Nordic Psychology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rnpy20

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To cite this article: Hilde Visnes Trå, Frode Volden & Reidulf G. Watten (2022): High Sensitivity: Factor structure of the highly sensitive person scale and personality traits in a high and low sensitivity group. Two gender—matched studies, Nordic Psychology, DOI: 10.1080/19012276.2022.2093778

To link to this article: https://doi.org/10.1080/19012276.2022.2093778

Published online: 11 Jul 2022.

Nordic Psychology, 2022
https://doi.org/10.1080/19012276.2022.2093778

RESEARCH ARTICLE

High Sensitivity: Factor structure of the highly sensitive person scale and personality traits in a high and low sensitivity group. Two gender—matched studies

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Abstract

Sensory Processing Sensitivity (SPS) is a heritable personality related trait which includes sensitivity to a variety of stimuli, emotional, cognitive, and behavioural reactions such as strong positive and negative emotional responses, deep cognitive processing of stimuli, and empathic behaviour. Two studies are reported. Study 1 investigated the factor structure of the Highly Sensitive Person scale (HSP) and gender differences in HSP. Study 2 described differences in Big Five personality traits between two HSP groups. Study 1 comprised a sample of adults, mostly university students, matched on gender (N men = 548, N women = 548; total $N = 1096$). Study 2 was based on a sample consisting of a High ($N = 164$) and Low ($N = 164$) HSP group also matched on gender (N men = 82 and N women = 82 in both groups; total $N = 328$). There were no age differences between men and women in the two samples. Results from Study 1 showed a correlated three-factor solution: The first factor reflected excitability, easily aroused, negative emotional reactivity, frustration, avoidance of upsetting situations and childhood shyness. Factor 2 comprised low sensory threshold and sensory discomfort. Factor 3 captured intensity of aesthetic reactions, preoccupation with details in the environment, and socio-emotional sensitivity. Gender differences were found, women had elevated HSP scores on all scales, also when controlled for personality traits. Study 2 showed that the highly sensitive individuals had a unique personality trait profile compared to low sensitives. They had higher scores on neuroticism, agreeableness, openness, and lower scores on conscientiousness. There were no differences in extraversion i.e., there was no tendency towards introversion among the high sensitives.

Keywords: factor structure, Highly Sensitive Person scale, personality traits, sensory processing sensitivity

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Study 1

Introduction

Sensory Processing Sensitivity (SPS) is a heritable personality related trait with a firm genetic basis (Assary et al., 2021) characterized by an ability to respond to external factors and register and process sensory information more deeply (Pluess, 2015). SPS involves sensitivity to a variety of stimuli such as caffeine, hunger, pain, subtleties, arts, but also human environments like groups, families, workplaces, schools, etc. (Aron et al., 2012; Aron & Aron, 1997; Jagiellowicz et al., 2011; Pluess, 2015). SPS is associated with emotional reactivity, awareness, self-other relations, reward processing and reflective thinking (Aron et al., 2012) and is reflected in several behavioural reactions such as a tendency to become easily aroused and frustrated, but also deep cognitive processing of stimuli, aesthetic sensitivity and empathic behaviour. Sensitive individuals are easily overstimulated, they are significantly affected by moods in others, and show marked empathic reactions towards affective cues such as facial emotions (Acevedo et al., 2014, 2018; Braem et al., 2017). SPS is also described in a number of animal species, including primates (Wolf et al., 2008), suggesting that SPS has a fundamental adaptational role for many biological organisms. SPS is now part of a broader Environmental Sensitivity theory covering several scientific fields, not only psychology (Greven et al., 2019).

Sensory processing sensitivity is usually measured with the Highly Sensitive Person scale (HSP) (Aron & Aron, 1997), a 27-item Likert type scale. However, the factor structure of the HSP has been a matter of dispute among SPS researchers—one general factor, two factors, three or more? Aron and Aron (1997) advocated a unidimensional structure, a view also corroborated by Hofmann and Bitran (2007) in their preliminary clinical study on SPS and anxiety disorders. They suggested that SPS was uniquely related to a subtype of generalized social anxiety disorders. In an evaluation of a revised German version of the HSP Konrad and Herzberg (2017) described a three-factor structure denoted Ease of Excitation (EOE), Aesthetic Sensitivity (AES) and Low Sensory Threshold (LST). These results were endorsed by the studies of Grimen and Diseth (2016) and Smolewska et al. (2006) also describing a comparable three-factor structure. Evans and Rothbart (2008) described a two-factor solution denoted Negative Affect and Orientation, and so did Lionetti et al. (2018) but their bifactor structure showed a general sensitivity factor and three subscales which comprised sensory threshold (LST), sensitivity to overstimulation (EOE) and aesthetic sensitivity (AES). A bifactor structure was also described by Iimura et al. (2022) using the 10-item version of the Japanese HSP scale. Finally, Chacón et al. (2021) presented a five-factor solution in an adult Spanish population. Apparently, there still seems to be some disagreement about the factor structure of the HSP scale.

The studies referred to are largely gender-biased. Almost 70% of the sample in the study of Smolewska et al. (2006) were women ($N = 594$, N men $= 237$); more than 83% of the participants in the study by Grimen and Diseth (2016) were women ($N = 137$, N men $= 28$); 68% and 63% of the participants in Study 1 (N women $= 105$, N men $= 49$) and Study 2 (N women $= 118$, N men $= 44$), respectively in the study by Sobocko and Zelenski (2015) were women; 84% of the sample in the study by Konrad and Herzberg (2017) were women

($N = 3015$, N men = 574), and 62.3% and 69% of the first and second sample, respectively in the study of Lionetti et al. (2018) were women (first sample N women = 564, N men = 342; second sample and N women = 159, N men = 71). A Japanese investigation (Yano et al., 2021) described a three-factor solution in a sample that was fairly gender balanced (N women = 867, N men = 759), but they used a 19-item version of the HSP scale (HSPS-J19) that was adapted to a three-factor model through confirmatory factor analyses (CFA). Evans and Rothbart (2008) did not report the gender distribution in their sample, only the total number ($N = 297$). In sum, the factor-structure of the HSP reported in studies so far could be a "female" factor structure not representative of both genders.

Gender differences are reported in SPS; women usually have higher HSP-scores than men (Benham, 2006; Chacón et al., 2021; Konrad & Herzberg, 2017; Licht et al., 2011). This is not surprising, since women typically have higher scores in neuroticism, agreeableness, and openness to feelings, lower scores in assertiveness and openness to ideas (Costa et al., 2001) and they are more relation-oriented and less thing-oriented than men (Lippa, 2010). Harmonious relations with others, pleasantness and likability are typical aspects of agreeableness, a trait also associated with SPS (Yano et al., 2021). These gender differences could therefore affect the HSP factor structure in gender-biased samples. For example, the association between neuroticism and HSP is well known (Smolewska et al., 2006) and women typically have higher neuroticism scores than men (Weisberg et al., 2011), and they also report higher scores than men on agreeableness and openness (Costa et al., 2001). On the other hand, gender differences in SPS could still exist, but conclusions on this issue cannot be drawn unless the influence of gender-related personality traits on the HSP scale is controlled for.

Factor rotation methods are another methodological issue. For instance, Grimen and Diseth (2016) used varimax rotation in their principal component analysis, a questionable choice since this kind of rotation requires independent factors. Research findings clearly show that the HSP factors are correlated, suggesting that rotations allowing the factors to be correlated would be more appropriate. Smolewska et al. (2006) used Direct Oblimin rotation, but their sample was quite small ($N = 167$), and too small to conduct a split-half confirmatory factor analysis (CFA). Evans and Rothbart (2008) used principal axis factoring (PAF) with oblique rotation (Promax), while Yano et al. (2021) used canonical correlations. Apparently, more studies are needed to determine the factor structure of HSP and these studies should be based on samples without gender bias to avoid a "female" factor structure, as seems to be case now due to a majority of gender-biased studies.

In the current study we firstly wanted to explore more detailed the factor structure of the HSP on a sample large enough to enable a split-half procedure by combining principal component analysis (PCA), confirmatory factor analysis (CFA) and parallel analysis (PA). As far as we can see PA has not been used in the SPS research field to assess the number of HSP factors so far, but it is an important statistical tool for decisions on factors to be retained (see more in Statistical analyses). From previous research reported in the Introduction we would expect to find evidence for quite a few factors, probably two or three. Secondly, because of the gender bias shown in previous SPS investigations we have used a sample with equal gender distribution to avoid a gender biased distribution of the participants. Thirdly, in spite of gender matched samples gender differences in SPS might still be a reality and could be linked to gender differences in personality traits. We,

therefore, investigated gender differences and controlled statistically for the influence of personality traits on the HSP. Summarized, the aims of Study 1 were to describe the factor structure of the HSP and to investigate gender differences in HSP controlled for Big Five personality traits.

Methods

Design

We used a matched population design allowing us to investigate the factor structure of the HSP not biased by gender or age.

Participants and procedure

The total sample consisted originally of 1405 subjects, 38 did not report gender and the net sample with complete gender status therefore consisted of 1367 subjects, 818 men and 549 women, predominantly Caucasian. One of the female participants was removed due to incomplete questionnaires so the total female sample consisted of 548 women. We then randomly selected 548 men from the 818 males in the total sample using the random procedure in the SPSS program. The final net sample consisted of 1096 participants (N men $=$ 548 women; N women $=$ 548) in the following age groups: 18–24 years: 20.8%; 25–34 years: 40.6%; 35–44 years: 16.8%; 45–54: 11.8%; 55–65: 6.7%; 65+: 3.0% There was no significant age difference between the groups, $\chi 2$ (5) $= 7.10$, $p = .213$. The majority were adult university students in addition to a community sample voluntary recruited by some of the students.

The sample was recruited as part of a mandatory course in scientific methodology and philosophy. The participants were informed about the study and were told that the purpose was to explore a possible relationship between behavioural style and the sensory system. They were not asked about their sensitivity before participation. The HSP questionnaires were filled out anonymously and in the following order: demographic data (age, gender), personality traits and HSP. Completed questionnaires were returned to the project group.

Ethics

Participation was voluntary and the participants provided written informed consent prior to taking part in the study. The participants were also informed that they could withdraw from the study at any time and without justification. The participants received no payment for participation. Ethical approval was given by an independent expert from another institution.

Measures

Assessment of sensory processing sensitivity

The Highly Sensitive Person scale (HSP) (Aron & Aron, 1997) was used to assess sensory processing sensitivity. The HSP consists of 27 items answered on a 7-point Likert scale (1 = *Not at all*; 7 = *Extremely*). The questions mainly focus on emotional and behavioural reactions, such as getting upset, overwhelmed, moved, annoyed or uncomfortable. For instance, "Are you easily overwhelmed by things like bright lights, strong smells, coarse

fabrics, or sirens close by?," "Are you deeply moved by the arts or music?," and "Do you seem to be aware of subtleties in your environment?" The HSP scale showed good internal consistency: Cronbach's Alpha = .87, Guttman Split-Half Coefficient = .84. A high Alpha does not imply a unidimensional measure, the dimensionality of the scale has to be assessed with additional analyses such as factor analyses (Taber, 2018).

Assessment of Big Five personality traits

Personality traits were measured with a Norwegian version of the BFI-44 (Big Five Inventory-44) (Engvik & Føllesdal, 2005; John & Srivastava, 1999) consisting of 44 items assessing five dimensions: extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience. The answers were registered on a 7-step Likert scale (1 = *Does not apply*; 7 = *Applies completely*). Cronbach's Alpha for the scales in the current study were acceptable: extraversion (α =.74), agreeableness (α = .71), conscientiousness (α = .74), neuroticism (α = .79), openness (α =.73).

Statistical analyses

Because the number of participants was quite large ($N = 1096$) and homogenous in terms of age and gender, we used a split-half procedure and split the total sample exactly in two samples, a calibration sample ($N = 548$) and a validation sample ($N = 548$). We then conducted principal component analyses (PCA) on the calibration sample ($N = 548$) and confirmatory factor analyses (CFA) on the validation sample.

The factors were allowed to be correlated in the PCA, and we therefore used Promax rotation with Kaiser Normalization (Eigenvalue > 1). The frequency of missing cases was very low and as follows for items HSP1 to HSP 27: 2, 1, 1, 60, 0, 3, 1, 1, 0, 1, 2, 4, 0, 1, 2, 2, 3, 2, 3, 1, 1, 0, 2, 3, 0, 3, 1. The average percentage for the 27 items was 0.35%, ranging from 0 to maximum 5.5 percent of the items (only one item—item 4—had a missing frequency of 5.5%). Most of the HSP items were in the range 0.1%–0.3%. The low missing rate is probably explained by the fact that the project was part of a mandatory course for most of the participants. Due to the very low missing rate, missing values were replaced with the arithmetic mean values of the items (mean imputation). The advantage of this method is that it preserves the mean of data and keeps the full sample size. In addition, we did Parallel analyses (PA) to further ascertain the number of factors to be extracted. That statistical method compares eigenvalues from the data matrix with eigenvalues from a Monte Carlo simulated random data matrix of the same size (O'connor, 2000). Because factor analyses of uncorrelated data also can produce eigenvalues equal to 1 according to Horn (1965), who first showed this statistical effect, it is important to control for random generated eigenvalues before a decision is made on how many factors to retain in a factor analysis. In our data only components with greater eigenvalues than the eigenvalues from the random data were retained. Parallel analysis is now a recognized method for retaining components in many research fields (Hayton et al., 2004; Zwick & Velicer, 1986).We used the SPSS Syntax for Parallel Analysis from O'connor (2000).

The confirmatory factor analyses (CFA) on the validation sample ($N = 548$) were based on the PCA results of the calibration sample. Items loading on more than one factor were removed from the analyses. Several standard indices of model fit were used in addition to

the Chi-square goodness-of-fit: the comparative fit index (CFI), the normal fit index (NFI), the Tucker-Lewis index (TLI), and the root mean square error of approximation (RMSEA). Cut-off criteria for good model fit were a CFI and TLI above .95 and a RMSEA at .05 or lower (Hu & Bentler, 1999), but as pointed out by Chen et al. (2008) universal cut-off values to determine model fit should be interpreted with caution. We have therefore combined several model fit indices (Schreiber, 2017). We also tested differences between the CFA models from these analyses with a one-factor and a two-factor CFA model using Chi-square statistics.

Measurement invariance

Measurement invariance reflects an aspect of construct validity of an instrument indicating that a questionnaire, psychological test, etc., measures the same construct in the same way across groups (Dimitrov, 2010; Wang et al., 2018). We evaluated configural invariance, metric invariance, and scalar residual invariance across gender by applying multi-group analysis of nested CFA models (MG-CFA) (Lu et al., 2018). In addition to model fit and chi-square differences we also used changes in CFI and RMSEA statistics to assess invariance across groups (Feitosa et al., 2017). If CFI and RMSEA changes were less than 0.010 and 0.015, respectively (ΔCFI $<$ 0.010 and a Δ RMSEA $<$ 0.015) invariance was indicated (Chen, 2007). The analyses were carried out with AMOS and the Statistical Package for the Social Sciences (SPSS) version 27.

Results

Table 1 presents eigenvalues from the Parallel analysis compared to the eigenvalues of the actual data set. Only the eigenvalues from the first three factors were greater than the eigenvalues from the random data.

Table 2 shows the factorial structure of the HSP for the first half of the sample. Kaiser-Meyer-Olkin Measure of Sampling adequacy (KMO) was .89, Bartlett's Test of Sphericity: $\chi 2$ (351) $=$3448.24, $p =<$ .001. The analysis suggested extraction of three factors, and this was also consistent with the results of the parallel analysis. The three factors explained 37.39% of the total variance. The first factor was the largest explaining 24.18% of the variance; factors 2 and 3 explained 7.37% and 5.84% of the variance, respectively.

Table 1. Parallel analysis on the first half of the sample, the calibration sample.

Actual eigenvalues	Random eigenvalues	95% Percentile eigenvalues
6.534	1.429	1.489
2.003	1.386	1.408
1.567	1.322	1.359
1.192	1.281	1.315
5. 000	1.244	1.270
6. 000	1.208	1.237

Actual eigenvalues compared to random data eigenvalues (average eigenvalues and 95% percentile eigenvalues) for the first six factors in the factor analysis. Loadings greater than the random eigenvalues are marked in boldface script. Note: $N = 548$, 27 variables.

Table 2. Factor structure of the HSP scale of first half of the total sample, the calibration sample.

Factor 1. Ease of excitation (EOE)	**Loadings**
14. Do you get rattled when you have a lot to do in a short amount of time?	.72
16. Are you annoyed when people try to get you to do too many things at once?	.66
21. Do changes in your life shake you up?	.65
17. Do you try hard to avoid mistakes or avoid forgetting things?	.55
26.When you must compete or be observed while performing a task, do you become so nervous or shaky	54
that you do much worse than you would do otherwise?	.47
3. Do other people's moods affect you?	.52
23. Do you find it unpleasant to have a lot going on at once?	.47
20. Does being hungry create a strong reaction in you, disrupting your concentration or mood?	.52
19. Do you become unpleasantly aroused when a lot is going on around you?	.46
24. Do you make it a high priority to arrange your life to avoid upsetting or overwhelming situations?	.43
27. When you were a child, did parents or teachers seem to see you as sensitive or shy?	.42
Factor 2. Low sensory threshold and sensory discomfort (LSTD)	
7. Are you easily overwhelmed by things like bright lights, strong smells, coarse fabrics or sirens close by?	.63
25. Are you bothered by intense stimuli, like loud noises of chaotic scenes?	.62
18. Do you make a point to avoid violent movies and TV shows?	.59
11. Does your nervous system sometimes feel so frazzled that your just have to go off by yourself?	.50
9. Are you made uncomfortable by loud noises?	.49
6. Are you particularly sensitive to the effects of caffeine?	.46
4. Do you tend to be sensitive to pain?	.44
Factor 3. Aesthetic and social sensitivity (AESS)	
22. Do you notice and enjoy delicate or fine scents, tastes, sounds, works of art?	.61
2. Do you seem to be aware of subtleties in your environment?	.58
8. Do you have a rich, complex inner life?	.58
10. Are you deeply moved by the arts or music?	.53
15. When people are uncomfortable in a physical environment do you tend to know what needs to be done to make it more comfortable (like changing the lighting of the seating)?	.46

Promax rotation with Kaiser normalization, pattern matrix. Factors, items, and factor loadings. Loadings below .40 are not reported.
Note: Total $N = 548$ (N men $= 274$, N women $= 274$). HSP items 1 and 5 had factor loadings $<.40$. In addition, HSP item 12 loaded on more than one factor and was not reported.

The first factor reflected predominantly high arousability ("Do you become unpleasantly aroused when a lot is going on around you"), negative affectivity such as emotional frustration ("Do changes in your life shake you up?"), easily upset and confused ("Do you get

rattled when you have a lot to do in a short amount of time, but also perfectionism ("Do you try hard to avoid mistakes or avoid forgetting things?"),) and a tendency toward introversion ("When you were a child, did parents or teachers seem to see you as sensitive or shy?"). We have denoted this factor Ease of Excitation (EOE).

Factor 2 captured cross-modal low sensory threshold ("Do you tend to be sensitive to pain?"; "Are you particularly sensitive to the effects of caffeine?") and sensory discomfort ("Are you easily overwhelmed by things like bright lights, strong smells, coarse fabrics or sirens close by?; "Are you made uncomfortable by loud noises?") We denoted this factor Low Sensory Threshold and Sensory Discomfort (LSTD).

The third factor comprised aesthetic sensitivity, intensity of aesthetic reactions ("Are you deeply moved by the arts and music?"), but also elements of orientation sensitivity such as awareness to details in the environment ("Do you seem to be aware of subtleties in your environment?") and social sensitivity ("When people are uncomfortable in a physical environment do you tend to know what needs to be done to make it more comfortable like changing the lighting of the seating?"). We named the third factor Aesthetic and social sensitivity (AESS). Cronbach's Alpha of the three subscales showed the following values: EOE: .81, LSTD: .77, and AESS: .61.

Figure 1 depicts the final model of the CFA-analysis on the second half of the sample. The model showed significant Chi-square goodness-of-fit: $\chi 2(227) = 586.10$, $p = < .001$, CMIN/DF = 2.58, CFI = .89, NFI = .83, TLI = .87, and RMSEA = .05 (Low 90 = .04, High 90 = .06). Totally, the CFA model described the underlying data reasonably well and showed an acceptable model fit confirming the three-factor solution, although the CFI and TLI indexes were somewhat low. The factors were positively intercorrelated: EOE and LSTD: .82; EOE and AESS: .42, and LSTD and AESS: .51

We also tested at two-factor solution. The first factor comprised 24.2% of the variance and the second factor 7.3%, totally 31.5%. The parameters were as follows: $\chi 2(89) = 398.6$, $p = .000$, CMIN/DF = 4.48, CFI = .85, NFI = .82, TLI = .80, and RMSEA = .08 (Low = .07—High = .09).

Finally, we tested a one-factor solution of the HSP comprising 24.18% of the total variance. The CFA model showed a significant Chi-square goodness-of-fit: $\chi 2(170) = 606.30$, p .000, CMIN/DF = 3.57, CFI = .84, NFI = .79, TLI = .80, and RMSEA = .07 (Low = .06, High = .07). This model fit (RMSEA =.07) was not as good as the three-factor model (RMSEA = .05). Consequently, when comparing the three models, a correlated three-factor solution seems to be the most suitable factorial structure of the HSP.

The factor structure was comparable to other research findings field such as Smolewska et al. (2006), but there were also a differences in rank order of the three factors: EOE, AES, LST versus EOE, LSTD, AESS in our study. The items loading on the factors were also quite similar. In our EOE scale, 9 of 11 items in our scale were the same as the items in the EOE scale of Smolewska et al. (2006): item 13, 14, 16, 17, 20, 21, 24, 26, and 27. Four out of 6 items in the LSTD scale were the same: 7, 9, 18, and 25, and all 5 items loading on our AESS scale (2, 8, 10, 15, 22) were also found in the AES scale of Smolewska et al. (2006).

Measurement invariance

Results of the measurement invariance tests are presented in Table 3 showing fit indexes for the three models. Model 1 shows acceptable goodness-of-fit for configural invariance,

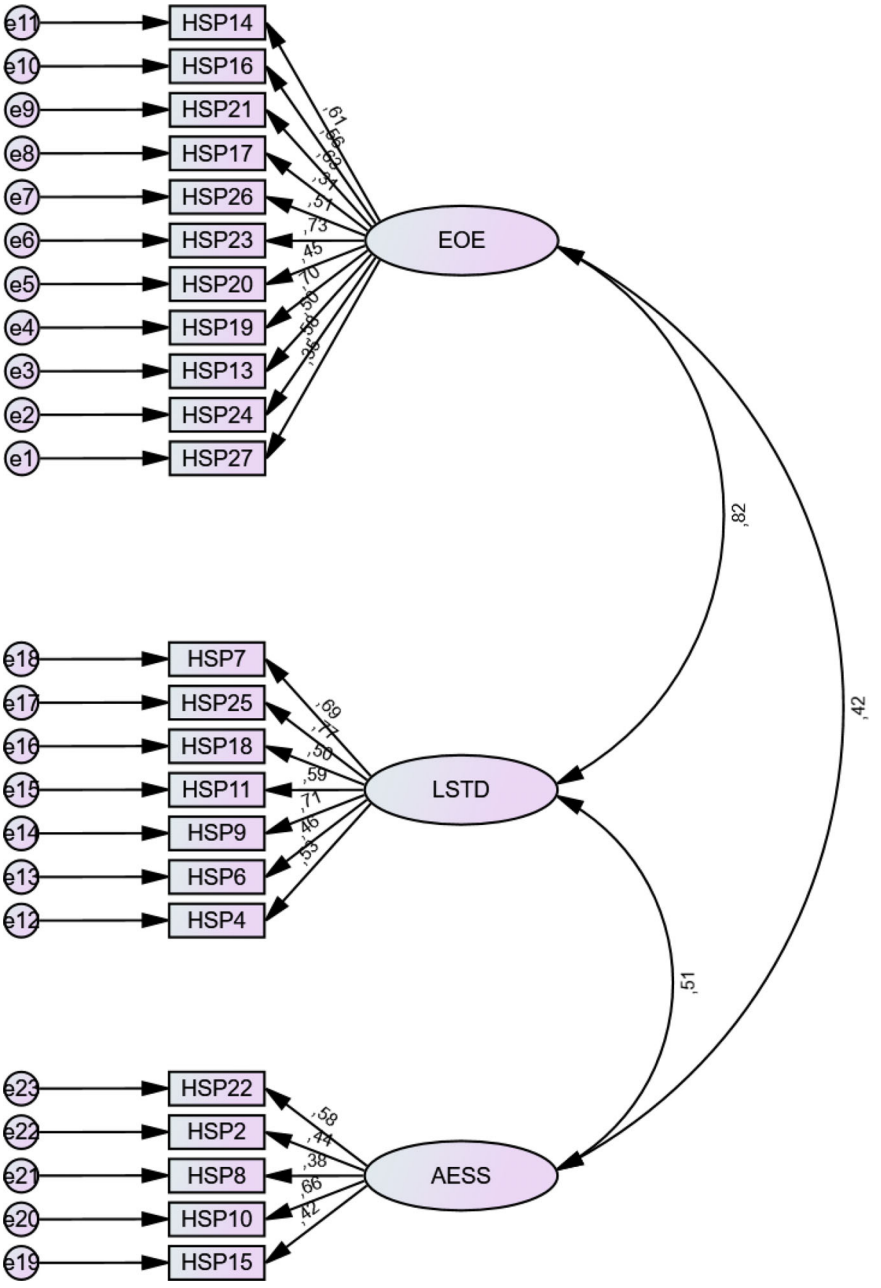

Figure 1. Confirmatory Factor Analysis of first half of the total sample showing the correlated three—factor solution (standardized estimates): Ease of excitation (EOE), Low sensory threshold and sensory discomfort (LSTD), and Aesthetic and social sensitivity (AESS); N = 548 (N men = 274, N women = 274).

Table 3. Measurement invariance across gender.

Model fit			Model difference						
Model	χ2	df	RMSEA (90% CI)	CFI	Δχ2	Δdf	Δ RMSEA	Δ CFI	*p*-value
Model 1 configural	939.601	454	0.044 (0.040–0.048)	0.839	–		–	–	
Model 2 metric	969.980	474	0.044 (0.400.48)	0.836	30.374	20	0.000	0.003	.064
Model 3 scalar	1081.632	497	0.046 (0.043–0.050	0.806	142.026	43	0.002	0.033	.000

Multi-group analysis of nested CFA models.
Note: Model 1 Configural model = same factor structure in the groups; Model 2 Metric model = same factor loading in the groups; Model 3 Scalar = same intercept in the groups. $N = 548$.

the RMSEA index is good (0.044), but CFI and TLI should be somewhat higher. In Model 2 we have restricted the factor loadings to be equal for both genders and there were no significant differences between Model 1 and Model 2 ($p = .064$). Hence, there is also metric invariance in the model, men and women attribute the same meaning to the latent constructs. The models 3 show negligible changes in the RMSEA (0.044 to 0.046) and the changes are also within the criterion to define structural invariance (<0.015), but the CFI changes were not within the criterion (<.0.01) and the chi-square tests were significant. We, therefore, conclude that we do not have full scalar invariance, i. e. that the differences in the latent constructs capture the differences in the shared variance of the HSP items.

Gender differences in HSP

In addition to the mean score of the HSP scale, the mean scores for each of the three factors (EOE, LSTD, AESS) were calculated as additive indexes divided by the number of items in the scales.

There was a significant main effect of gender for the four HSP scales. Pillai's Trace: F (4,1004) = 33.57, $p < .001$, $\eta_p^2 = .118$. The univariate tests showed that women had higher HSP values than men (adjusted for multiple comparisons): 4.27 (SD = 0.77) versus 3.74 (SD =0 .74), F (1,1007) = 122.69, $p < .001$; higher EOE values: 4.38 (SD = 0.94) versus 3.87 (SD = 0.89), F (1,1007) = 79.72, $p =< .001$; higher LSTD values: 3.75 (SD = 1.12) versus 3.14 (SD = 1.06), F (1,1007) = 77.72, $p =< .001$, and higher AESS values: 4.55 (SD = 0.95) versus 4.15, F (1,1007) = 42.96, $p =< .001$.

Table 4 shows the result of the analyses on gender differences in HSP, EOE, SDS and AESS controlled for personality traits (used as covariates in the MANCOVA). The overall MANOVA showed significant differences, Pillai's Trace: F (4,999) = 20.92, $p =< .001$, $\eta_p^2 = .077$. The univariate tests showed that the gender differences were reduced, but not removed. Women still had higher values on all the four scales. HSP: F (1,1002) = 75.49, $p =< .001$, $\eta_p^2 = .070$; EOE: F (1,1002) = 33.15, $p =< .001$, $\eta_p^2 = .032$; LSTD: F (1,1002) = 48.46, $p =< .001$, $\eta_p^2 = .046$; AESS: F (1,1002) = 34.17, $p =< .001$, $\eta_p^2 = .033$. The estimated mean values are shown in Table 4.

Table 4. Gender differences in the HSP and the subscales EOE, LSTD and AESS controlled for Big Five personality traits.

	Women			Men			
	(*N* = 489–548)			(*N* = 520–548)			
	M	*S.E.*	*C.I.*	*M*	*S.E.*	*C.I.*	*p*-value
HSP	4.17	.03	4.12–4.23	3.84	.04	3.79–3.89	<.001
EOE	4.23	.03	4.17–4.30	3.98	.03	3.92–4.05	<.001
LSTD	3.64	.04	3.56–3.73	3.22	.04	3.14–3.30	<.001
AESS	4.53	.04	4.46–4.60	4.21	.04	4.15–4.28	<.001

Personality traits were used as covariates in the Multivariate Analysis of variance (MANCOVA). Estimated marginal means with Bonferroni corrections for multiple comparisons.
Note: HSP = Highly Sensitive Person scale total score; EOE = Ease of Excitation; LSTD = Sensory Threshold and Sensory Discomfort; AESS = Aesthetic and Social Sensitivity; *M* = Mean value; *S.E.* = Standard Error; *C.I.* = 95% Confidence Interval Lower Bound and Upper Bound.

Discussion

The aim of Study 1 was to describe the factorial structure of the HSP in a sample that was not biased by gender or age. The results showed that HSP had three factors, one major and two minor factors. Although the associations between the factors were firmly positive (.82 between EOE and LSTD, .42 between EOE, and AESS, .51 between LSTD and AESS), both the results from the factor analyses and the CFAs do not support a unidimensional structure of the HSP (Aron & Aron, 1997). However, the strong relation between EOE and LSTD (.82) could suggest a bi-factor solution where EOE and LSTD were combined into one factor, but according to the CFAs three factors described the underlying data better than two factors. Results from the parallel analysis also supported a three-factor solution. We, therefore, suggest that the HSP consists of three correlated factors.

These results are also in agreement with other researchers showing a three-dimensional factorial structure (Konrad & Herzberg, 2017; Smolewska et al., 2006; Yano et al., 2021).

The rank-order and item composition of the factors deviated a little from previous studies, but not so much. For example, when comparing the factors EOE, LSTD and AESS in our study with the three factors EOE, AES, LST reported by Smolewska et al. (2006) we find both similarities and differences. The three items loading highest on the EOE factor (14, 16, 21—Table 2) were common, but not in the same rank order (14, 23, 21). For the LSTD factor (7, 25, 18) two items were common (25, 7), and two items were also common for the AESS factor (22, 2, 8 and 8, 22, respectively). The rank order of the three factors was a little different: EOE, LSTD and AESS in our study and EOE, AES and LST in the study of Smolewska et al. (2006). In sum, the composition of the HSP factors showed more similarities than differences. Nevertheless, we denoted factor 2 and 3 slightly different than has commonly been done. The internal consistency of the factors was also acceptable. The number of items in a scale will influence the value of the coefficient (Taber, 2018) and it is therefore not surprising that the EOE subscale had higher alpha values than the AESS subscale scale. The EOE scale has twice as many items as the AESS scale.

The first and largest factor captures predominantly excitability and negative affectivity. The factor loads on several items reflecting emotional reactivity and is also found in

neuroticism: unpleasant emotions, worrying, irritability, easily frustrated, behavioural overreaction to problems and negative events, elevated stress reactivity and an anxious avoidant behavioural style (Barlow et al., 2014a; Miller & Pilkonis, 2006). Studies have also shown that this factor is firmly associated with neuroticism (Lionetti et al., 2019; Smolewska et al., 2006). However, as suggested by Aron et al. (2012), this factor might also be interpreted in another way: If one prefers to observe and reflect before acting but is very often hindered in this process, it is plausible that negative emotional reactions such as frustration, irritability, etc., will emerge. This implies that negative affectivity shown in this factor is a result of increased sensitivity and not the other way around, a suggestion with interesting implications for our theoretical understanding of neuroticism. In Study 2 we explored this issue in more detail.

Factor 2 (LSTD) loaded firmly on sensory discomfort and was also strongly positively associated with the EOE-factor (.82) suggesting a relationship between emotional excitation, negative affectivity, low sensory threshold and discomfort. It is difficult to ascertain whether sensory discomfort and complaints are related to emotional reactivity or low sensory threshold. However, previous studies have found that neuroticism is associated with a number of somatic health complaints (Denovan et al., 2019; Vassend et al., 2017) and since the EOE factor is firmly related to neuroticism (Sobocko & Zelenski, 2015) and to the LSTD factor in the current study, it is more reasonable to emphasize the discomfort aspect more than the threshold aspect of this factor. Moreover, Evans and Rothbart (2008) also discussed this factor and pointed to the lack of items in the HSP assessing sensory sensitivity (only one item). However, sensitivity is a complex phenomenon both at the sensory and conceptual level. Low sensory threshold could of course lead to sensory, cognitive and emotional overload and thus to discomfort, but the overload reactions could also be linked to more intense reactivity (Eman et al., 2019). Further studies on sensory thresholds and intensity both across sensory modalities and behaviour in relation to SPS are, therefore, warranted. These might include, for example, an examination of the association between LSTD and sensation seeking.

The third factor denoted AESS, captured orientation sensitivity in terms of environmental, aesthetic sensitivity but also social orientation sensitivity. This includes not only sensing and being aware of other people's emotional reactions, but also taking behavioural actions to reduce registered emotional discomfort in others. This factor was the most distinct of the three and was moderately associated with EOE (.42) and LSTD (.51).

HSP was initially seen as a unidimensional scale and Aron et al. (2012), therefore, were cautious about drawing firm conclusions about facet structure from factor analyses. They pointed out inconsistencies in samples and methods, the possibility of non-normal distribution of the HSP scores, and gender artifacts. However, they also stated that one or more subscales in a general trait of SPS would not be surprising: "*Indeed, we think here are at least the four we described in the previous main section* (*inhibition of behaviour, sensitivity to stimuli, etc*." (p. 273). Our findings based on a fairly large sample not biased by gender or age showed that three factors concur with this view. We also believe that exploring the factor structure in more detail will likely imply an extension of the 27-item HSP scale by adding more items tapping specifically inhibition of behaviour, sensitivity to stimuli, depth of processing, and emotional/physiological reactivity.

Finally, we have shown that women are more sensitive than men, also when we control for gender differences in Big Five personality traits. Women had elevated scores both on the HSP total scale and the three subscales. The results indicate that men and women have the same factor structure on the HSP scale, the same items loads on the same factors, but they are at different levels on the scale. The general higher sensitivity in women compared to men could be seen in an evolutionary perspective where high sensitivity represented an adaptational advantage: women become pregnant, women give birth to children, women take care of babies and women are also the major care givers for their children, at least when they are small (Pailhé et al., 2019). Hence, high sensitivity in women to smells, tastes, sounds, etc., could be advantageous for their children. Typically, women also have higher food sensitivity than men (Michon et al., 2009). However, with respect to children high sensitivity can also be disadvantageous. Goldberg and Scharf (2020) investigated parenting practices in adolescence and adolescence and found that highly sensitive parents showed inconsistency, intrusiveness and attachment anxiety resulting in experience of considerable stress during this period. Apparently, high sensitivity in women is a two-edged sword and could be an indication of a mis-match between evolutionary based characteristics and the complexity, stress and demands of modern societies (Benham, 2006).

Study 2

Introduction

Elevated neuroticism is commonly found in the SPS literature and describes several of the characteristics of the highly sensitive person (Aron et al., 2012; Sobocko & Zelenski, 2015) also shown in neuroticism: emotional reactivity, anxiety, stress-vulnerability, being easily emotionally aroused and frustrated, and showing low threshold to stimuli (Barlow et al., 2014b; Griffith et al., 2010; Homberg et al., 2016). Association with introversion and openness is also reported (Aron & Aron, 1997; Lionetti et al., 2019; Smolewska et al., 2006). Key elements in these traits are reflective thinking, cognitive exploration, a refined sense of aesthetics, emotional involvement and creative phantasy (DeYoung, 2015). These findings are endorsed by experimental studies on sensory restrictions showing that highly sensitive individuals experience more mystical and altered states of consciousness than low sensitives (Jonsson et al., 2014; Kjellgren et al., 2009). These characteristics fit well with the core elements of the highly sensitive person such as sensitivity to environmental subtleties, deep and complex cognitive processing of sensory information and intense aesthetic experiences (Homberg et al., 2016). However, the relationship between SPS and extraversion, agreeableness, and conscientiousness seem to be more unclear. In an investigation on a sample of older adolescents and young adults Bröhl et al. (2020) reported that facets within the neuroticism and the openness scales were associated with SPS, facets of extraversion were only weakly associated with SPS, whereas facets of agreeableness and conscientiousness showed almost no relationship with SPS. These results were also confirmed in a study on self-selected highly sensitive individuals, using the facet scales of the NEO-PI-3 personality test (Bröhl et al., 2022).

The research findings on extraversion, conscientiousness and agreeableness are somewhat unexpected because brain imaging studies on sensitive individuals have documented activation in brain areas involved in action planning, self-control, self-other relations and empathy (Acevedo et al., 2014, 2018), core elements in extraversion, agreeableness, and conscientiousness. These findings are also supported by neuroimage investigations on functional correlates of Big Five traits among healthy adults (Sampaio et al., 2014).

Research designs and analytical methods are other issues. Most of the studies on personality and SPS are correlational, e.g. correlations, canonical correlations, regression analyses (Sobocko & Zelenski, 2015; Yano et al., 2021), and they describe associations between SPS/HSP and various personality traits. However, associations between variables in groups present another empirical picture of the underlying data than differences between groups. For instance, selecting groups based on psychometric criteria and then look back at the groups' personality traits will yield another theoretical and causal perspectives than correlational approaches.

The aim of the current study was to describe the personality trait profiles in a high and low SPS group using a sample matched on gender. Our main hypothesis was that there would be differences between the high and low HSP group and in the main Big Five dimensions: neuroticism, openness, agreeableness, conscientiousness and extraversion.

Methods

Design

We used a factorial MANOVA (Multivariate Analysis of Variance) design consisting of two groups, a high and low SPS group matched on gender. This research design would allow us to describe and test directly possible personality differences between the two groups. In addition to main effects, we could statistically test interactions and control for effects of variables used as covariates.

Participants

Participants were voluntarily recruited from the original population of Study 1($N = 1405$) and recruited into two groups, one high HSP and one low HSP group according to their scores on the Highly Sensitive Person scale (for criteria see Assessment of high and low SPS below). Totally, 253 participants (N men = 82; N women = 171) and 561 participants (N men = 415; N women = 146) were in the high (18%) and low (39.9%) HSP group, respectively. The number of men in the high HSP group was the basic set-point ($N = 82$), and then we randomly selected (the random procedure in the SPSS) 82 women from the high HSP group, and 82 men and 82 women from the low HSP group, totally 164 gender matched participants in each group. There were no significant age differences between the groups: $\chi 2$ (5, $n = 328$) = 6.85, p = .232.

Assessment of high and low SPS

Like Study 1 we used the Highly Sensitive Person scale (HSP) (Aron & Aron, 1997) scale to measure SPS (see Study 1). To allocate the participants into a high and low HSP group we applied the cut-off criteria by Lionetti et al. (2018). Participants scoring above 4.67 on the

HSP scale were included in the high HSP group and those scoring below 3.71 were included in the low HSP group. The final net samples of the high HSP group and low HSP group were $N = 164$ (N men $= 82$, N women $= 82$) and $N = 164$ (N men $= 82$, N women $= 82$), respectively. Lionetti et al. (2018) described three HSP groups (low, medium, high) based on two student samples, but there is also compelling evidence for two groups (Wolf et al., 2008). Three instead of two HSP groups is an interesting question, and although evidence for a three group solution could be found, for example based on Latent Class Analysis, this analysis requires quite large samples, at least 500, preferably around 1000 (Yang, 2006). However, our sample was too small to use LCA for that purpose and we, therefore, decided to investigate two extreme groups, one high and one low HSP group.

Assessments of Big Five personality traits

We used the same personality test as in Study 1, a Norwegian version of the BFI-44 (Big Five Inventory-44) (Engvik & Føllesdal, 2005; John & Srivastava, 1999).

Procedure

The groups were voluntarily recruited as part of a basic course in scientific method and philosophy (see Study 1). The questionnaires were filled out anonymously in the following order: Demographic data (gender, age), HSP and BFI-44. Completed questionnaires were returned to the project group. The participants did not know on beforehand that the topic of the study was sensitivity.

Statistical analyses

Multivariate analyses of variance (MANOVA) with Bonferroni adjustments for multiple comparisons in addition to univariate ANOVAs were used to test the differences in personality traits. Dependent variables were the scores on extraversion, agreeableness, openness, emotional stability, and conscientiousness and the values of the two items assessing environmental sensitivity. The independent variable was the HSP groups: 1 = high HSP, and 2 = low HSP. Gender was included as a covariate if gender differences in personality traits were found (MANCOVA). The analyses were carried out with the Statistical Package for the Social Sciences (SPSS) version 27.

Results

Figure 2 presents the results of the MANCOVA analyses. We found a significant main effect of gender on conscientiousness (women had higher scores than men), and we therefore used the BFI scores as covariates in all the analyses. We report the estimated mean scores of the traits for the high and low HSP group.

The multivariate tests showed an overall significant effect: Pillai's Trace F (5,321) $= 123.51$, $p < .000$. Compared to the low HSP group the high HSP group had significantly higher scores on agreeableness, F (1,325) $= 169.08$ (95% Confidence Interval Lower and Upper Bound, respectively: 6.21–6.53 and 4.74 and 5.05), $p =< .000$ ($\eta 2 = .34$), neuroticism, F (1,325) $= 194$, 18 (95% C.I: 4.15–4. 44 and 2.73–3.09), $p =< .000$ ($\eta 2 = .37$), and openness,

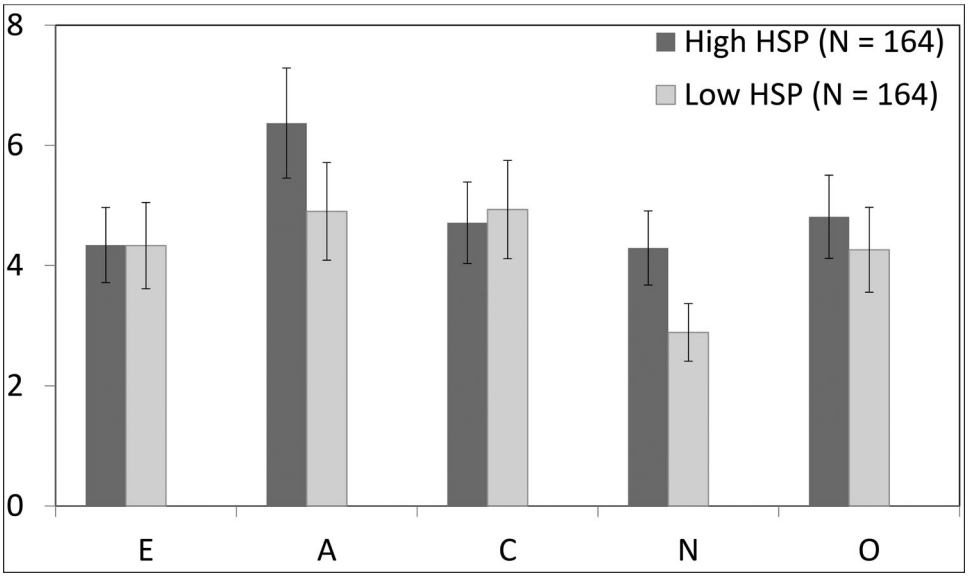

Figure 2. Differences in personality traits between the High and Low HSP group matched by gender. Multivariate Analysis of Variance with Bonferroni corrections for multiple comparisons. E = Extraversion; A = agreeableness; O = openness; N = neuroticism; C = conscientiousness; ns = no significant. Error bars = Standard Error; N men = 82 and N women = 82 in both the High HSP and Low HSP group.

F (1,325) = 37.55 (95% C.I.: 4.70–4.94 and 4.14–4.39), $p =< .000$ ($\eta 2 = .10$), but slightly lower scores on conscientiousness, F (1,325) = 4.62 (95% C.I. 4.57–4.85 and 4.79–5.07), $p = .035$ ($\eta 2 = .014$). In addition, there was a significant interaction with gender for openness, F (1,325) = 5.19, $p = .023$ ($\eta 2 = .02$). High HSP men had lower openness scores than high HSP women, whereas low HSP men showed higher openness than did low HSP women. There was no interaction with gender for the other traits and there was no main effect of gender for O, F (1,325) = 2.15, $p = .143$. Finally, there were no significant differences in extraversion between the groups F (1,325) = .002, $p = .961$.

Discussion

Our results clearly show that there are differences in personality traits between those with elevated HSP scores compared to those with low HSP scores. We found significant differences in all big five personality traits except extraversion. None of the differences could be attributed to gender differences between the groups.

The high HSP group had elevated neuroticism scores and the question arises as to how we should interpret these findings. Aron et al. (2012) suggested that elevated neuroticism could be seen as a result of high sensitivity rather than as a consequence of an underlying personality dimension because the evoked emotional reactions could be related to activation of the aversive motivational BIS system, a system sensitive to signals of novelty, non-reward and punishment (Carver & White, 1994). When a highly sensitive person is overwhelmed by sensory inputs, too much to do in a short period of time or too many tasks to

perform at once and is at the same time hindered from observing and reflecting about time as mirrored in the SPS phenomenon "pause-to-check" (Aron et al., 2012), they may become emotionally frustrated, mentally overloaded and can show several negative emotional reactions. Such reactions could be linked to activation of the BIS, an assumption supported by fMRI-findings showing activation in Prefrontal Cortex (PFC) for high-sensitive individuals (Acevedo et al., 2014). The PFC is involved in self-control, action planning, and responsiveness. Thus, continuous activation of the BIS system could lead to emotional reactions similar to those shown in the EOE factor in our results from Study 1.

Prolonged emotional activation related to neuroticism can also be related to fatigue. A recent study on work-related fatigue showed that neuroticism predicted increased need for recovery after work, probably due to prolonged emotional, cognitive and psycho-physiological reactions (Fostervold & Watten, 2022). Hence, some of the health implications of high sensitivity (Jagiellowicz et al., 2020) could be linked to elevated to prolonged emotional activation associated with elevated neuroticism.

The high HSP group had higher openness scores, a finding supported by previous investigations (Smolewska et al., 2006) and also reflected in the AESS factor in in Study 1. The interaction with gender is interesting and shows that although there was a significant main effect of group (low vs. high), the picture is more nuanced. Sensitive women had the highest openness scores of all, but the lowest openness scores among low sensitives. For men it was vice versa. This finding suggests that openness is more related to sensitivity in women than in men. This is a new finding that should be more investigated in future personality studies.

The highly sensitives also had largely elevated scores in agreeableness compared to the low HSP group. The mean-value was the highest of all scales in the group (6.37). Previous studies, such as the meta-analytic study of Lionetti et al. (2019) did not find any correlations between SPS and agreeableness, so this is a new finding. It is not surprising, however, and is in agreement with our results on the AESS factor in Study 1. That factor captured environmental and aesthetic sensitivity but also social sensitivity i.e., not only being aware of the socio-emotional reactions of other people but also making an effort to alleviate the emotional discomfort in others. People high in agreeableness are harmonious, kind, forgiving, co-operative; they usually withdraw from social conflicts, and are very good at reading other individuals' minds (Nettle & Liddle, 2008). This trait reveals a socio-cognitive sensitivity that fits well with the AESS factor. Another interesting aspect is that high agreeableness seems to have a self-regulating role in modulating neuroticism-related distress, probably linked with good, effortful control associated with agreeableness (Ode & Robinson, 2007). Thus, elevated agreeableness may have positive implications for health and well-being in highly sensitives.

We show that the high HSP group had slightly lower scores on conscientiousness than the low HSP group. The meta-study of Lionetti et al. (2019) found that conscientiousness was unrelated to SPS, so this is also a new finding. In addition, it illustrates the methodological advantage of splitting up samples in extreme groups and testing differences between groups instead of associations within groups. The difference was moderate and with rather low power (.574), but the finding was not surprising when seen in the context of the other personality dimensions, and especially openness. High conscientiousness reflects characteristics such as targeted activity, effortful control and orderliness (Costa &

McCrae, 2017), but also lower creativity, which again is linked with lower openness (George & Zhou, 2001). High sensitivity is associated with aesthetic sensitivity (Aron et al., 2012; Homberg et al., 2016) and the elevated openness among high sensitives as shown in this study fit well with their lower conscientiousness. This suggestion is also endorsed by studies on creative professions in arts and culture such as musicians who also show elevated openness and lowered conscientiousness (Gjermunds et al., 2020).

General discussion

The results from both studies clearly indicate that the highly sensitive person is not the same as the highly neurotic person. Although highly sensitives had elevated neuroticism scores, they also had higher openness and higher agreeableness, slightly lower conscientiousness and no tendency towards introversion. Thus, the high sensitives had a unique Big Five trait profile compared to low sensitives.

The EOE factor described in Study 1 was the most dominant HSP factor and elevated neuroticism scores were prominent in the high HSP group. These results may also shed some new light on core elements of neuroticism. Although the Big Five taxonomies are widely agreed upon and useful for empirical research and classification, the nature of neuroticism is still disputed (McCrae, 2013). The concept itself has been criticized for being atheoretical, overinclusive, and inappropriate for studying the development of personality from early childhood (Block, 2010). Nevertheless, three factors seem to be well established: withdrawal-anxiety, vulnerability-stress-reactivity, and depression-unhappiness. The first two factors are also shown in highly sensitives and could be linked to the evolutionary, bio-genetic roots of SPS, similarity across species in basic neuro-genetic functions (Aron et al., 2012; Homberg et al., 2016), empirical fMRI-findings and other neuroscientific evidence in humans. These factors are substantiating the role of brain systems involved in SPS (Acevedo et al., 2014, 2018) and support the notion that SPS could be an underlying neurobiological factor in neuroticism, as suggested by Homberg et al. (2016).

The heritability rate of SPS is high, approximately 47%, and it is genetically correlated with extraversion and neuroticism (Assary et al., 2021). Neuroticism and openness also have strong genetic components. For example, Power and Pluess (2015) in a sample of more than 5000 adult Europeans showed a significant heritability estimate for neuroticism (15%) and openness (21%), but not for extraversion, agreeableness and conscientiousness. In a twin study, Boomsma et al. (2018) reported a general heritability of 47% for neuroticism. Hence, the association between HSP and neuroticism and openness in our study could reflect common genetic variance between these three traits. Although heritability estimates do not tell us *what* is inherited, they do indicate a genetic relationship of some kind which should be further examined in allelic genetic investigations.

There were no differences in extraversion between the groups; the mean values in the low and high HSP groups were the same (4.33). In their thorough review of SPS, Aron et al. (2012) suggested that introversion could overlap with some aspect of SPS, most notably the BIS-trait inhibition of behaviour. If so, we should have found differences in extraversion between the two groups, the high HSP group should be lower on extraversion. This was not the case; the highly sensitives were not more introverted than the low sensitives. Thus, underlying introversion in Big Five terms does not appear to be related to SPS. In their

correlational study, Smolewska et al. (2006) also found no relationship between extraversion and SPS, but a moderate association between the HSP and the BIS, findings which support the original position of Aron and Aron (1997) that high sensitivity reflects high BIS function. However, the BAS function could also be involved. Our trait results showing both elevated agreeableness and openness suggest that approach-reward systems also are activated. As documented in the revised version of Gray's Reinforcement Sensitivity Theory the BIS and the BAS can be simultaneously activated and, thus, influence both punish-mediated and reward-mediated behaviour (Corr, 2008). In that case, personality characteristics influenced by the activated BIS and BAS systems such as neuroticism, openness and agreeableness could be manifested in the highly sensitives. Future studies should look more closely into associations between the SPS and the BIS/BAS systems (Corr & Cooper, 2016; Reuter et al., 2015).

Strengths and limitations

The results on the factorial structure of the HSP scale and differences in personality traits between a high and low HSP group were matched on samples without gender bias. Thus, our findings could be attributed to gender differences. This is a methodological strength compared to other investigations in the field. However, there are limitations. The sample size in Study 2 was quite limited ($N = 164$ in each of the groups) and a larger gender-matched sample would be preferable. The participants in both studies were also young, most of them under the age of 30, and since personality traits are somewhat plastic below that age, a larger age distribution would be preferable (Terracciano et al., 2006). For example, conscientiousness tends to increase with age (Jackson et al., 2009), so that particular trait may be shown to be more prominent if the age span was broader. Neuroimage data could shed more light upon the mechanisms of emotional regulation which is a crucial element in SPS. Experimental investigations have shown that high sensitivity is associated with unique patterns of brain activation in the temporal, occipital and brain areas involved in object recognition, categorization, discrimination and shape analysis (Jagiellowicz et al., 2011). Further fMRI studies in this area are recommended. A final limitation is that we have not used instruments measuring intensity of sensation, inventories such as the Arnett Inventory of Sensation Seeking (AISS; Arnett, 1994). Future studies should include assessment of sensation seeking.

Conclusions

Study 1 showed that the HSP scale consisted of three associated factors: Ease of emotional reactivity (EOE), Low sensory threshold and sensory discomfort (LSTD) and Aesthetic and social sensitivity (AESS). Women had higher scores both on the HSP scale and the subscales (EOE, LSTD, AES). Study 2 study revealed significant differences in big five personality traits in a high and low HSP group. Highly sensitive individuals had a unique personality trait profile consisting of elevated neuroticism, agreeableness and openness and slightly lower conscientiousness. There were no differences in extraversion between the high and low HSP group. Our results also indicate that high sensitivity can shed some light on core elements of neuroticism, openness, and agreeableness.

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Data availability statement

More information about sharing of the data supporting the results can be obtained by email from the authors.

Disclosure statement

No potential conflict of interest is reported by the authors. No financial interest or benefit has arisen from the direct application of this work.

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