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Sensory Processing Sensitivity in childhood: Investigation of the construct validity of the Highly Sensitive Child Scale-Parent Report with behavioral traits

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Abstract

The aim of the present study was to validate the factor structure of the Greek version of the Highly Sensitive Child Scale – Parent Report (HSCS) and to delineate the ways in which SPS early in life may be associated with constructs of interest, especially in relation to affective traits and empathy. The study consisted of a sample of 153 children (M = 9.97; SD: 1.28, min: 7.5; max: 49.0% girls). The results showed that SPS in children was strongly positively correlated with cognitive and affective empathy, depression and anxiety, ADHD traits, sensitivity to reward and punishment, fear/shyness, and responsiveness to social approval. Follow-up investigation underlined that SPS was better predicted positively by both elevated cognitive empathy and sensitivity to punishment traits. The findings provide new insights into the empirical correlates of SPS early in life that may be particularly useful in designing early interventions to mitigate potential mental health risks.

Keywords: Sensory Processing Sensitivity; Highly Sensitive Child Scale; Emotionality;· Childhood

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Introduction

Environmental exposures through the lifespan may differentially impact individuals, due to individual differences in sensitivity and reactivity (e.g., Pluess, 2015). The documented differential susceptibility mechanisms in humans have been suggested to be regulated by evolutionary reasoning (e.g., Wolf, Van Doorn, & Weissing, 2008), and can be well described by the overarching meta-framework of Environmental Sensitivity (ES; Greven et al., 2019; Pluess, 2015). ES incorporates three psychological models of sensitivity, namely the Differential Susceptibility Hypothesis (Belsky, 1997), the Biological Sensitivity to Context (Boyce & Ellis, 2005), and Sensory Processing Sensitivity (SPS: Aron & Aron, 1997; Aron et al., 2012). Current views in the literature further support the strong genetic contributions of ES (Keers et al., 2016; Homberg, Schubert, Asan & Aron, 2016) that can explain 47% of its variance, compared to 22–35% variance of the Big Five personality traits (Assary et al., 2021; Assary et al., 2024).

Most relevant to the present study, Sensory Processing Sensitivity (SPS) has been widely documented as a reliable plasticity marker of ES, with high SPS individuals being sensitive to positive and negative influences in context (Pluess et al., 2018). More recent observations have reported that SPS is a quantitative and normally distributed continuous trait (Lionetti et al., 2018; Pluess et al., 2018; Tillmann, Bertrams, El Matany, & Lionetti, 2021). Based on this recent approach, three groups have been proposed: ‘high’ (approximately 30%), ‘medium’ (approximately 40%), and ‘low’ (remaining 30%) SPS. High SPS individuals, compared to the two other groups, have been consistently found to have increased depth of processing information, higher awareness of subtleties, and also pronounced susceptibility to overstimulation coming from their environment (e.g., Greven et al., 2019). Recent advancements in the field, have also pointed on the role of SPS in parents in influencing the offspring’s neurocognitive mechanisms of emotional processing (Christou et al. 2024).

In recent years, the 21-item child and adolescent version of the Highly Sensitive Person Scale (HSPS; Aron & Aron, 1997) has been developed, known as the Highly Sensitive Child Scale (HSCS; Weyn et al., 2022), which is a developmentally modified version of the original adult scale, with good psychometric properties. Previous evidence has supported the existence for (a) bifactor model with a general sensitivity factor and two specific factors (i.e., Ease of Excitation–Low Sensory Threshold and Aesthetic Sensitivity). Measuring children’s individual differences in the registration and processing of specific characteristics of their environment may be significant for the early identification of behavioral outcomes (Pluess, 2015).

From a developmental perspective, Lionetti et al. (2019) found SPS in children to be correlated with neuroticism (r = .42), and moderately correlated with both negative (r = .29) and positive (r = .21) affect. In addition, the documented cognitive overload that individuals with high SPS experience has been described as a putative susceptibility mechanism mediated by emotion regulation difficulties, which involves an individual’s ability to adjust the intensity and duration of their emotional reactions including empathic behavior (Pluess et al., 2018). Accordingly, Bröhl et al., (2022), in a study with adults looking at the association between SPS and the Five Factor Model, self-identified highly sensitive individuals were found to be consistently high in anxiety and depression, as well as in facets of Fantasy, Aesthetics, Feelings (i.e., Openness to Experience).

Additionally, with a growing literature on sensory processing difficulties in Attention Deficit Hyperactivity Disorder (ADHD), who are also characterized as hypersensitive or hyposensitive to tactile, auditory, and visual stimuli (e.g., Robertson & Simmons, 2013), there is a need to further look into the associations between SPS and ADHD symptomatology early in life. Especially taking into account the growing literature supporting the continuum approach in ADHD research (e.g., Greven et al., 2016), and the observed overlap on emotional reactivity in both high SPS (Aron et al., 2012; Avecedo et al., 2014; Jagiellowicz et al., 2016) and ADHD symptoms (Greven et al., 2018) it is necessary to assess whether emotional reactivity could lead to the core symptoms (i.e., inattention, hyperactivity, and impulsivity), associated with the disorder. Although such associations have been already documented in the adult literature (Panagiotidi et al., 2020), currently there is no available evidence investigating such associations early in life.

The present study

This present investigation sought to evaluate the validity of the Greek-Cypriot translation of the Highly Sensitive Child Scale in relation to a range of relevant criterion measures and extend to children what is known about the SPS nomological networks reported in the adult literature. In particular, the study contributes incrementally to prior work in adults on the behavioral correlates of SPS by testing for relations of environmental sensitivity with indexes of childhood behavioral problems, personality, and temperamental traits. To assess the construct validity of the 21-item Highly Sensitive Child Scale – Parent report (Weyn et al., 2022), we evaluated associations with behavioral, temperamental, and personality scores of conceptual relevance to environmental sensitivity. We hypothesized that higher SPS would be related to higher anxiety and depression symptoms in children (e.g., Bröhl et al., 2022). The hypothesis is driven by evidence suggesting that high SPS individuals are more likely to experience anxiety and depression (e.g., Greven et al., 2019), as well as other negative clinical outcomes such as poorer social skills (Hofmann & Bitran, 2007). Moreover, we hypothesized that high SPS in children will be associated with empathic behavior, in light of the adult literature highlighting that high SPS individuals are significantly affected by moods in others and exhibit strong empathic reactions to emotional expressions (Acevedo et al., 2014, 2018).

Finally, taking into account recent reports showing associations between SPS and Behavioral Inhibition System/ Behavioral Activation System (see Lionetti et al., 2019), we hypothesized that significant positive correlations will be evident between SPS and sensitivity to reward and sensitivity to punishment traits. With regards to ADHD traits, and in line with recent reports in the adult literature (Panagiotidi et al., 2020), the study hypothesized that there will be a positive association between higher SPS and elevated ADHD traits.

Method

Participants

The sample consisted of 153 children (M = 9.97; SD: 1.28, *min*: 7.5; *max*: 12.5; 49.0% girls) and their parents (M = 40.09; SD: 4.85; 85.0% females). To address concerns regarding sample size adequacy, an a priori power analysis for structural equation modeling was conducted using the power4SEM R package (Jorgensen et al., 2021), based on average factor loadings reported in Weyn et al. (2022), which ranged between .50 and .70. Assuming a moderate effect size (λ = .60), α = .05, 1-β = .80, and 21 observed indicators, the recommended minimum sample size was estimated to be N = 145. Our sample of 153 participants therefore meets this threshold, indicating sufficient power for detecting the intended factor structure. Children were randomly selected after screening from a nationwide study conducted in our lab at the local University, where 47 private and public pre-schools and 69 primary schools were randomly selected from three districts in Cyprus (Nicosia, Larnaca and Limassol). At the original screening phase, schools selected to participate in the initial data collection were extensively informed about the aims of the study, and after obtaining consent from school boards, were provided with a description of the study. All participants were Greek-Cypriots, which is the largest ethnolinguistic community in Cyprus, and had a good knowledge of the Greek language. Therefore, the sample can be considered primarily working and middle class, and have similar standings in terms of within-country socioeconomic status (SES).

Questionnaires

SPS instruments *for both parents and children* were translated, back-translated and adapted to Greek and English following the guidance given by the original standardization team (Pluess et al., 2018; Weyn et al., 2022). Child's Sensory Processing Sensitivity: The Highly Sensitive Child scale-21 items measures parents' ratings of a child's SPS (from 1 = not at all to 7 = extremely; Weyn et al., 2022). The three dimensions include EOE (five items, e.g., "My child gets nervous when he/she has to do a lot in little time"; Cronbach's α = .61), AES (four items, e.g., "Some music can make my child really happy"; Cronbach's α = .61), and LST (three items, e.g., "Loud noises make my child feel uncomfortable"; Cronbach's a = .61). In addition, the average score of all 12 items was also created, indicating children's overall SPS (Cronbach's α = .89). Cronbach's α of .60 or lower were considered as low, between .60 and .70 as acceptable, and .70 or higher as a good (Weyn et al., 2022). Child self-report data were initially collected alongside parent reports to enable multi-informant comparisons. However, during pilot testing, younger participants (ages 7–9) exhibited difficulty comprehending abstract items (e.g., 'I notice when small things change in my environment'), frequently providing inconsistent or missing responses. Given these developmental limitations in self-assessment reliability (De Los Reyes et al., 2019) and following established protocols for SPS research in children (Pluess et al., 2018), we retained only parent-report data for the primary analysis. This approach aligns with the HSC scale's validation studies, where parent-child agreement was moderate (r = 0.35–0.40) for total scores but weaker for specific subscales (Weyn et al., 2022). To this end, for the needs of the present study only parental reports of SPS are reported (Mean age of parents M = 40.1; 141 females). Therefore, children who are similar in environmental sensitivity may score differently on the HSC scale (Schmitt et al., 2011). In addition, moderate associations between child and mother reports on the total scale and EOE-LST dimension, but not for AES has been previously reported (Weyn et al., 2022). To this end, taken the age range of the participants of our sample parental reports of SPS was deemed as the most reliable approach.

Empathy: The Basic Empathy Scale – BES was employed to assess children's cognitive and affective empathy (Jolliffe & Farrington, 2006). The 20-item measure assesses the degree to which each person understands and feels the emotions of others. In particular, the cognitive component of empathy included items such as, 'S/he is not usually aware of he/his loved ones feelings'. The affective component of empathy included items such as, 'S/he doesn't become sad when he/she sees other people crying'. For the cognitive component, the alpha was .61, and for the affective component the alpha was .78, which were comparable to previous work (Jolliffe & Farrington, 2006). Parents responded to each item on a five-point Likert-type scale.

Sensitivity to Reward and Punishment: Items to assess children's sensitivity to reward and punishment were selected from the Reward Sensitivity of the parent report version of the revised Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ-C; Colder et al. 2011). Items in the parent-report SPSRQ-C were re-worded to be appropriate for child report. The parental report version of the questionnaire measuring sensitivity to punishment and reward (Colder & O'Connor, 2004) contained 33 items that are rated by parents and is divided in a Punishment Sensitivity scale (15 items), and three Reward Sensitivity scales: Reward Responsivity (7 items), Impulsivity/Fun-Seeking (7 items), and Drive (4 items). For the needs of the present study only the Sensitivity to Punishment and the Sensitivity to Reward subscales were employed. The Sensitivity to punishment subscale included items such as e 'Criticism or scolding hurts your child very much'. The sensitivity to reward subscale included items such as 'Does your child generally prefer activities that involve immediate reward'. Items are rated on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The reliability of the questionnaire is .87 (coefficient alpha) for Sensitivity to Punishment, and .85 for Sensitivity to Reward, which is comparable to previous child studies (Colder & O'Connor 2004; Luman et al., 2012). In addition, SPSRQ-C subscales for fear shyness (example item: 'Your child is a shy person'; α = .87), and responsiveness to social approval (example item: 'It is important to your child that they make a good impression on others'; α = .71) were also calculated.

Psychopathology: Child affective symptoms [i.e., anxiety (α = .81) depression (α = .86)] were assessed with the Checkmate plus Child Symptom Inventory for Parents-4 (CSI-4; Gadow & Sprafkin, 2002). The tool also assesses ADHD symptoms of inattention and hyperactivity (18-items; α = .92; e.g., "I have trouble paying attention"). Previous research has provided evidence for the validity of the parent-reported symptoms measured with the CSI-4 in community and clinical samples in Cyprus and U.S. (Fanti & Centifanti, 2014).

Plan of Analyses

Validation of the factor structure of the HSC Scale was conducted by using Confirmatory Factor Analysis (CFA), in which the cross-loadings of items are constrained to be zero (Boateng et al., 2018). As previous studies using the original HSC items found evidence for a bifactor model (Weyn et al., 2022), the fit of a correlated-trait model (first-order factor structure) was compared with the fit of a bifactor model (second order factor structure) with the same first-order factors as the correlated trait model. By employing a bifactor model allows us to investigate the possibility of whether a potential overlap in factors is due to a general factor. CFAs were conducted in R (Version 4.0.1, lavaan package; Rosseel, 2012), using maximum likelihood robust to address nonnorma lity (Satorra & Bentler, 1994) and FIML to address potential issues with missing data. In particular, model fit was considered acceptable when (a) the comparative fit index (*CFI*) was at least .90, (b) the root mean square error of approximation (*RMSEA*) was not larger than .06, and (c) the standardized root mean squared residual (*SRMR*) was maximally .08 (Kline, 2013). In the present study, we adhered to the standardization approach originally employed by Pluess et al. (2018) in the development and validation of the Highly Sensitive Child (HSC) Scale. Specifically, we reported unstandardized factor loadings in our confirmatory factor analysis (CFA), consistent with the methodological framework of the original scale. This decision was guided by our aim to maintain comparability with the initial validation study and ensure alignment with the analytical choices made by the original authors. During the translation and validation process, our approach was informed by direct consultation with the team that developed the HSC Scale in English. As part of this process, we followed their lead in the application of CFA procedures, including the reporting of unstandardized estimates. While standardized factor loadings are often used to assess the relative contribution of each item to a latent construct, unstandardized loadings allow for a more direct comparison across studies using the same scale, particularly when preserving the original measurement structure. It is important to note that unstandardized factor loadings can sometimes exceed 1.00 due to scale differences and estimation methods (Kline, 2015). This does not indicate a mis-specified model but rather reflects the nature of the metric used in estimation. Given our objective to ensure consistency with the original validation study, we retained this approach in our analyses and reporting. This analysis was followed by correlation analyses to explore complex relationships among SPS and other behavioral characteristics.

To further examine the unique and combined contributions of emotional, temperamental, and psychopathological traits to SPS, we conducted a hierarchical multiple regression analysis. This approach was selected to allow for the stepwise evaluation of the explanatory power of distinct predictor sets, while controlling for the variance shared among them. Hierarchical regression is particularly useful in psychological research when theoretical or empirical evidence supports a specific ordering of variables or when the research question aims to determine whether additional predictors explain variance beyond previously entered blocks.

In Step 1, all main-effect predictors were entered simultaneously to assess their individual contributions to SPS after controlling for intercorrelations. These included cognitive and affective empathy, depression, anxiety, ADHD traits, fear/shyness, sensitivity to reward and punishment, and responsiveness to social approval. This step was guided by prior empirical studies suggesting these traits are independently associated with environmental sensitivity (e.g., Pluess et al., 2018; Lionetti et al., 2019).

In Step 2, we introduced an interaction term between cognitive empathy and sensitivity to punishment. This inclusion was theoretically motivated by the increasing recognition that SPS reflects a form of social-affective plasticity that may arise from the joint influence of empathic cognitive processes and heightened punishment sensitivity, both of which are linked to deeper processing of emotionally salient cues (Acevedo et al., 2014; Bröhl et al., 2022). Although exploratory in nature, this interaction was empirically justified by findings suggesting that cognitive empathy modulates the behavioral impact of affective traits and environmental contingencies, particularly in children (Colder & O'Connor, 2004; Jolliffe & Farrington, 2006). All the analyses were conducted in SPSS 29 (IBM Statistics, 2022).

Results

Descriptive Statistics

The Means (*M*), Standard Deviations (*SD*), Skewness, Kurtosis, and internal consistency coefficients (Cronbach's α) for the parent-reported behavioral, temperamental, and emotionality dimensions are presented in Table 2. T-tests were conducted to compare questionnaire scores between males and females, and no significant differences based on children's gender were evident. The questionnaire data from 153 children are reported and no missing data are noted.

Validation of the Factor Structure of the HSC-21 Scale

The fit of a two-factor correlated traits model (first-order) was compared with a bifactor model that included the same two specific first-order factors. The correlated traits model showed limited fit, $\chi^2(189) = 764.62$, $p < .001$, *CFI* = .83, *RMSEA* = .082, *SRMR* = .072. In contrast, the bifactor model demonstrated comparatively better fit, $\chi^2(186) = 741.05$, *CFI* = .86, *RMSEA* = .077, *SRMR* = .066, and was therefore retained as the preferred solution, consistent with the structure originally proposed by Weyn et al. (2022).

As shown in Table 1, all items loaded significantly on the general sensitivity factor, with loadings ranging from .45 to .72. Loadings on the specific group factors (EOE-LST and AES) were smaller (.10; .35) and in several cases non-significant, indicating that the bifactor structure is largely driven by the general sensitivity factor, with residual variance captured by the group factors. This pattern, together with the superior fit indices, supports the bifactor model as the most appropriate representation of the factor structure of the HSC-21 in this sample.

Correlation Analyses

Pearson product-moment revealed positive correlations between child overall SPS, anxiety (r = .381, p < .001), and depression (r = .318, p < .001; see also Table 2). Strong positive correlations were also observed between child overall SPS and cognitive (r = .300, p < .001) and affective empathy (r = .368, p < .001). In terms of disorder-specific characteristics positive correlations are reported between child overall SPS and ADHD symptoms (r = .203, p = .004). Lastly, strong positive correlations were evident between higher SPS and fear/shyness (r = .276, p = .001), responsiveness to social approval (r = .325, p < .001), and sensitivity to reward (r = .278, p < .001), and punishment (r = .389, p <.001).

Tab. 1. Unstandardized Factor Loadings From the Bifactor CFA Model of the HSC-21 Scale

		General SPS				EOE-LST				AES			
Item	**Item Description**	*λ*	SE	z	*p*	*λ*	SE	z	*p*	*λ*	SE	z	*p*
HSC3	Gets nervous when has to do a lot in little time	.58	.08	7.25	< .001	.20	.09	2.22	.026				
HSC4	Finds it unpleasant to have a lot going on at once	.62	.09	6.89	< .001	.18	.08	2.05	.041				
HSC6	Gets nervous when observed, performs worse	.55	.10	5.50	< .001	.15	.09	1.67	.095				
HSC9	Overwhelmed in crowded places	.60	.09	6.67	< .001	.22	.08	2.75	.006				
HSC2	Feels uncomfortable with loud noises	.65	.08	8.13	< .001	.14	.07	2.00	.046				
HSC5	Doesn't like loud noises	.64	.08	8.00	< .001	.19	.08	2.38	.017				
HSC11	Quickly feels pain	.47	.09	5.22	< .001	.12	.09	1.33	.183				
HSC13	Startles when touched	.56	.08	7.00	< .001	.20	.08	2.50	.012				
HSC14	Sensitive to bright light	.61	.08	7.63	< .001	.16	.09	1.78	.075				
HSC16	Sensitive to loud noises	.68	.07	9.71	< .001	.21	.08	2.63	.009				
HSC18	Startled by sudden noises	.64	.08	8.00	< .001	.17	.09	1.89	.059				
HSC20	Sensitive to being touched	.59	.08	7.38	< .001	.23	.09	2.56	.010				
HSC21	Upset when other children touch	.52	.09	5.78	< .001	.19	.08	2.38	.017				
HSC1	Notices small changes in environment	.66	.08	8.25	< .001					.21	.08	2.63	.009
HSC7	Quickly notices how something smells	.57	.09	6.33	< .001					.18	.09	2.00	.046
HSC8	Cares how food tastes	.54	.09	6.00	< .001					.20	.08	2.50	.012
HSC10	Notices small details in surroundings	.71	.07	10.14	< .001					.25	.09	2.78	.005
HSC12	Good at distinguishing tastes	.63	.08	7.88	< .001					.19	.09	2.11	.035
HSC15	Notices new clothes/haircuts	.68	.08	8.50	< .001					.14	.10	1.40	.162
HSC17	Has an eye for details in surroundings	.70	.07	10.00	< .001					.20	.09	2.22	.026
HSC19	Delicate sense of smell	.54	.09	6.00	< .001					.18	.09	2.00	.045

*Note. All factor loadings are unstandardized estimates from the bifactor CFA model of the HSC-21 Scale. Each item loads on the general sensitivity factor (SPS) and on one specific group factor (EOE-LST = Ease of Excitation/Low Sensory Threshold; AES = Aesthetic Sensitivity). *p < .05. **p < .01. ***p < .001.**

Tab. 2. Descriptive Statistics and Correlations among child SPS levels and behavioral traits.

	1	2	3	4	5	6	7	8	9	10
1. HSC	1									
2. E-aff	.368**	1								
3. E-cog	.300**	.596**	1							
4. Dep	.318**	.053	-.093	1						
5. Anx	.381**	.146	-.002	.609**	1					
6. ADHD	.203*	.019	-.174*	.477**	.577**	1				
7. F-S	.276**	.101	-.142	.443**	.387**	.251**	1			
8. R-S	.325**	.137	.113	.252**	.365**	.292**	.278**	1		
9. S-R	.278**	-.024	-.024	.332**	.402**	.484**	.219**	.753**	1	
10. S-P	.389**	.206*	-.072	.522**	.543**	.342**	.949**	.388**	.335**	1
M	3.67	3.65	3.80	4.12	1.19	1.55	2.16	2.71	2.45	2.26
SD	.98	.62	.57	.62	.26	.43	.78	.78	.73	.69
Skewness	.106	-.624	-.359	1.83	1.06	.996	.562	-.045	.262	.562
Kurtosis	-.149	-.020	-.428	3.29	1.40	.934	-.011	-.667	-.770	.262
Cronbach's alpha	.89	.82	.83	.80	.78	.92	.75	.80	.92	.78

*Note. HSCS score: total score of child sensory processing sensitivity; E-aff =Empathy – Affective; E-cog = Empathy – Cognitive; Dep = Depression traits ; Anx = Anxiety traits; ADHD = ADHD traits; F-S = Fear – Shyness; R-S = Responsiveness to Social Approval; S-R = Sensitivity to Rewards; S-P = Sensitivity to Punishment. *p<.05. **p<.01.*

Regression Analyses

Findings from Step 1 revealed that after taking into account the shared variance of the variables included in the regression model, only cognitive empathy and anxiety were positively associated with child SPS, (see Table 3). In Step 2, the interaction between cognitive empathy and sensitivity to punishment was entered to examine whether the combined presence of these two traits further predicted variability in child SPS. While the interaction term did not reach statistical significance, its inclusion was theoretically grounded in dual-process models of emotion regulation and prior findings on social-affective sensitivity. This exploratory step aimed to test whether children with both high cognitive empathy and heightened punishment sensitivity may represent a subgroup with particularly elevated environmental sensitivity. Although non significant, this trend warrants further exploration in future studies using larger samples or more refined interaction modeling. The regression model overall was significant [F(12, 150) = 6.47, *p < .001*] and accounted for approximately 30% of the variance in child SPS. Among the predictors, cognitive empathy and sensitivity to punishment emerged as significant, independent predictors (*p = .014* and *p = .022*, respectively). The interaction term, while not statistically significant in the final model, contributed to the theoretical exploration of potential moderating mechanisms in SPS development and warrants further investigation in future studies with larger samples and increased statistical power.

Discussion

In this study, children's SPS was found to represent distinctive dispositional tendencies with unique patterns of associations with measures of behavior, temperament, and personality. As noted in the introduction, SPS has been widely documented as a reliable plasticity marker of ES, with high SPS individuals being sensitive to positive and negative influences in context (Pluess et al., 2018) and does not consist a psychopathology-related trait. Based on the CFA analysis the significant factor loadings indicate that the indicators are appropriate measures of their respective latent constructs. The significant covariance between EOE-LST and AES suggests that the model captures meaningful relationships between constructs. The chi-square test suggests some lack of fit, which could imply that the model might not fully explain the observed data. This might be due to omitted variables, model misspecification, or other issues. In conclusion, while the CFA model shows strengths in terms of significant factor loadings and covariances that are in line with the bifactor solution with a general sensitivity factor and two specific factors (i.e., EOE-LST and AES) proposed by recent research (Weyn et al., 2022), the significant chi-square test statistic indicates that the model may have some shortcomings in adequately explaining the observed data. It's essential to further explore potential reasons for the lack of fit, such as examining modification indices, considering alternative model specifications, or revisiting the theoretical framework. Therefore, while the model shows promise in terms of structural validity, further refinement or adjustment may be necessary to improve model fit and overall validity.

Moreover, the correlation analyses described associations between SPS and anxiety and depression symptoms that provide evidence for the construct validity of the HSC scale, which is consistent with the adult literature (e.g., Greven et al., 2019). The study highlights the possibility that early in life high SPS individuals may experience cognitive overload, and in combination with harsh environmental influence may lead them to negative thinking and dysfunctional cognitive processes that are core characteristics for a range of affective problems and disorders (Pluess et al., 2018). Moreover, the documented strong correlations between child SPS and empathy, are also consistent with the adult and child literature (e.g., Acevedo et al., 2014, 2018) highlighting that individuals high in SPS have been shown to be significantly affected by moods in others and exhibit strong empathic reactions in response to emotions.

Finally, consistent with the study's hypothesis, a significant correlation between SPS and ADHD traits was evident, which is in line with recent reports in the adult literature (Panagiotidi et al., 2020). Collectivity, the study sheds light on the validity

Tab. 3. Regression Analyses of behavioral characteristics as Predictors of SPS.

	Step 1							Step 2						
						95% CI							95% CI	
Predictor	B	SE	β	t	p	LL	UL	B	SE	β	t	p	LL	UL
Age	-.04	.05	-.06	-.88	.381	-.14	.05	-.04	.05	-.06	-.88	.382	-.14	.05
Child Sex	.15	.14	.08	1.1	.273	-.12	.42	.15	.14	.08	1.09	.278	-.12	.41
E – Af	.17	.15	.10	1.13	.261	-.13	.46	.17	.15	.10	1.11	.269	-.13	.46
E – Cog	.37	.15	.22	2.48	.014	.08	.65	.37	.15	.22	2.46	.015	.08	.66
Depression	.43	.34	.11	1.27	.206	-.24	1.11	.43	.36	.11	1.16	.249	-.29	1.15
Anxiety	.11	.24	.05	.46	.647	-.36	.58	.11	.25	.05	.47	.639	-.38	.60
ADHD	-.04	.17	-.02	-.24	.812	-.38	.30	-.04	.17	-.02	-.23	.817	-.38	.31
F-S	-.58	.34	-.46	-1.70	.091	-1.25	.09	-.58	.34	-.47	-1.70	.091	-1.25	.09
R-S	.05	.12	.04	.40	.691	-.19	.28	.05	.12	.04	.38	.706	-.19,	.28
S-R	.05	.16	.04	.36	.717	-.26	.37	.05	.16	.04	.36	.717	-.27	.36
S-P	1.00	.43	.71	2.30	.023	1.86	.14	1.00	.44	.72	2.20	.030	.10	1.90
E-cog × S–P								-.00	.07	-.00	-.12	.910	-.14	.13

*Note. HSCS score = total score of child Sensory Processing Sensitivity. E-aff = Affective Empathy, E-cog = Cognitive Empathy, ADHD = ADHD traits, F-S = Fear–Shyness, R-S = Responsiveness to Social Approval, S-R = Sensitivity to Reward, S-P = Sensitivity to Punishment. *Significant at p < .05.*

constructs of SPS early in life with a range of behavioral traits that may be of significant importance for the development of emotionality and affectivity. Moreover, the study reported associations between high SPS and elevated scores of responsivity to rewards and responsivity to punishment, which is in agreement with recent meta-analytical reports (see Lionetti et al., 2019).

Furthermore, the pattern of findings coming from the regression analyses highlights the contribution of cognitive empathy and sensitivity to punishment, above and beyond the rest of the predictors of interest, in predicting SPS. The reported associations are in line with the literature pointing that high SPS early in life may be affected by moods in others and exhibit strong empathic reactions to emotional expressions (Acevedo et al., 2014, 2018), as well as with sensitivity to punishment mediated by activation of the BAS/BIS systems (see Lionetti et al., 2019). However, although the initial correlation analyses highlighted associations between child SPS and anxiety and depressive symptomatology, further regression analyses did not confirmed such strong associations. This pattern of findings is in disagreement with the literature suggesting that SPS individuals are more likely to experience anxiety and depression (e.g., Greven et al., 2019), as well as other negative clinical outcomes such as poorer social skills (Hofmann & Bitran, 2007). As the relevant literature is still in its infancy, this area of inquiry requires further multi-level investigation.

This study, however, has some limitations. The first limitation is the sample size. A total of 153 children participated in this research which was extracted from a broader study that investigates the neurocognitive mechanisms of emotional processing in relation to SPS. A larger sample size will help to obtain more reliable results in terms of accurately estimating the validity constructs of SPS in child samples. Developmentally wider sampling will also be important to be achieved, to look into the potential developmental differences among different age groups. Second, the sample of this study consists of children of specific developmental, cultural, and socioeconomic characteristics, and the generalizability of the study is limited to this group. In addition, some of our analyses did not take into account measurement error, and other forms of validity and retest reliability were not investigated. Future research in this area of inquiry that incorporates such additional analyses will be important to be conducted.

Accounting for cultural and socioeconomic differences in the observed associations will be of paramount importance in future studies. Moreover, a potential limitation of the study is its cross-sectional design. It is widely accepted that although structural relationships indicate possible effects between variables, the results of this study do not report cause-effect relationships among the studied constructs. As an improvement to this limitation, experimental studies can be designed and conducted to examine the multi-level effects of emotionality and affectivity in highly sensitive individuals early in life.

Moreover, potential limitations of the study are the reliance on parental-report measures and the use of a nonclinical sample of neurotypical children. On our study, the reliance solely on parent reports, while justified by young children's limited metacognitive capacity to self-assess sensitivity traits, may introduce reporter bias. Parents' perceptions of their child's SPS could be influenced by their own sensitivity levels or parenting stress (De Los Reyes et al., 2019). Future studies should combine parent reports with teacher ratings or age-adapted child self-reports (e.g., simplified Likert scales with visual aids) to triangulate data sources, particularly for children under 10. In a similar vein, future studies will be important to be conducted in clinical and high-risk populations of children, which will aid in a better understanding of the contribution of SPS to human emotionality across the lifespan. However, it is important to note that this is the first study to evaluate the Greek-Cypriot translation of the HSC scale and is informative for nonclinical populations.

Finally, the demographic characteristics of the study's sample, such as socioeconomic status (SES) and educational level, might have influenced the findings reported in the current study. This means that findings most readily apply to White middle-class families and further research is needed to demonstrate potential applicability to families of other racial backgrounds or SES.

Notwithstanding these limitations, the findings reported here are the first to underscore the construct validity of the HSC scale with a set of behavioral, temperamental, and personality characteristics early in life. Moreover, the study raises additional questions with regard to the effects of potential overlaps between behavioral constructs that so far have not been taken into account in the extant literature. In particular, especially accounting for the findings highlighting that above and beyond individual contributions of other behavioral, temperamental, and personality characteristics, cognitive empathy and sensitivity to punishment were jointly the more reliable predictors of SPS in our sample, future studies will be important to consider the potential differential effects of such associations for better and for worse. To this extent, future interventions that account for the observed associations between SPS, cognitive empathy, and additional constructs of temperamental sensitivity will be imperative in increasing the impact of early life adjustment.

Ethical Approval

This study was approved by the Cyprus Bioethics Review Board (Approval No. 2019/73) at the University of Cyprus, approved on 5 September 2019.

Data Availability Statement

Data is available on request from the authors.

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Conflict of Interests

The authors declare no conflicts of interest.

Author Contributions

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

Supplementary material
Not applicable

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