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Is environmental sensitivity a unique trait? A multi-sample study on the association between sensitivity, personality, and psychological adjustment

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ABSTRACT

We aimed to investigate the extent to which Environmental Sensitivity (ES), as captured by the Highly Sensitive Person, 12-item scale (HSP-12), is distinguishable from traditional personality traits, contributes to psychological adjustment over and above personality, and if this contribution depends on the rearing environment. We also explored the HSP-12 psychometric properties and invariance across countries (UK and Italy) and samples (university and general population). Across multiple adult samples ($N = 4459$), we provided evidence that ES can be reliably assessed with the HSP-12 across countries and groups. We also showed that ES is distinguishable from established personality traits and is associated with lower well-being and negative affect, beyond personality. An environment perceived as caring played a buffering role.

1. Introduction

The notion that the quality of the environment interacts with individual differences in predicting development and adjustment is a well-known phenomenon in psychology, but it is only recently that, informed by the concept of Environmental Sensitivity (Pluess, 2015), there has been a significant increase in empirical studies investigating this person-environment interplay. This has been possible also thanks to the development of relatively easy-to-adopt measures to capture individual differences in sensitivity to stimuli (Davies et al., 2021; Lionetti, Aron, et al., 2019; Pluess et al., 2020). The term Environmental Sensitivity refers to a conceptual framework that summarises different theories, including Differential Susceptibility (Belsky & Pluess, 2009), Biological Sensitivity to Context (Boyce & Ellis, 2005), and Sensory Processing Sensitivity (Aron & Aron, 1997). It also refers to individual traits that capture human differences in the perception and processing of stimuli across childhood, adolescence, and adulthood (Davies et al., 2021; Lionetti et al., 2018; Pluess et al., 2018). Individuals with increased Environmental Sensitivity, due to the deeper perception and processing of stimuli (Aron & Aron, 1997), are better able to recognize details in their surroundings and more strongly influenced by what is going on. They are, for better and worse, more influenced by the high and low quality of the environment (Pluess, 2015). This theoretical proposition, confirmed by empirical findings, has important implications for a variety of contexts, including work environments (Evers et al., 2008; Redfearn et al., 2020), family contexts (Lionetti et al., 2022; Moscardino et al., 2021; Slagt et al., 2018), schools (Iimura & Kibe, 2020; Nocentini et al., 2019), peer relationships (Fischer et al., 2022), and clinical settings (Aron, 2020; de Villiers et al., 2018).

Despite the relevance of the Environmental Sensitivity concept for understanding individual's adjustment, it is still lively debated the extent to which it overlaps with existing personality traits (Bröhl et al.,

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2020; Lionetti, Aron, et al., 2019), and its contribution over and above personality in predicting psychological outcomes (Hellwig & Roth, 2021). Moreover, most evidence comes from studies on university students. The moderating role of the environment on the association between sensitivity and individual adjustment has been sparsely explored in adult samples, and studies exploring the association between sensitivity and psychological outcomes most often focused on vulnerabilities only, with a few exceptions (for a review, see Greven et al., 2019). With the current paper, we aim to contribute to this field of research by exploring across multiple and independent samples the extent to which Environmental Sensitivity is distinguishable from traditionally assessed personality traits as captured by the Five Factor Model of personality, the extent to which it contributes to individual adjustment over and above the Big Five personality traits, and if this contribution depends on the quality of the environment. Before doing this, we will explore the psychometric properties of the Highly Sensitive Person scale, 12 item version (Pluess et al., 2020), the scale invariance across UK (from the original HSP-12 validation sample, Pluess et al., 2020) and Italian samples, and between students and the general population.

1.1. Assessment and factor structure of environmental sensitivity in adulthood

One of the most widely adopted measures to assess Environmental Sensitivity is the Highly Sensitive Person (HSP) scale, introduced over twenty years ago as a 27-item questionnaire (Aron & Aron, 1997). Its development has informed subsequent parent-reported (Slagt et al., 2018; Sperati et al., 2022) and child-reported (Pluess et al., 2018) questionnaires and observational procedures (Lionetti, Aron, et al., 2019) to measure sensitivity in children, with promising empirical findings (Greven et al., 2019; Pluess et al., 2020). The HSP scale was first proposed by Aron and Aron (1997). It was the result of an initial interview process with 39 adults (of which 12 % were students) recruited from psychology classes at the University of California at Santa Cruz and through announcements in a campus staff newsletter and a local arts association newsletter, that identified themselves as highly sensitive, introverted, or easily overwhelmed by stimuli. The authors further followed up the analyses on a sample of over 900 undergraduate psychology students and individuals from a community sample. This process resulted in a 27-item scale version deemed to capture a single sensitivity factor (Aron & Aron, 1997). However, subsequent exploratory and confirmatory factor analysis approaches converge towards separate components (Smolewska et al., 2006), including (1) Ease of Excitation (EOE, namely, being easily overwhelmed by internal and external stimuli), (2) Aesthetic sensitivity (AES, i.e., openness for, and pleasure of, aesthetic experiences and positive stimuli), (3) Low Sensory Threshold (LST, capturing sensitivity to external stimuli as bright lights or loud noises). Yet, empirical studies have often considered the total score rather than sub-components when studying positive and negative outcomes associations, likely because it is more coherent with the theoretical definition of the sensitivity concept and considering the relatively good internal consistency of items (Aron & Aron, 1997). Recently, a bifactor model has been suggested to reconcile the competitive three-factor model with the originally hypothesized one-factor structure based on data from child and adult samples (Lionetti et al., 2018; Pluess et al., 2018). This solution includes a general sensitivity factor and recognizes the HSP scale's multidimensionality as represented by the three EOE, AES, and LST components, and it has also been found to fit well for the HSP-12 item scale (Pluess et al., 2020).

In this contribution, before exploring the association between Environmental Sensitivity, as captured by the HSP-12, and personality and psychological adjustment, we will test the HSP-12 item factor structure in an Italian sample and explore the scale invariance with the English-speaking UK sample derived from Pluess et al. (2020), and between students and the general population.

1.2. Environmental sensitivity and established personality and temperament traits

The extent to which sensitivity can be distinguished from established personality and/or temperament traits has been, and it is, a widely discussed topic. Aron and Aron (Aron et al., 2012; Aron & Aron, 1997), who developed the Highly Sensitive Person scale as a measure of sensitivity to the environment, repeatedly highlighted theoretical differences between the concept of sensitivity and other traits such as neuroticism, fearfulness, inhibition and shyness given the tendency for both fearful and sensitive individuals to show a cautious, pause-to-check approach, when encountering unfamiliar situations. This theoretical reasoning was further supported by empirical evidences in which they controlled for neuroticism in empirical studies (Aron et al., 2012; Aron & Aron, 1997). Yet, in adults, based on self-report evidence, other authors (Evans & Rothbart, 2008) suggested that sensitivity as assessed via the HSP scale is primarily comprised of items reflecting orthogonal temperament trait of negative affect and orienting sensitivity, while in pre-schoolers (when sensitivity was assessed at an observational level) data suggested that the sensitivity trait can be clearly distinguished from traditionally observed temperament traits (Lionetti, Aron, et al., 2019). A relatively recent meta-analysis (Lionetti, Pastore, et al., 2019) exploring available evidence on the association between sensitivity and personality as captured by the Five-Factor Model (FFM) of personality traits showed that sensitivity moderately correlated with Neuroticism in both children and adults and weakly with Openness to Experience in adults. Extraversion, Agreeableness, and Conscientiousness showed no relevant associations with sensitivity. These moderate associations with personality traits point to the distinctiveness of sensitivity as measured with the HSP scale. Additional results (Pluess et al., 2020) among the general population in the UK confirmed that sensitivity correlated with Neuroticism and Openness but also detected a weak correlation with lower Extraversion. Multiple regression further suggested that the five personality factors account for only about a third of the variance of the HSP-12. Importantly, all Neuroticism facets were distinguishable from the HSP-12 subscales, despite the shared variance with anxiety, depression, self-consciousness, and vulnerability. The only personality facet that could not be distinguished from the HSP Aesthetic Sensitivity factor was Artistic Interest, an Openness facet. Trying to shed further light on Environmental Sensitivity and personality, Bröhl et al. (2020) suggested that sensitivity can be seen as a blend of facets across Neuroticism and Openness. The strongest associations were with facets referring to proneness to internalizing behaviours and affinity towards art and knowledge. On the contrary, Hellwig and Roth (2021) observed that the relation between sensitivity, as captured by the HSP scale, and emotion recognition can be fully explained by Neuroticism and Openness to Experience, suggesting a conceptual similarity between the two personality traits and sensitivity (as Evans and Rothbart (2006) suggested in relation to temperament traits). However, the samples were modest ($Ns < 300$) and composed only of university students. On the contrary, Tabak et al. (2022) found, across independent samples of over 1000 subjects, that Environmental Sensitivity, as captured by the HSP scale in adults, explained unique variance in empathy, social anxiety, and theory of mind, over and above Neuroticism, Extraversion, Agreeableness, and Openness, hence suggesting that sensitivity is clearly distinguishable from traditionally assessed personality traits.

Although the Five Factor Model (FFM) of personality is the most established personality framework, lexical research has provided evidence for six main personality dimensions (Ashton & Lee, 2020; Ashton et al., 2004). The six dimensions of the HEXACO model (Lee & Ashton, 2004) are Honesty-Humility (H), Emotionality (E), eXtraversion (X), Agreeableness (A), Conscientiousness (C), and Openness to Experience (O) (Ashton & Lee, 2007). The variance of Agreeableness and Emotional Stability of the FFM is redistributed into the HEXACO Honesty-Humility, Emotionality, and Agreeableness. Both models include an Agreeableness factor. However, the HEXACO Agreeableness does not include aspects

linked to sentimentality but does include anger. Therefore, anger is not in the factor HEXACO Emotionality, the conceptual equivalent to the FFM-Neuroticism that contains anger. Because of these differences and the relationship between the HSP-scale and the FFM Neuroticism, using the HEXACO could provide additional information about the relationships between Sensitivity and personality traits. However, to our knowledge, no published research has examined these associations.

In the current paper, we will explore, across multiple independent samples, associations between Environmental Sensitivity, as captured by the HSP 12-item scale, and personality traits, as captured by the HEXACO Personality Inventory. Moreover, we will explore the predictive role of sensitivity on a series of outcomes related to psychological adjustment when controlling for personality traits.

1.3. Environmental sensitivity and psychological adjustment

Traditionally, HSP has been associated with various maladaptive psychological outcomes and psychopathology symptoms in adult samples (for a review, Greven et al., 2019). Relationships between Environmental Sensitivity, positive emotions, and psychological resources have been less explored. This is likely due to a strong interest in uncovering the basis of maladjustment among highly sensitive individuals. Empirical data indeed shows that Environmental Sensitivity positively correlates with anxiety, depression, and poor social skills among college students (Liss et al., 2008). In the general population, Environmental Sensitivity is also negatively associated with subjective happiness (Sobocko & Zelenski, 2015), higher levels of stress (Bakker & Moulding, 2012; Benham, 2006; Evers et al., 2008), less adaptive strategies to deal with stress (Brindle et al., 2015), greater perception of home chaos (Wachs, 2013), higher rates of turnover intentions in expatriate workers (Andresen et al., 2018) and more physical symptoms (Benham, 2006; Ghorbani Taghlidabad & Tasbihsazan Mashhadi, 2018). It is also over-represented in individuals with Type 1 diabetes (Goldberg et al., 2018). Interestingly, a study reported that the lowest levels of life satisfaction for high sensitive individuals were reached when adults scoring high on sensitivity reported negative childhood experiences, reflecting a dual-risk (sensitivity combined with negative rearing experiences) effect (Booth et al., 2015). However, when researchers have started to include positive aspects of the environment, empirical data supports Environmental Sensitivity as a resource as well. In children, an increased Environmental Sensitivity correlates with ruminative thinking but only when the quality of the environment is less than optimal (Lionetti et al., 2021). Highly sensitive children show better social competence and emotional well-being when their environment (family or school context) is supportive (Lionetti et al., 2022; Lionetti, Aron, et al., 2019; Nocentini et al., 2019; Pluess & Boniwell, 2015; Slagt et al., 2018). For highly sensitive children, high respiratory sinus arrhythmia, a marker of adaptive regulatory strategies at the physiological level, has a stronger positive effect on well-being (Moscardino et al., 2021), especially in contexts that may challenge children's well-being, such as low socio-economic status families. In other words, they seem more able to benefit from more adaptive physiological regulatory competences. However, the moderating role of the environment on the association between sensitivity and psychological adjustment in adulthood has been much less investigated. And when explored, studies mainly focused on negative psychological outcomes only (Liss et al., 2005). Interestingly, a recent qualitative study showed that highly sensitive individuals reported more well-being when they experienced low-intensity positive emotion and practiced self-acceptance and self-compassion as well as nature and contemplative practices (Black & Kern, 2020). Similarly, in a quantitative study, Cadogan et al. (2023) identified an increase in positive affect in response to a nature exposure intervention for those with higher levels of sensitivity. Overall, these findings suggest that despite the often reported positive associations between sensitivity and negative affect one should not ignore the potential for heightened positive emotions in highly sensitive individuals (conditional on specific condition). Similarly, sensitivity in adults was found to correlate with positive emotions after a positive mood manipulation laboratory task (Pluess et al., 2023).

In this contribution, we will investigate the associations between sensitivity and positive and negative psychological outcomes and the extent to which the perceived quality of the rearing environment moderates these associations, with the expectation that positive as well as negative aspects of the environment will impact the association between sensitivity and outcomes, in a for-better-and-for-worse manner.

1.4. The current study

1.4.1. Aims

This study aims to contribute to the literature on Environmental Sensitivity by exploring bivariate associations with personality, associations with psychological outcomes controlling for personality traits, and moderated by the perceived quality of the rearing environment. Before doing this, we will also explore the HSP-12 item scale psychometric proprieties and invariance across samples. We will achieve these aims by combining independent samples, composed of students recruited from universities (samples 1 to 4, Table 1) and individuals from the general population (sample 5, Table 1) across different regions of Italy. For testing invariance, we will also consider an independent community sample of UK resident individuals (from Pluess et al. (2020) in which the HSP-12 item scale has been originally validated (sample 6, Table 1).

Pertaining to the psychometric properties of the scale, we hypothesize that the model that will best fit the data of the HSP-scale will be a bifactor model with three unique factors and one general sensitivity factor (Lionetti et al., 2018). We also expect some measurement invariance when comparing the Italian and UK samples, and when comparing students and individuals from the general population. Moreover, we hypothesize that the HSP-scale will correlate with some of the six personality HEXACO dimensions, especially Emotionality. However, we expect these correlations to be always lower than 0.80 (Cheung et al., 2023) and the HSP-scale to show incremental validity in predicting psychological outcomes over and above the six personality dimensions. Incremental validity would support the HSP's usefulness as a valid instrument to predict well-being indexes independently from other personality traits, and inform on the trait's applied and theoretical relevance to better understand individuals' adjustment. Finally, we expect the contribution of HSP-12 to psychological adjustment to be moderated by the quality of the environment. That is, we expect that rearing environments perceived as positive would decrease the association between sensitivity and negative affect, and potentially predict higher well-being. Similarly, we expect a rearing environment perceived as less than optimal to increase psychological vulnerabilities for higher sensitivity levels.

2. Method

2.1. Participants and procedure

The total sample included 4459 participants from different Italian regions and the UK. We did not perform any power analysis and we aimed to collect a sample as big as possible in light of available resources (see Analysis Plan for more details on power). Within the total sample, 1351 participants were mainly Italian university students. The remaining participants were from the general population, recruited in Italy via a snowball procedure and in the UK through a website designed for data collection purposes (Prolific). All participants completed the 12-item version of the HSP scale online (Aron & Aron, 1997; Pluess et al., 2020). Then, depending on the sample, participants completed different additional measures (see Table 1 for details and samples' characteristics). The Ethical Review Board of the universities responsible for the data collection provided the approval. Anonymized data are available on GitHub at *link to the public repository available before publication.*

Table 1
Sample's description and measures.

	Total	Sample 1 (Milan1)	Sample 2 (Milan2)	Sample 3 (Florence)	Sample 4 (Trieste)	Sample 5 (General pop, IT)	Sample 6 (General pop, UK)
N	4459	290	464	358	239	2386	722
Female	3642	196	392	316	163	2097	478
Male	810	94	72	40	76	287	241
Missing gender	3			2			1
Other gender	2						2
M age (*SD*)	22.93 (5.93)	22.46(2.83)	23.82(1.88)	20.14(3.60)	30(10.1)	40.81(12.49)	33.54(8.11)
HSP-12 ($n = 4459$)		X	X	X	X	X	
HEXACO ($n = 636$)		X	X				
SWL ($n = 948$)		X	X		X		
PGWB-S ($n = 615$)		X	X				
PGWB_L ($n = 229$)					X		
DASS ($n = 430$)			X				
PERMA ($n = 358$)				X			
PBI ($n = 450$)			X				
Life Events ($n = 290$)		X					

2.2. Measures[1]

All reliability indices for measurement scales are reported in Table 6.

2.2.1. The 12-item HSP scale

All participants answered the 12 items of the HSP scale (Pluess et al., 2020) (e.g., "Do you find it unpleasant to have a lot going on at once?") on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Scores are averaged to yield a total sensitivity score, with higher scores indicating higher levels of sensitivity. All items followed a back-translation procedure that the original authors of the questionnaire authorized. The Italian translation is available upon request from the website https://sensitivityresearch.com. Aron and Aron (1997) reported good internal reliability for the original version of the 27-item HSP scale, with Cronbach's alphas of 0.87 and 0.85, depending on the sample. Similar values have been reported for the 12-item scale (Pluess et al., 2020).

2.2.2. The 60-item HEXACO Personality Inventory

The HEXACO (Ashton & Lee, 2009) inventory was used for investigating personality traits. It assesses the six personality dimensions: conscientiousness, extraversion, agreeableness, openness to experience, emotionality, and honesty–humility with 10 items for each with a 5-point Likert response scale ranging from 1 (strongly disagree) to 5 (strongly agree).

2.2.3. Negative and positive life events measure

To capture the quality of the environment, participants were asked to list up to 10 major life events (Pluess et al., 2010) that had occurred in the past 6 months and rate their impact on a 7-point scale ranging from −3 "very negative" to +3 "very positive." A total score was calculated by summing the participant's ratings, with lower values representing more negative and higher values more positive events.

2.2.4. Psychological general well-being index

The Psychological General Well-being Index (PGWBI), (Dupuy, 1984; Grossi et al., 2006) consists of 22 items, rated on a 6-point scale, which assess the psychological and general well-being of respondents in six health-related Quality of Life domains: lack of anxiety (5 items), lack of depression (3 items), positive well-being (4 items), self-control (3 items), general health (3 items), and vitality (4 items) referring to the last 4 weeks of the respondent's lifetime. We removed the suicide tendencies item from the depression subscale for ethical reasons. The scores for all domains can be summarized into a global summary score, which reaches a theoretical maximum of 110 points, representing the highest achievable level of well-being (Dupuy, 1984).

2.2.5. Short version of the Psychological General Well-Being Scale

The short version of the Psychological General Well-Being Scale (PGWB-S; (Grossi et al., 2006) contains 6 items measuring anxiety, depressed mood, positive well-being, self-control, general health, and vitality rated on a 6-point scale, where a higher score indicates a higher level of psychological well-being.

2.2.6. Satisfaction with life

Participants completed the five items of the Satisfaction with Life Scale (SWL, (Diener et al., 1985)) with a 7-point Likert scale with higher values corresponding to a higher degree of life satisfaction. The total score is calculated to represent a level of satisfaction ranging from 5 to 35. (Pavot & Diener, 1993) proposed that a score of 20 represents the neutral point on the scale, the point at which the respondent is about equally satisfied and dissatisfied. For example, scores between 15 and 19 represent slightly dissatisfied with life, scores between 21 and 25 represent slightly satisfied, and scores between 26 and 30 represent satisfaction, and scores from 5 to 9 are indicative of being extremely dissatisfied with life.

2.2.7. Parental Bonding Index

The Parental Bonding Index (Parker et al., 1979) was used to assess the quality of the perceived environment during childhood. The scale is composed of 12 items for assessing a positive environmental variable, Care, and 13 items to capture Overprotection. Items are rated on a 4-point response format from 0 to 3. Each subscale score is computed by summing the different items, with a higher score indicating higher care or overprotection.

2.2.8. PERMA

The PERMA scale (Butler & Kern, 2015, 2016; Giangrasso, 2021) measures well-being in terms of five pillars: Positive emotion, Engagement, Relationships, Meaning, and Accomplishment, or PERMA with 18 items (3 items for each dimension) on 11-point scales from 0 (not at all) to 10 (completely). A higher score corresponds to the greater presence of the investigated dimension.

2.2.9. Depression, Anxiety, and Stress Scale

The *Depression Anxiety Stress Scales*-21 was used (DASS-21, (Parkitny & McAuley, 2010) adopting the validated Italian version (Bottesi et al., 2015). Each item is scored on a *4-point Likert scale* ranging from 0 ("did not apply to me at all") to 3 ("applied to me very much"). Scores are summed, with higher values capturing higher levels of negative affect.

[1] Other measures were included in the different samples. We did not analyze the data considering them so they will not be mentioned in the text.

2.2.10. Analysis plan

First, in order to investigate the dimensionality of the HSP, we applied a Confirmatory Factor Analysis (CFA) to test the goodness of fit for the hypothesized bifactor model in the Italian student sample with three unique factors and one general sensitivity factor (Lionetti et al., 2018). We compared this solution to alternative models, i.e., one-factor (as originally proposed by Aron and Aron (1997)) and three-factor structure (Smolewska et al., 2006). For the evaluation of the goodness of fit, we considered as fit indices the Tucker-Lewis index (TLI), the Comparative Fit Index (CFI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residuals (SRMR). CFI and TLI values above 0.95 and 0.97, respectively, are considered indicators of an acceptable and good fit. For RMSEA, values lower than 0.05 and SRMR values lower than 0.08 are considered to reflect a good fit (Schermelleh-Engel et al., 2003). Lastly, the Akaike information criterion (AIC) was used to compare nested models in evaluating differences in fit. Lower values of AIC would indicate a superior model fit when comparing nested models (Sun, 2005).

To test if the HSP scale measures the same construct for different groups, we tested for measurement invariance of the best model across two additional samples to draw comparisons in factor structure, the magnitude of loadings, and intercepts. One sample was drawn from the general population in the UK ($N = 722$, Mage $= 33.54$, $SD = 8.10$, range 19–51 years, 66 % female). The sample, recruited through the website Prolific, was previously used to investigate the HSP-12's properties by Pluess et al. (2020). The second sample was drawn from the general population, but this time in Italy ($N = 2387$, Mage $= 41$, $SD = 12.49$, range 18–88, 88 % female) and was recruited via a snowball procedure through social media, originally to investigate depression, anxiety, and post-traumatic growth during the COVID-19 outbreak. We tested for configural, metric, and scalar invariance in sequential order for two models, the first comparing language (Italian student sample vs. UK sample) and the second comparing the Italian student sample and the Italian general population sample. Configural invariance models test whether the model's basic structure is the same in both groups. In contrast, metric invariance testing entails constraining items to have equal loadings, thus testing whether the relative strength of associated items on each factor is the same. Lastly, scalar invariance testing involves additionally constraining the model intercepts to be equal, allowing for comparisons of latent means (Wang et al., 2018).

Considering the Structural Equation Modelling (SEM) analysis required for the modelling of Confirmatory Factor Analysis, conventions suggest that the sample size should be at least 100 participants (in some cases, 200 or 300 for complex models) (Jackson, 2001; Anderson & Gerbing, 1984). Following a participant-parameter (N:q) ratio recommendation of 10:1 (Bentler & Chou, 1987), for a model with 24 parameters, we would need at least 240 participants to achieve adequate power. Therefore, with large samples exceeding 500 participants, we expect to achieve reasonable power for the SEM and measurement variance analyses.

Second, we explored associations between sensitivity and personality with Pearson's r bivariate correlations. Third, with a series of multiple linear regressions, we explored the HSP scale's ability to predict a series of psychological outcomes alone and controlling for personality variables, hence further testing incremental validity. Finally, we investigated whether the HPS scale moderates the association between the environment and psychological outcomes with a series of moderation analyses.

3. Results

3.1. Factor structure

Confirmatory Factor Analyses were run in R using package lavaan with maximum likelihood (ML) as the estimation method (Rosseel, 2012). Fit statistics are presented in Table 2 for the Italian student sample ($N = 1351$). We compared the goodness of fit of the bifactor model and the three-factor model (EOE, AES, and LST without the general factor). The bifactor model showed a better fit when considering the Chi-square difference, $\Delta\chi^2(12) = 389.18$, $p < .001$, and considering AIC, for which the bi-factor model demonstrated the lowest value. The bi-factor model factor loadings are presented in Table 3.

Table 2
Fit statistics for the HSP model structure, Italian sample 1–4.

	χ^2	df	CFI	TLI	AIC	RMSEA	SRMR
1 Factor	1605.842	54	0.658	0.581	56,447	0.146	0.117
3 Factor	530.862	54	0.895	0.871	55,372	0.081	0.118
Bi-Factor	141.685	42	0.978	0.965	55,007	0.042	0.028

Note. $N = 1353$.

3.2. Measurement invariance

Model fit statistics are shown in Table 4. First, we compared the Italian student sample with the general population UK sample. A model testing for scalar invariance could not be identified. Chi-square difference testing indicated that the configural and metric models were significantly different from each other, $\Delta\chi^2(20) = 76.041$, $p < .001$. We tested a partial metric invariance model and a partial scalar invariance model, allowing only part of the loadings and intercepts to be constrained. Chi-square difference testing indicated that the configural and partial metric models were significantly different from each other, $\Delta\chi^2(16) = 51.631$, $p < .001$, as well as the partial metric and partial scalar models, $\Delta\chi^2(8) = 146.18$, $p < .001$. Therefore, we can only conclude that Italian and UK respondents demonstrate similar factor structures in their responses to the scale. We cannot make comparisons of latent means for each item, given that the scalar model demonstrated significantly worse fit indices. Even though the metric invariance models were statistically different from the configural model based on chi-square difference, some have argued against solely relying on chi-square for model comparisons due to chi-square being sensitive to small deviations (Putnick & Bornstein, 2016). Chen (2007) suggests cut-off values of −0.01 change for CFI, RMSEA change of 0.015, and SRMR change of 0.030. Using these guidelines, the metric invariance model may be considered sufficiently similar to the configural model regarding fit indices. Thus, there may be supporting evidence that the two groups demonstrate the same factor structure of responses (configural model) and a comparable magnitude of responses. In fact, upon examining the factor loadings from the metric invariance model (Table 5), the strongest and weakest loading items on each factor are the same for both groups, except for the aesthetic sensitivity factor.

We tested a second model comparing the general population Italian sample with the Italian student sample, using the sequential method previously described. Using Chen (2007) cut-off values, results indicated that a metric invariance scale could be accepted while a scalar invariance scale was rejected due to a large change in CFI (Table 4, lower).

This suggests that responses follow the same factorial structure and similar magnitude of loadings when comparing the Italian student sample and the Italian general population sample. However, we cannot conclude that the mean response level is the same (Table 5). Furthermore, while some of the factor loadings appear to be relatively low, suggesting that some items are not performing as well as others, they are performing similarly in all populations suggesting the issue does not lie with the translation of the scale or reflect cultural differences.

3.3. Internal consistency

We computed McDonald's omega as a reliability indicator (see Table 6) on the Italian sample ($N = 1351$). The overall HSP scale and the three subscales showed acceptable to good internal reliabilities. The HSP-LST subscale demonstrated the lowest reliability, confirming the

Table 3
Bi-factor model standardized loadings of the HSP, Italian sample.

	Ease of excitation	aesthetic sensitivity	Low sensory threshold	General factor
HSP8	**0.817**			**0.459**
HSP6	**0.648**			**0.453**
HSP4	**0.596**			**0.483**
HSP9	**0.231**			**0.543**
HSP12	**0.217**			**0.494**
HSP5		0.**750**		**0.140**
HSP10		**0.742**		**0.238**
HSP3		0.**376**		**0.252**
HSP1		**0.339**		0.016
HSP11			0.656	0.**609**
HSP2			0.427	**0.465**
HSP7			0.023	0.**255**

Note. $N = 1353$ Significant loadings are formatted in bold.

Table 4
Fit statistics for measurement invariance testing.

	X^2	df	CFI	TLI	AIC	RMSEA	SRMR
Italian student vs. UK general pop. comparison							
Configural invariance	305.895	84	0.968	0.950	85,620	0.051	0.031
Metric invariance	381.936	104	0.960	0.950	85,656	0.051	0.038
Partial metric invariance	357.526	100	0.963	0.952	85,639	0.050	0.037
Partial scalar invariance	503.705	108	0.944	0.931	85,769	0.060	0.044
Italian student vs. Italian general population comparison							
Configural invariance	447.404	84	0.970	0.953	160,371	0.048	0.032
Metric invariance	511.130	104	0.966	0.957	160,395	0.046	0.037
Scalar invariance	697.621	112	0.952	0.943	160,565	0.053	0.042

Note. Italian student vs. UK $N = 2075$. Italian student vs. Italian general population $N = 3737$.

Table 5
Metric Invariance Model factor loadings (standardized).

	Ease of excitation	Aesthetic sensitivity	Low sensory threshold	General factor	Ease of excitation	Aesthetic sensitivity	Low sensory threshold	General factor
	Italian student sample				UK general population			
HSP8	**0.797**			**0.456**	**0.567**			**0.586**
HSP6	**0.696**			**0.383**	**0.535**			**0.533**
HSP4	**0.639**			**0.430**	**0.488**			**0.593**
HSP9	**0.289**			**0.505**	**0.201**			**0.636**
HSP12	**0.231**			**0.498**	**0.150**			**0.585**
HSP5		**0.770**		**0.157**		**0.703**		**0.162**
HSP10		**0.717**		**0.204**		**0.692**		**0.223**
HSP3		**0.417**		**0.180**		**0.365**		**0.179**
HSP1		**0.315**		0.059		**0.295**		0.063
HSP2			0.542	**0.484**			0.440	**0.575**
HSP11			0.482	**0.631**			0.381	**0.730**
HSP7			0.002	**0.300**			0.002	**0.370**
	Italian student sample				Italian general population			
HSP8	**0.775**			**0.505**	**0.684**			**0.529**
HSP6	**0.631**			**0.493**	**0.575**			**0.534**
HSP4	**0.574**			**0.526**	**0.509**			**0.555**
HSP9	**0.158**			**0.560**	**0.142**			**0.597**
HSP12	**0.159**			**0.529**	**0.148**			**0.584**
HSP5		**0.765**		**0.195**		**0.729**		**0.200**
HSP10		**0.697**		**0.251**		**0.668**		**0.259**
HSP3		**0.410**		**0.285**		**0.358**		**0.267**
HSP1		**0.347**		**0.090**		**0.349**		**0.097**
HSP11			**0.811**	**0.550**			**0.731**	**0.608**
HSP2			**0.400**	**0.397**			**0.345**	**0.420**
HSP7			**0.123**	**0.281**			**0.116**	**0.324**

Note. Italian student vs. UK $N = 2075$. Italian student vs. Italian general population $N = 3737$.
Significant loadings are formatted in bold.

Table 6
Reliabilities and correlations for HSP and HEXACO scales.

	Mc Donald's ω	*M*	*SD*	HSP	HSP_AES	HSP_LST	HSP_EOE
HSP	0.83	4.92	0.80		**0.54**	**0.71**	**0.82**
Aesthetic Sensitivity	0.68	5.60	0.92			**0.20**	**0.12**
Low Sensory Threshold	0.62	4.13	1.28				**0.37**
Ease Of Excitation	0.83	4.86	1.21				
HEXACO							
Honesty/Humility	0.75	3.39	0.67	0.02	**0.11**	0.00	−0.04
Emotionality	0.75	3.61	0.67	**0.50**	**0.19**	**0.36**	**0.45**
Extraversion	0.79	3.42	0.65	**−0.22**	0.06	**−0.09**	**−0.33**
Agreeableness	0.74	3.23	0.67	**−0.12**	−0.02	−0.08	**−0.13**
Conscientiousness	0.79	2.94	0.62	0.05	**0.16**	0.03	−0.04
Openness	0.75	3.69	0.64	**0.20**	**0.54**	0.04	−0.04

Note. Significant loadings are formatted in bold.

low item loadings in the CFA analyses. Reliability indices were comparable to Lionetti et al. (2018).

3.4. Association with personality traits

We investigated the correlations between the HSP-12 with positive and negative mental health indices and HEXACO personality dimensions ($N = 636$, see Table 6). The overall HSP score correlated strongly and positively with Emotionality, and relatively low to moderate associations were found with Openness and Extraversion, positive and negative respectively. No associations emerged for Conscientiousness and Honesty/Humility. HSP-AES was strongly and positively correlated with Openness and moderately with Honesty/Humility, Emotionality, and Conscientiousness. HSP-LST was moderately and positively correlated with Emotionality and weakly with Extraversion. HSP-EOE correlated positively with Emotionality, moderately and negatively with Extraversion, and weakly and negatively with Agreeableness. In sum, as expected, Emotionality correlated with all HSP aspects, whereas the other personality dimensions related to specific aspects of the HSP.

3.5. Bivariate associations with psychological adjustment outcomes

We examined the correlations between the HSP and a series of psychological outcomes (PERMA, DASS, SWL, and PGWB long and short versions). Results[2] (see Table 7) indicated substantial correlations between the HSP, the three HSP-subscales, and the DASS. Note that the Ease of Excitation was the subscale showing the strongest correlations with negative outcome variables. The more sensitive the individuals were, the more they reported depression, anxiety, and stress-related symptoms. Regarding the flourishing measure (PERMA), all correlations were modest. The ones that stand out are the positive ones between Aesthetic sensitivity and Engagement and the negative ones between Ease of Excitation and Positive Emotion, Meaning, and Accomplishment. Satisfaction with Life (SWL) did not correlate with any aspect of the HSP scale. Regarding general well-being (PGWB), the total HSP index and the Ease of Excitation showed the strongest negative correlations with the overall index, both the short and long versions.

Considering the significant correlations between the HEXACO dimensions and the HSP, we also investigated whether associations were stable when controlling for personality traits. For each criterion separately, we entered first the HEXACO subscales and then, in a second step, the HSP score (see Table 8). For the prediction of the overall psychological well-being score, the inclusion of the HSP index added a small but significant portion of variance. Similarly, the HSP predicted the total Depression, Anxiety, and Stress (DASS) score over and above the six significant personality dimensions (for results regarding each subscale separately, please see Appendix), adding a significant portion of variance. Overall, these analyses indicated that the HSP predicts something in psychological outcomes that is not predicted by standard personality traits.

3.6. The moderating role of the environment

We tested whether the HSP scale predicted psychological adjustment differently depending on the quality of the perceived environment. We thus explored whether experienced life events and perceived quality of parenting during childhood moderated the association between the HSP-12 item total score and depression, stress and anxiety (DASS), and well-being (PGWB). We tested 12 moderations models applying a Bonferroni correction for multiple testing (significance level at $p < .004$). The only significant moderation effects emerged when considering the association between the DASS depression and anxiety subscales and the PBI care subscale.

For the DASS depression subscale ($N = 432$), the model explained 24.6 % of variance. HSP ($B = 2.35$, $SE = 0.29$, 95 % CI 1.78; 2.92) and PBI care ($B = -0.20$, $SE = 0.03$; 95 % CI -0.26; −0.14) were significant predictors. The interaction term was significant, $B = -0.12$, $SE = 0.04$, 95 % CI -0.20; −0.04. Simple slope analyses indicate a significant positive effect of HSP on depression for low, medium, and high levels of PBI care, but the effect decreases as the PBI care index increases (low: $B = 3.15$, $SE = 0.41$, 95 % CI 2.34; 3.96; medium: $B = 2.35$, $SE = 0.29$, 95 % CI 1.78; 2.92; high: $B = 1.55$, $SE = 0.40$, 95 % CI 0.77; 2.33 (see Fig. 1, left panel).

For the DASS anxiety subscale, the pattern was similar. The model explained 15.4 % of the variance. HSP ($B = 1.91$, $SE = 0.28$, 95 % CI 1.36; 2.47) and PBI care ($B = -0.10$, $SE = 0.03$; 95 % CI -0.16; −0.04) were significant predictors. The interaction term was significant, $B = -0.11$, $SE = 0.04$, 95 % CI -0.19; −0.04. Simple slope analyses indicate a significant positive effect of HSP on the anxiety index for low, medium, and high levels of PBI care, but the effect decreases as the PBI care index increases (low: $B = 2.69$, $SE = 0.40$, 95 % CI 1.91; 3.48; medium: $B = 1.91$, $SE = 0.28$, 95 % CI 1.36; 2.47; high: $B = 1.13$, $SE = 0.39$, 95 % CI 0.37; 1.89 (see Fig. 1, right panel). In other words, the more sensitive participants were, the more they reported anxiety and depression. However, a family environment perceived as highly caring played a buffering role, and the association between sensitivity and negative affect significantly decreased when participants had memories of a positive parenting environment.

4. Discussion

Across different fields of psychology, there has been increased interest over recent years in understanding how individual differences in Environmental Sensitivity contribute to different adjustment pathways, interact with the quality of the environment, and capture individual features that do not fully overlap with classic personality dimensions.

[2] Running the regression analyses with the inclusion of gender in a third step did not change the results. Therefore, gender is not a significant predictor of psychological outcomes in this sample.

Table 7
Descriptives and Correlations with HSP-12 and subscales.

	Mc Donald's ω	*M*	*SD*	HSP	HSP_AES	HSP_LST	HSP_EOE
DASS	0.94	42.46	13.01	**0.43**	**0.19**	**0.18**	**0.43**
Depression	0.88	13.32	4.98	**0.38**	**0.16**	**0.14**	**0.41**
Anxiety	0.84	12.18	4.55	**0.33**	**0.20**	**0.13**	**0.30**
Stress	0.90	16.96	5.36	**0.41**	**0.15**	**0.20**	**0.43**
PERMA	0.92	7.32	1.17	**−0.11**	**0.11**	0.02	**−0.25**
Positive Emotion	0.82	6.97	1.50	**−0.16**	0.08	−0.04	**−0.28**
Engagement	0.55	7.64	1.23	0.03	**0.23**	0.02	−0.10
Relationships	0.79	7.63	1.59	**−0.11**	0.05	−0.04	**−0.18**
Meaning	0.84	6.99	1.74	−0.09	0.02	0.06	**−0.20**
Accomplishment	0.74	7.37	1.28	−0.08	0.**11**	0.06	**−0.24**
Satisfaction With Life	0.86	16.32	4.69	−0.04	−0.03	−0.04	−0.02
PGWB-Short	0.79	20.40	5.90	**−0.36**	**−0.10**	**−0.15**	**−0.42**
PGWB-Long	0.93	85.58	14.68	**−0.36**	**−0.15**	**−0.22**	**−0.34**
Lack of Anxiety	0.88	19.83	4.76	**−0.35**	**−0.23**	**−0.22**	**−0.27**
Lack of Depression	0.60	9.18	1.79	**−0.26**	**−0.14**	**−0.14**	**−0.24**
Well-being	0.85	14.31	3.57	**−0.23**	−0.04	−0.11	**−0.26**
Self-Control	0.62	12.79	2.77	**−0.32**	−0.11	−0.12	**−0.37**
General Health	0.55	14.17	2.38	**−0.24**	−0.11	**−0.23**	**−0.17**
Vitality	0.79	15.30	3.24	**−0.29**	−0.08	**−0.20**	**−0.29**
PBI-Care	0.92	26.73	6.84	**−0.13**	−0.01	**0.10**	**−0.14**
PBI-Overprotective	0.87	11.91	6.77	**0.14**	−0.03	0.09	**0.17**
Life Events		3.62	4.95	−0.04	0.07	−0.02	−0.10

Note. Significant loadings are formatted in bold. PGWB: Psychological General Well-being. PBI: Parental Bonding Index.

Table 8
Incremental validity of the HSP over and above the HEXACO dimensions for predicting Psychological General Well-being and DASS scores.

	Psychological General Well-being - Short						DASS					
	Step 1 $R^2 = 0.32$			Step 2 $\Delta R^2 = 0.01$**			Step 1 $R^2 = 0.28$			Step 2 $\Delta R^2 = 0.04$***		
	B	*SE*	95 % CI	*B*	*SE*	95 % CI	*B*	*SE*	95 % CI	*B*	*SE*	95 % CI
HEXACO_HonestyHumility	0.45	0.31	−0.16; 1.07	0.40	0.31	−0.21; 1.01	**−2.37**	1.02	−4.37; −0.38	**−2.01**	0.99	−3.96; −0.06
HEXACO_Emotionality	**−2.69**	0.32	−3.30; −2.07	**−2.11**	0.36	−2.81; −1.40	**5.18**	0.97	3.27; 7.08	**3.28**	1.03	1.25; 5.31
HEXACO_Extraversion	**3.59**	0.31	2.99; 4.19	**3.38**	0.31	2.78; 3.99	**−7.01**	0.88	−8.74; −5.27	**−5.68**	0.91	−7.47; −3.90
HEXACO_Agreableness	**1.30**	0.33	0.67; 1.95	**1.21**	0.33	0.56; 1.85	**−2.70**	1.05	−4.77; −0.64	**−2.36**	1.03	−4.37; −0.34
HEXACO_Conscientiousness	**0.69**	0.32	0.06; 1.32	**0.70**	0.32	0.07; 1.32	**−3.24**	0.98	−5.16; −1.33	**−3.07**	0.95	−4.94; −1.20
HEXACO_Openness	**−0.91**	0.30	−1.50; −0.32	**−0.64**	0.31	−1.25; −0.03	**4.08**	0.91	2.29; 5.86	**2.61**	0.94	0.76; 4.46
HSP				**−1.01**	0.31	−1.62; −0.39				**4.37**	0.97	2.47; 6.27

Note: N = 615 for PGWB-S, N = 430 for DASS. Significant loadings are formatted in bold.

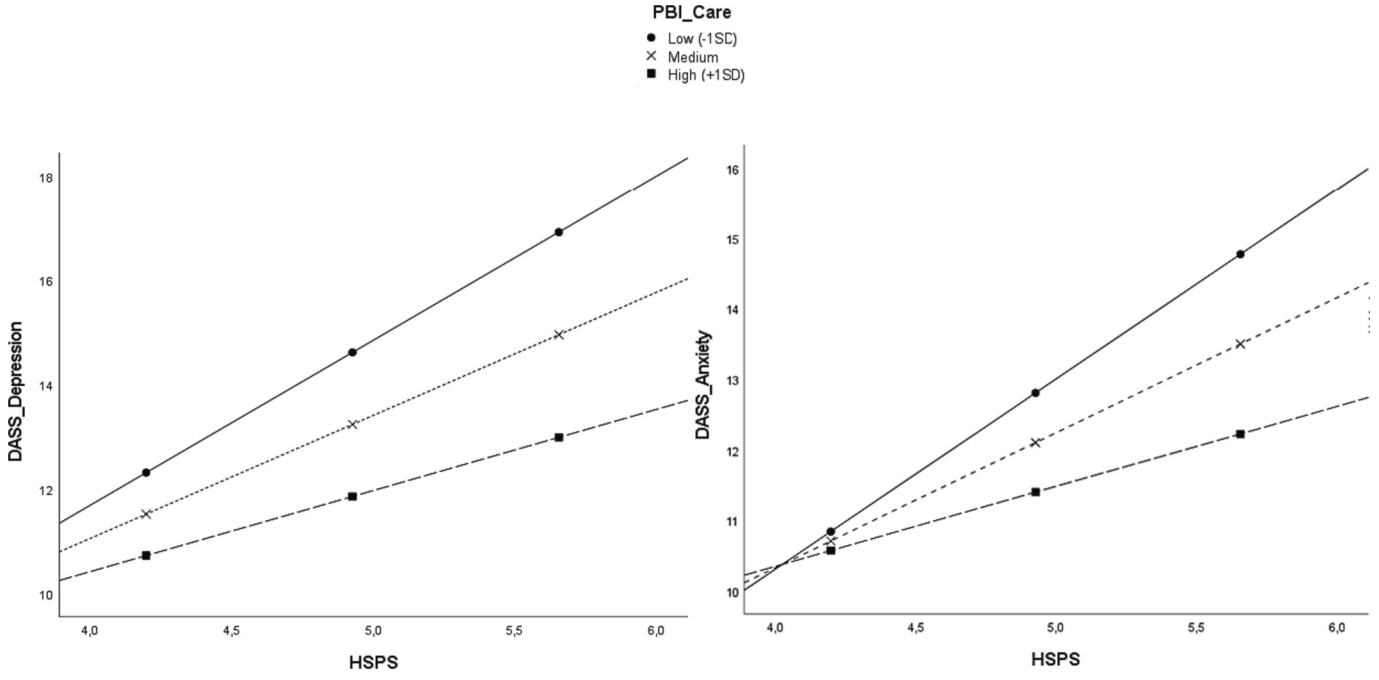

Fig. 1. Moderation effects of PBI care subscale scores on the relation between HSPS and DASS depression (left panel) and DASS anxiety (right panel).

Thanks to the self-report Highly Sensitive Person scale (Aron & Aron, 1997; Pluess et al., 2020), numerous studies have been conducted with promising findings, uncovering the role of Environmental Sensitivity for individual psychological adjustment. Overall, studies converged on the notion that individuals with higher sensitivity levels are more at risk of experiencing negative affect and more likely to benefit from exceptionally supportive contexts. Yet, there are still debates regarding the overlap of the Environmental Sensitivity construct with existing personality traits (Bröhl et al., 2020; Hellwig & Roth, 2021). And there are very few studies investigating the moderating role of the environment on the psychological adjustment of individuals depending on their sensitivity levels, particularly in adult samples, and considering positive outcome variables as well (Greven et al., 2019). In this contribution, we addressed these issues using multiple samples from different regions of Italy and the general population. Importantly, as findings can be considered reliable only if the measures are reliable, we explored the HSP-12 scale's factorial structure. We also involved an independent UK sample to test the measure's factorial structure and invariance across samples.

First, results supported a bifactor model with three-independent factors (EOE, AES, and LST) and a general sensitivity factor. Notably, the bifactor structure held for student samples and was an acceptable model for the general population. Thus, we conclude that for all samples, not only do the items on the HSP scale group together as expected (i.e., factor structure), but their comparative contributions to each factor are similar (i.e., metric invariance). However, the latent means of participants' responses in each sample were not similar enough to be considered invariant (i.e., scalar). To our knowledge, this is the largest sample in which the HSP factorial structure has been tested.

It is worth nothing that some of the factor loadings in our analysis were relatively low, specifically items loading on to the low sensitivity threshold (LST) factor, suggesting that the factor may be problematic regarding the structure of the scale. In fact, this was also shown in previous research with a sample of children where item 7 (part of the LST factor) performed poorly (Sperati et al., 2022). However, while some of the LST factor loadings were low and, in some cases, not significant, the performance of the items and factors were similar across samples, suggesting that the issue does not relate to concerns regarding translation of the scale and/or regarding differences in populations and samples.

Second, comparable to meta-analytical findings, the overall HSP score correlated relatively strongly and positively with Emotionality (also referred to as Neuroticism), mainly driven by the EOE factor followed by LST, but values were always well below the discriminant validity cut-off traditionally considered in the literature. It also correlated moderately and negatively with Extraversion, a result previously found in other independent studies from different countries (Lionetti et al., 2018). Interestingly, AES also correlated with Emotionality, though to a lower extent than EOE and LST. In line with previous meta-analytic data (Lionetti et al., 2018) and more recent empirical studies (Bröhl et al., 2020), there was also an absence of any relevant association between the HSP total score and Conscientiousness and Honesty/Humility. However, there was a positive association between these two personality dimensions and the HSP-AES subscale, which likely captures the positive side of sensitivity. Moreover, in line with existing findings, a positive correlation was found with Openness, mainly driven by the HSP-AES factor (for similar findings, see also Bröhl et al., 2020; Pluess et al., 2020). In sum, as expected, Emotionality correlated with all HSP aspects, whereas the other personality dimensions related to specific aspects of the HSP scale.

Third, the HSP correlated with depression, anxiety, and stress. Interestingly, there was a positive association between negative affect and the AES subscale, though to a lower extent than EOE and LST. No relevant associations were found between the HSP total score and positive outcomes, but AES was associated with higher engagement and accomplishment. In general, EOE was the subscale showing stronger correlations with the different psychological outcomes indexes, which may also be partly due to better internal consistency. Important to note, the HSP total score and factors continued to predict psychological outcomes meaningfully even when controlling for personality traits, including emotionality with which the correlation was relatively strong. In other words, as measured by the HSP-12 scale, Environmental Sensitivity captures something not fully explained by classic personality dimensions, that is relevant for understanding psychological adjustment.

The associations between HSP and psychological outcomes across several studies suggested Environmental Sensitivity to be mainly and inevitably a vulnerability. Similarly, our study found moderate associations between sensitivity and negative affect. Yet, when we enlarged the focus, including the environment in the framework of the analyses, a positive environmental variable, as the recollected (positive) care experienced by the individual in her/his family environment, played a significant buffering effect. More specifically, HSP predicted higher levels of negative affect to a significantly greater extent when the quality of the experienced family environment during childhood was low. Conversely, having experienced a more caring and nurturing relationship with parents protected highly sensitive individuals against higher levels of both anxiety and depressive symptoms, with HSP – negative affect associations being overall statistically significant but low in effect size. This result is coherent with the literature reporting highly sensitive individuals suffering from negative childhood experiences when sensitivity was investigated with a longer 27-item version (Aron et al., 2012). It shows that a highly robust yet shorter, 12-item scale can capture increased sensitivity to stimuli. Comparable findings were also found in a UK sample in which the 12-item version was developed (Pluess et al., 2020), but this is the first time that the quality of the family environment is considered. However, the moderating role of the environment emerged only in relation to negative outcomes, while pertaining to a positive outcome variable, as well-being, no moderation effects emerged.

4.1. *Strengths, limitations, and future directions*

This study comprises several independent samples, with more than four thousand individuals in total, and more than half are from the general population. To our knowledge, this is the largest sample in which the psychometric properties of the HSP scale have been tested and associations with psychological adjustment investigated. Findings provide further evidence in favour of the HSP-12 as a psychometrically sound measure that captures Environmental Sensitivity as an individual trait that does not completely overlap with any classic personality traits. In addition, we provided evidence of HSP to predict psychological outcomes after controlling for personality. Most importantly, the role of HSP on the individual's psychological adjustment was moderated by the effect of the environment, with perceived positive environments buffering against the HSP association with negative affect.

However, this study has some limitations. First, all measures were self-reported. When it comes to rating individual traits and perceived well-being, the individual perception is as relevant (and potentially even more) than other objective or externally rated indicators. But future studies should consider more objective markers or indirect measures of environment quality, to avoid biases or social desirability. Related to this, future studies should also consider more objective indicators of the quality of the early environment (despite the perceived or internalized quality of the relationships matters as well, e.g. see (Tammilehto et al., 2023)) and combine the investigation of the early family environment together with the investigation of the current environment for a more comprehensive assessment of external sources of distress and support. Second, we investigated personality, and, most importantly, we controlled for personality traits when exploring the role of HSP for adjustment. However, we did not collect measures at a facet level. Recent evidence (Bröhl et al., 2020) suggests that considering the facet

level of personality may further allow for disentangling overlap and clarify boundaries and similarities across somewhat related constructs. Third, the countries in which data have been collected should be considered when generalizing findings to other contexts and nations. For example, as a protective factor, we considered the role of the family environment (parents). Still, other studies involving samples from countries with a more marked collectivist orientation could consider additional environmental factors related, for example, to the quality of the community or the support perceived by broader social groups or families at large. Finally, despite the large number of participants from the general population, the sample included a relatively high proportion of females, emphasising the need for more gender balanced samples in future studies as well as the importance to explore sensitivity in males (see also Falkenstein (2019)).

5. Conclusion

According to theoretical reasoning and empirical studies, individuals react differently to the environment, with some being more perceptive and sensitive to stimuli. Such differences in Environmental Sensitivity can be measured with questionnaires such as the HSP-12. Here, we provide evidence for the good psychometric properties of the self-report HSP-12 scale in the students' sample and in the general population for its factorial invariance with a UK sample at a factor structure level. Moreover, our findings provided additional evidence for sensitivity as relatively distinct from other personality traits in predicting individual's adjustment and pointed towards the role of perceived rearing environment during childhood in influencing the psychological adjustment of highly sensitive individuals. In conclusion, this paper suggests that it is possible to measure Environmental Sensitivity reliably in adults with the Highly Sensitive Person 12-item scale, that sensitivity predicts the adjustment across students and the general population over and above personality with a potential vulnerability effect. Still, this vulnerability markedly decreases when the individual can count on positive family relationships while growing up. The availability of validated measures of this trait may further contribute to the study of the interplay between the environment and the individual, with important implications for both theoretical and applied contexts.

CRediT authorship contribution statement

Francesca Lionetti, Annalaura Nocentini, Barbara Penolazzi, Michael Pluess, Alessandra Santona, Emanuele Preti: Conceptualization

All authors: Investigation and Review

Francesca Lionetti: writing original draft, introduction and discussion section

Raynae Shontae Casandra Dumpfrey and Juliette Richetin: formal analysis and writing original draft, data analysis section

Francesca Lionetti, Michael Pluess and Emanuele Preti: Supervision and final revision

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data are available at the link reported below: https://gitfront.io/r/user-3757127/nUG4Tx6JyY71/HSP12-IT-UK/.

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Appendix A

	DASS_Stress						DASS_Anxiety						DASS_Depression					
	Step 1 $R^2 = 0.23$			Step 2 $\Delta R^2 = 0.05$***			Step 1 $R^2 = 0.21$			Step 2 $\Delta R^2 = 0.02$*			Step 1 $R^2 = 0.30$			Step 2 $\Delta R^2 = 0.03$***		
	B	*SE*	95 % CI	*B*	*SE*	95 % CI	*B*	*SE*	95 % CI	*B*	*SE*	95 % CI	*B*	*SE*	95 % CI	*B*	*SE*	95 % CI
HonestyHumility	−0.77	0.44	−1.62; 0.09	−0.60	0.42	−1.43; 0.23	−0.78	0.39	−1.54; −0.02	−0.70	0.38	−1.45; 0.06	−0.83	0.38	−1.59; −0.08	−0.72	0.38	−1.46; 0.02
Emotionality	2.13	0.42	1.32; 2.95	1.25	0.44	0.39; 2.12	1.96	0.37	1.24; 2.68	1.54	0.40	0.75; 2.32	1.08	0.37	0.37; 1.80	0.49	0.39	−0.28; 1.27
Extraversion	−1.97	0.38	−2.71; −1.22	−1.35	0.39	−2.11; −0.59	−1.73	0.34	−2.39; 1.07	−1.43	0.35	−2.12; −0.74	−3.32	0.33	−3.97; −2.66	−2.90	0.35	−3.58; 2.22
Agreableness	−2.26	0.45	−3.15; −1.38	−2.1	0.44	−2.96; −1.24	−0.20	0.40	−0.98; 0.59	−0.12	0.40	−0.90; 0.66	−0.25	0.40	−1.03; 0.54	−0.14	0.39	−0.91; 0.63
Conscientiousness	−0.77	0.42	−1.59; 0.05	−0.69	0.40	−1.49; 0.11	−1.32	0.37	−2.05; −0.59	−1.28	0.37	−2.00; −0.56	−1.16	0.37	−1.88; −0.43	−1.10	0.36	−1.81; −0.39
Openness	1.27	0.39	0.51; 2.04	0.59	0.40	−0.19; 1.38	1.44	0.34	0.76; 2.12	1.12	0.37	0.40; 1.86	1.36	0.34	0.68; 2.03	0.90	0.36	0.20; 1.61
HSP				2.03	0.41	1.22; 2.84				0.97	0.37	0.24; 1.71				1.36	0.37	0.64; 2.09

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