mementos from the outdoors in my room, such as shells or rocks or feathers.	.40	-.16	.03	.12	.77
Latent Factor Correlations						
	SF1	-.19*	1			
	SF2	.01	.00	1		
	SF3	.09	-.04	-.02	1	

Note. g = General Environmental Identity Factor. SF = Specific Factor. * Latent factor correlation significant at $p < .01$. Loadings $> |.20|$ are in **bold**.

items as an index of an individual's environmental identity. First, factor loadings in the ESEM bifactor model were consistently higher on the general environmental identity factor than specific factors. Indeed, loadings on the specific factors were generally very poor (almost all lower than $|.40|$)

meaning it was difficult to interpret the meaning of these shared sources of variance. Second, the values for omega hierarchical and ECV were high. Specifically, omega hierarchical indicated 94% of the variance in mean EID scale scores was attributable to the general environmental iden-

Table 5. Estimations of the association between Environmental Identity and Connectedness with Nature via observed means and factor correlations.

Method of computing correlation	Correlation with Connectedness with Nature
Observed means	.660
Unidimensional model of EID	.765
ESEM-Bifactor model of EID	.747

Note. All correlations significant at $p < .001$. EID = Environmental Identity

tity factor. Moreover, the ECV for the EID scale was .82, which implies factor loadings from a unidimensional model are a good approximation of factor loadings on the general factor in a bifactor model. Third, the fact that ω and ω_H were practically the same (difference of .003) indicated that the general factor of the ESEM bifactor model was the sole determinant of systematic variance associated with mean EID scale scores. Finally, we found that the relationship between environmental identity and connectedness with nature was largely unchanged by whether the EID scale was modeled as a unidimensional model or an ESEM bifactor model.

Combined, these findings offer evidence that EID scale items are essentially unidimensional and, therefore, capture a theoretically unidimensional construct. Put differently, our results showed that the nuisance effects of the specific factors in the ESEM bifactor model were mostly trivial. Consequently, we strongly advise against calculating individual subscale mean scores based on these specific factors. Indeed, these specific factors represent additional portions of variance not accounted for by the general factor and are not equivalent to theoretical dimensions of environmental identity. We also suggest strong caution interpreting any findings on the relation between EID subscales and outcomes because of the strong and inseparable contribution from the general factor. More positively, a key implication of this finding is that the EID scale appears to be sufficiently unidimensional that researchers can have confidence applying structural equation modeling (SEM) and IRT models that assume unidimensionality.

Despite the relevance of our findings, it is necessary to acknowledge limitations of the study. First, the study only used self-report data; a methodological choice that is criticized for introducing bias to data (e.g. social desirability effects). Second, the chosen sampling method has implications for the external validity of the findings. Non-probability sampling methods make it difficult to generalize research findings from a sample to the general population because they are characteristically non-random, meaning that is uncertain whether the present study findings would replicate in other Portuguese samples. A related issue is whether our findings, and the findings in past work, can be generalized outside of the ethnic and cultural contexts in which they are based. Cross-cultural studies testing measurement invariance are needed to determine if the EID scale measures the same essentially unidimensional construct in different cultural contexts. As far as we are aware, this has not yet been accomplished in the literature. Tests of measurement invariance are also important for determin-

ing whether the construct of environmental identity has the same meaning across other groups of individuals, such as men versus women. Other avenues for future research include applying the multitrait-multimethod matrix approach (Campbell & Fiske, 1959) using measures of other theoretically related variables, including those assessing pro-sustainable development behaviors, to provide a more robust assessment of the EID scale's construct validity. Beyond the sphere of psychometric assessment, one necessary avenue for future research is to adopt longitudinal designs to describe (a) how environmental identity changes across important developmental periods (such as across adolescence), (b) the predictors of this change, and (c) the impact of such change on relevant outcomes, such as the adoption of pro-sustainable development behaviors.

To conclude, this study supports the use of the EID scale, and specifically the European Portuguese translation. We found an ESEM bifactor model had good fit to our data. In addition, based on (a) most items being more strongly related to the general factor than specific factors, (b) high values for omega hierarchical and ECV, and (c) finding that the relationship between environmental identity and connectedness with nature was largely the same for the unidimensional model and ESEM bifactor model, we conclude the EID scale captures an essentially unidimensional construct. Therefore, computing and interpreting a mean EID scale score is appropriate and preferable over computing means for individual subscales.

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Competing Interests

The authors state that there are no conflicts of interest to declare.

Supplemental Materials

Table S1. Factor loadings for the bifactor-CFA model. Docx

Data Accessibility Statement

Raw participant data are available on the paper's project

page (available at: <https://osf.io/ymb2v/>).

PDT

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Table S1

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