Sensory Processing Sensitivity and the Association with Attention-Deficit/ Hyperactivity Disorder (ADHD) Traits, and ADHD-Related Strengths in the General Population

L.M. Schippers[1,2,], M. Hoogman[1,3], C.U. Greven[3,2]*

[1]Radboud University Medical Centre, Donders Institute for Brain, Cognition and Behaviour, Department of Psychiatry

[2]Karakter Child and Adolescent Psychiatry, Nijmegen, The Netherlands

[3]Radboud University Medical Centre, Donders Institute for Brain, Cognition and Behaviour, Department of Cognitive Neuroscience

* Corresponding author

Contact information for the corresponding author

Prof. C.U. Greven, corina.greven@donders.ru.nl

Abstract

Sensory processing sensitivity (SPS) is a normally distributed personality trait reflecting sensitivity to stimuli. However, despite societal interest, it is unclear how SPS relates to Attention-deficit/hyperactivity disorder

(ADHD). Here we aimed to 1) explore the relation between SPS and ADHD traits, and their respective subdimensions, 2) compare people with and without an ADHD diagnosis on SPS subdimensions, 3) assess relations between SPS and several ADHD-related strengths. 496 adults were recruited from the general population via the online platform Prolific. Participants filled in questionnaires on SPS (Highly Sensitive Person Scale with subdimensions: ease of excitation, low sensory threshold, aesthetic sensitivity), ADHD traits (Adult ADHD Self Report scale with subdimensions: inventiveness, hyperactivity-impulsivity), and nine questionnaires on ADHD-related strengths. We performed correlation and case-control analysis. SPS and subdimensions correlated positively with ADHD traits and subdimensions. Furthermore, people with an ADHD diagnosis scored higher on SPS than those without. SPS correlated positively with the ADHD-related strengths of hyperfocus and cognitive flexibility, and the SPS aesthetic sensitivity subdimension additionally with curiosity, humour, and empathy; these associations remained significant correcting for ADHD traits. Concluding, SPS and ADHD positively associated, using continuous and case-control analyses. SPS also positively correlated with several strengths.

Keywords

Sensory processing sensitivity, attention-deficit/hyperactivity disorder, positive psychology, hyperfocus, cognitive flexibility, aesthetic sensitivity

Lay abstract

Sensory processing sensitivity (SPS) is a personality trait that reflects differences between people in sensitivity and reactivity to environments. About 20% of the population can be considered high SPS: “highly sensitive”, experiencing their sensitivity as both positive and negative. In previous qualitative research, people with ADHD, a condition characterised by inattentiveness and/or hyperactivity/impulsivity, reported to experience SPS as a positive aspect of their ADHD. However, very little is known about the relations between SPS and ADHD. Because of the interest of people with ADHD in SPS, we wanted to answer two questions: first, how SPS relates to ADHD; and second, if and how SPS relates to several strengths related to ADHD in previous research. Almost 500 people filled out online questionnaires on SPS, ADHD, and strengths. For the first question, we confirmed that people who score higher on SPS, also had more ADHD traits. We also showed that people with an ADHD diagnosis, score higher on SPS than people without an ADHD diagnosis. For the second question, we found that people who score higher on SPS, had greater cognitive flexibility and hyperfocus, two of the nine strengths we investigated. People who score higher on certain aspects of SPS related to the positive SPS subscale, also scored higher on curiosity, empathy, and humour. Future research might highlight the importance for practitioners to be alert of the co-occurrence of ADHD and high SPS. Moreover, it might lead to changing ADHD interventions to the needs of people with ADHD and high SPS.

Main text

Introduction

Sensory processing sensitivity (SPS) is a personality trait that describes inter-individual differences in sensitivity and responsivity to internal and external stimuli. The trait is normally distributed in the population, with about 20-30% of the population found at the higher end of the spectrum (Aron & Aron, 1997; Lionetti et al., 2018). SPS is typically assessed with the Highly Sensitive Person (HSP) scale (Aron & Aron, 1997) that can be divided into three subdimensions: ease of excitation (EOE), low sensory threshold (LST), and aesthetic sensitivity (AES) (Smolewska et al., 2006).

Much research has focused on associations of the HSP scale with internalising symptoms, such as burnout, stress, depressive symptoms, anxiety, and negative affect (Kenemore et al., 2023; Lionetti et al., 2019; Pérez-Chacón et al., 2021; Redfearn et al., 2020). Especially the EOE and LST subdimensions of the HSP scale tend to correlate with such internalising symptoms. In contrast, the AES subscale tends to associate with positive outcomes, such as entrepreneurial intention, imagination, artistic interest, openness and enhanced intervention response (Harms et al., 2019; Lionetti et al., 2024; Pluess & Boniwell, 2015; Pluess et al., 2023; Smolewska et al., 2006; Verheul et al., 2024). Overall, however, there is scarce evidence on how SPS relates to mental health beyond internalising symptoms, and how it relates to positive traits or strengths. In this study, we therefore address these literature shortcomings.

Little is known about how SPS relates to or differs from neurodevelopmental traits such as attention-deficit/hyperactivity disorder (ADHD), despite such questions arising from ADHD organisations (Schippers et al., 2022). ADHD is a common neurodevelopmental condition characterised by inattentiveness and/or hyperactivity/impulsivity (*Diagnostic and statistical manual of mental disorders: DSM-5™, 5th ed*, 2013). About 5.9% of children and 2.5% of adults live with ADHD (Faraone et al., 2021). Two studies showed that ADHD traits positively correlated with HSP scale total scores in the general population, without examining HSP subdimensions (Panagiotidi et al., 2018, 2020). Another study replicated the SPS-ADHD trait association in students for the total HSP scale score, and combined EOE and LST subdimensions, but found no significant association with the AES subscale (Turjeman-Levi & Kluger, 2022). These findings should be replicated in a non-student sample and separating HSP subdimensions. Additionally, to our knowledge, all previous research focused on continuous ADHD traits rather than comparing people with and without ADHD. Hence, it remains unknown whether SPS may be elevated in those with an ADHD diagnosis.

In the present study, we make use of data collected by (Schippers et al., 2024) with the original purpose to shed light on the relations between ADHD and potential ADHD-related strengths. People with an ADHD diagnosis had self-attributed SPS and several other traits as ADHD-related strengths in qualitative research (Schippers et al., 2022), and Schippers at al. (2024) subsequently confirmed the association of ADHD

traits with SPS and other ADHD-related strengths quantitatively in a population-based sample. However, the studies did not examine whether HSP subscale levels are elevated in those with a diagnosis of ADHD. Furthermore, given that several of the ADHD-related strengths could also be relevant for SPS, and given the scarcity of research on strengths associated with SPS, the sample provides a unique opportunity to study such associations.

Therefore, we conduct secondary analyses on the Schippers at al. (2024) data with three main aims. First, we aimed to explore the relation between SPS and ADHD traits, and their respective subdimensions. Second, we aimed to compare people with and without an ADHD diagnosis on SPS subdimensions. Third, we aimed to assess relations between SPS and several ADHD-related strengths, with and without correction for ADHD traits. Studying positive traits might help people make better use of the positive potential of the SPS trait.

Methods

Here secondary analyses are presented on a dataset for which main analyses were preregistered (Schippers & Hoogman, 2021).Detailed methods are described elsewhere (Schippers et al., 2024).

Participants

We collected data using the online platform Prolific. Participants filled out questionnaires in two waves, between November and December 2021. Inclusion criteria were: age between 18-60 years, English as first language, current residence in the UK, UK nationality, and no literacy

difficulties. 694 participants completed wave one questionnaires, and were invited to participate in wave two. For wave two, we aimed to recruit 500 participants on a first come, first serve basis. This led to full datasets of 496 participants in wave two. Suspected ADHD was based on self-report of having been diagnosed either in childhood or adulthood, or to be in the process of receiving a diagnosis. See Table S1 for an overview of participant characteristics.

Questionnaires

The first wave contained a questionnaire on SPS, ADHD traits, a question on ADHD diagnosis and four questionnaires on potential ADHD-related strengths. The second wave contained five questionnaires on potential ADHD-related strengths. To assess SPS, the Highly Sensitive Person Scale (HSP Scale) was used, which contains 27 questions divided into three subdimensions: aesthetic sensitivity (AES), ease of excitation (EOE) and low sensory threshold (LST) (Aron & Aron, 1997; Smolewska et al., 2006) (Table S2). To assess ADHD traits, the well-validated Adult ADHD Self Report scale (ASRS) was used. It contains eighteen questions that relate to DSM-5 ADHD symptoms, distributed in two subdimensions: inattentiveness, and hyperactivity/impulsivity (Kessler et al., 2005). For the other questionnaires, see Table S3.

Analyses

Only the Grit scale passed the Shapiro-Wilk test for normality. Therefore, we performed non-parametric tests. To address aim one, we first performed Kendall’s tau correlation analyses between SPS and ADHD

questionnaire scores, and their respective subdimensions. We used effective number of tests (Meff) method (Li & Ji, 2005) to correct for multiple testing. Given the interest in disentangling associations between ADHD and SPS, we included ADHD subdimensions and SPS subdimensions, but for the other questionnaires used only total scores. This resulted in twelve independent variables, and a p-value threshold for significance of $p < 0.004$. Despite gender differences in both ADHD traits and SPS traits, no previous study has studied the role of gender effects in these associations (Faraone et al., 2024; Trå et al., 2022). We therefore performed the analyses in aim one separately for the total sample, and exploratorily for men and women separately. To address aim two, we compared people with and without a self-reported ADHD diagnosis on total and subscale scores of the HSP scale. We used Hedge's g to estimate effect size. To address aim three, we performed Kendall's tau correlation analyses between SPS total scores and subdimensions, and strengths and their subdimensions. We performed the correlation analyses with and without correcting for ADHD traits, to explore the influence of ADHD traits on the relation between SPS and ADHD-related strengths. Lastly, we performed a network analysis, identical to the one in Schippers et al. (2024), now visualising the ASRS and HSP subdimensions by depicting their subdimensions in different colours. We included age as covariate for all aims, and sex in analyses not separated for sex.

Results

SPS and ADHD traits

SPS correlated positively with ADHD traits for the SPS total score (r = .36, p < .001) and all three subdimensions (r = .21 - .34, p < .001). Similarly, positive correlations were found between the SPS total score and ADHD subdimensions, inattentiveness, and hyperactivity/impulsivity (r = .32 - .33, p < .001), and SPS subdimensions and ADHD subdimensions (Table 1). Correlations were significant both for men and women and were similar in strength.

SPS and ADHD diagnosis

People with ADHD diagnosis (n=20) scored significantly higher than people without ADHD diagnosis (n= 674) on total SPS score (p < .001, Hedge's g = - 1.05) and on the SPS subdimensions (LST and EOE p < .001, Hedges g = -1.09 and -0.77 respectively, AES p = .002 Hedge's g = -0.79).

SPS and strengths

Overall, associations between SPS and ADHD-related strengths were similar with (Table 2) and without (Table S4) correction for ADHD traits. Here we discuss the results with correction for ADHD traits. We found significant positive correlations between total SPS and hyperfocus and cognitive flexibility (r = .14 - .22, p < .001), and negative correlations between total SPS and sociability, enthusiasm, up for anything and

perseverance (r = -.09- -.30, p < .001). The correlations for the LST and EOE subdimensions were similar in direction as for total SPS, except for a negative correlation of EOE with curiosity (r = -.15, p < .001). However, for the AES subscale, the correlation with cognitive flexibility was not significant, but there were additional positive correlations with empathy, humour, and curiosity (r = .12 - .16, p < .001). The negative correlations with enthusiasm, sociability and perseverance were not significant, and correlations with up for anything and flexibility were weaker than for total SPS (r = -.05, p = .05, and r = -.08, p = .009, respectively).

Network analysis (Figure 1) revealed that although ADHD and SPS are close, they form separate clusters, suggesting separate constructs. Moreover, EOE and LST cluster closely together, while AES forms a more separate cluster.

Discussion

In the current study, we investigated the relations of SPS with ADHD traits, ADHD diagnosis, and with ADHD-related strengths in a population-based sample. Regarding our first aim, we found small positive associations between SPS and continuous ADHD trait scores, in line with previous studies (Panagiotidi et al., 2018, 2020; Turjeman-Levi & Kluger, 2022). In contrast to previous research (Turjeman-Levi & Kluger, 2022), we found that SPS and ADHD traits were associated across all SPS subdimensions and ADHD dimensions, including the AES subscale. Associations of ADHD traits with AES were small, and those with the EOE

and LST modest. Additionally, results were similar for both men and women.

Regarding our second aim, we showed for the first time that people with a self-reported ADHD diagnosis scored higher on all SPS subdimensions than people without an ADHD diagnosis, with large effect sizes. Future studies should investigate whether high SPS might be a stratification marker for ADHD (an extension to diagnosis clarifying for instance the course or severity), indicate a mechanistic marker (reflect underlying process), or act as a transdiagnostic trait (a mechanism found across conditions, acting for example as a risk or maintaining factor) (Buitelaar et al., 2022). Such research might lead to adapting ADHD interventions to the needs of people with ADHD and high SPS, and have implications for practitioners to be alert of the co-occurrence of ADHD and high SPS.

Regarding our third aim concerning associations with strengths associated with ADHD in previous research, we found a positive association of SPS with hyperfocus and cognitive flexibility, not described in literature before. However, correlations with sociability, enthusiasm, up for anything, and perseverance were negative. However, we measured sociability as the opposite of shyness, and up for anything as the opposite of intolerance of uncertainty, which have been negatively associated with SPS before (Aron et al., 2005; Attary & Ghazizadeh, 2021; Panchyshyn et al., 2023; Uljarević et al., 2016). Most correlations between SPS and ADHD-related strengths became somewhat weaker, but remained significant, after correction for ADHD traits, suggesting that SPS shows

associations with these variables independently of ADHD traits. Further supported by network analysis results, this suggests that high SPS and ADHD are related, but separate constructs. Lastly, correlations between SPS and the included strengths differed for the SPS subdimensions, with AES having the most positive correlations.

This study has several general strengths and limitations outlined in (Schippers et al., 2024). A specific limitation is that because the study was originally focussed on strengths in ADHD, we chose strengths previously related in literature to ADHD and not SPS. This has however led to surprising findings that we might not have found setting up this study from an SPS lens, such as associations with hyperfocus. Future research should replicate results using clinical assessments of ADHD diagnosis, and objective measures of strengths.

Conclusion

SPS showed small associations with continuous ADHD scores, and a large effect size in a case-control comparisons. Moreover, SPS was associated with several variables previously identified to be ADHD-related strengths even after correcting for ADHD traits.

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Declaration of conflicting interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. MH received a

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Ethical approval and informed consent statements

Ethical considerations

This study was marked as exempt for ethical review by our local medical ethical committee (METC, Nijmegen, The Netherlands, file number: 2021 13,211).

Consent to participate

All participants gave written informed consent to participate before starting the questionnaires.

Consent for publication

All participants gave written informed consent for publication before starting the questionnaires.

Data availability statement

Data will be made available on the OSF preregistration page.

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Table 1.

Kendall's correlation coefficients between SPS and ADHD scores

	Total SPS score			*EOE*			*LST*			*AES*		
	Total	*Men*	*Women*	*Total*	*Men*	*Women*	*Total*	*Men*	*Women*	*Total*	*Men*	*Women*
Total ADHD	.36**	.33**	.39**	.31**	.28**	.34**	.34**	.31**	.38**	.21**	.20**	.21**
Inattentiveness	.33**	.29**	.38**	.32**	.27**	.36**	.32**	.28**	.37**	.16**	.14**	.18**
Hyperactivity/ impulsivity	.32**	.26**	.34**	.25**	.23**	.27**	.31**	.28**	.33**	.22**	.22**	.22**

Note. SPS, sensory processing sensitivity, EOE, ease of excitation, LST, low sensory threshold, AES aesthetic sensitivity. Covariate: age. ** p < .001

Table 2.

Kendall's correlation coefficients between SPS and SPS subdimensions and strengths

Strengths	N	HSP scale subdimensions			
		Total SPS r (p-value)	**Ease of excitation r (p-value)**	**Low sensory threshold r (p-value)**	**Aesthetic sensitivity r (p-value)**
Empathy (TEQ)	694	.06 (0.03)	.07 (.008)	-.04 (.14)	**.15 (<.001)**
Sociability (CBSS)		**-.23 (<.001)**	**-.30 (<.001)**	**-.18 (<.001)**	-.02 (.30)
Hyperfocus (AHQ)		**.22 (<.001)**	**.28 (<.001)**	**.16 (<.001)**	**.18 (<.001)**
Humor (MSHS)		.00 (0.87)	-.02 (0.38)	-.05 (.03)	**.12 (<.001)**
Curiosity (CEI)		-.07 (0.03)	**-0.15 (<.001)**	-.06 (0.06)	**.16 (<.001)**
Enthusiasm (BFAS)	496	**-.11 (<.001)**	**-.14 (<.001)**	**-.13 (<.001)**	.05 (0.09)
Up for anything (IUS)		**-.30 (<.001)**	**-.36 (<.001)**	**-.23 (<.001)**	-.05 (.05)
Flexibility (CFS)		**.14 (<.001)**	**.21 (<.001)**	**.16 (<.001)**	-.08 (0.008)
Perseverance (Grit)		**-.09 (.002)**	**-.12 (<.001)**	-.07 (.01)	.01 (0.85)
Subdimensions					
MSHS Production and Social Use of Humor	694	.00 (0.86)	-.04 (0.07)	-.02 (.26)	**.10 (<.001)**
MSHS Adaptive Humor		**0.07 (.004)**	**.05 (.04)**	**.**01 (.70**)**	**.15 (<.001)**
MSHS Negation to use Humor		**-.05 (0.05)**	.00 (0.98)	**-.14 (<.001)**	.01 (0.55)
MSHS Attitude toward Humor		-.03 (0.21)	-.03 (0.29)	**-.09 (<.001)**	.04 (0.12)
MSHS Appreciation of Humor		.03 (0.25)	**.05 (.04)**	**-.06 (0.008)**	**.09 (0.001)**
Grit consistency of interest	496	**-.08 (.006)**	**-.12 (<.001)**	**-.08 (.006)**	**.08 (0.006)**
Grit perseverance of effort		**-.07 (.02)**	**-.07 (.02)**	-.04 (.20)	**-.06 (.04)**
CEI stretching		-.01 (0.70)	**-.09 (.001)**	-.03 (0.28)	**.20 (<.001)**

CEI embracing	**-.11 (<.001)**	**-.19 (<.001)**	**-.09 (0.002)**	**0.11 (<.001)**

Note. TEQ, Toronto Empathy Questionnaire, CBSS, Cheek and Buss Shyness Scale, HSP, Highly Sensitive Person Scale, AHQ, Adult Hyperfocus Questionnaire, MSHS, Multidimensional Sense of Humor Scale, CEI, Curiosity and Exploration Inventory, BFAS, Big Five Aspects Scale, IUS, Intolerance of Uncertainty Scale, CFS, Cognitive Flexibility Scale, GRIT, Grit scale. Covariates: age, sex, ADHD traits.

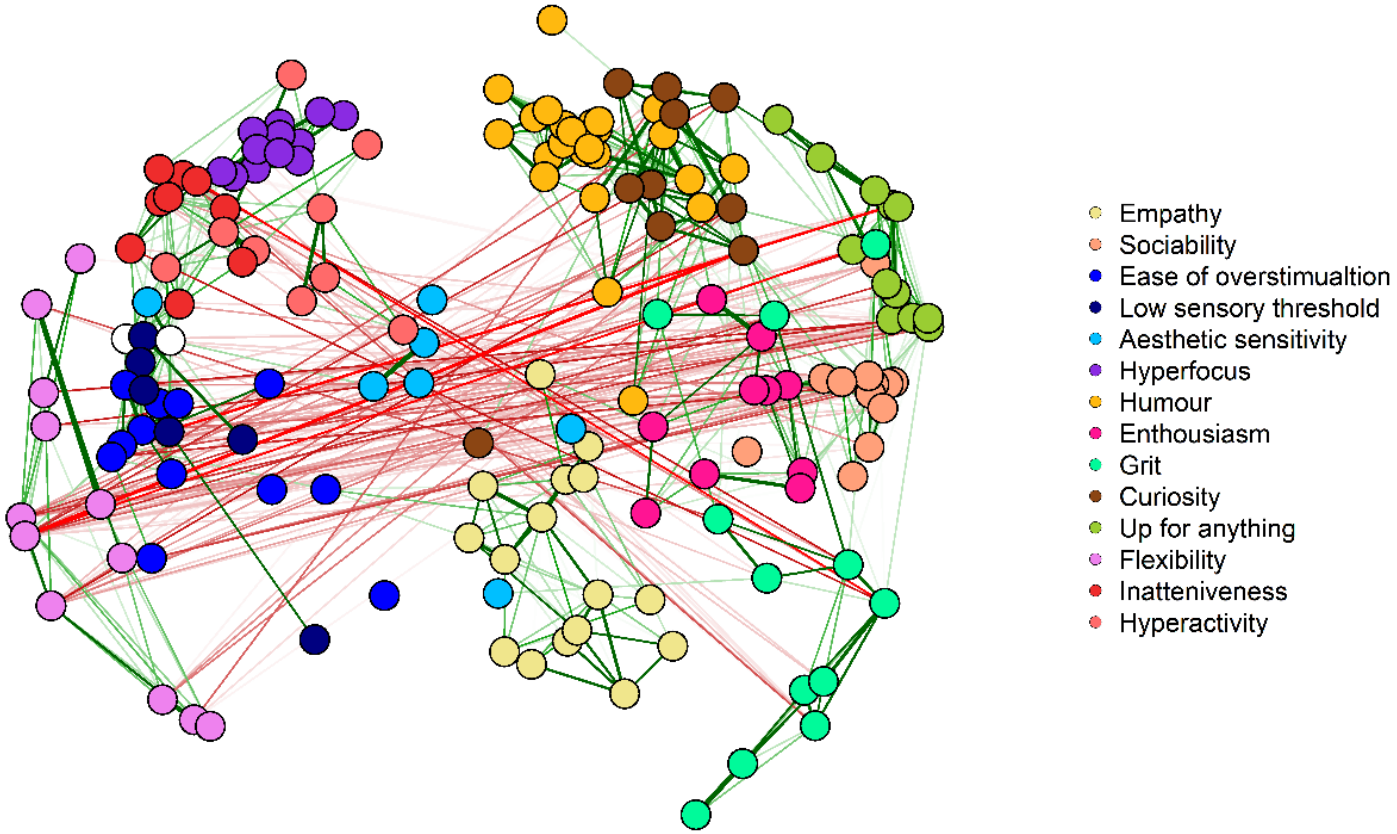

Fig. 1. Network representing all questionnaire items. Each node (circle) represents one questionnaire item. Edges (lines) represent correlations. Red edges represent negative correlations, green edges represent positive correlations. Thicker

edges represent stronger correlations. The network is visualised using multidimensional scaling using the qrgap package in R (Epskamp et al., 2022). For the network estimation, we used a Graphical Least Absolute Shrinkage Operator (GLASSO), with a gamma of 0.5. We calculated item redundancy using the goldbricker function from the R package Networktool, planning to combine items with >95% overlap, but this did not lead to the combination of any items.