

The Effect of Environment on Psychological Outcomes of the Highly Sensitive Person: A Systematic Scoping Review

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Abstract

Background: Those high in the temperament trait Sensory Processing Sensitivity (SPS) are more at risk of mental health issues due to sensitivity to unfavourable environments, while thriving in favourable environments. The literature has grown exponentially in recent years examining high SPS mental health outcomes in applied settings. In this systematic scoping review, we mapped and evaluated the methodological rigueur of existing research on the impact of physical, psychological and social environments on psychological outcomes of those with high levels of SPS.

Methods: Conducted following the guidelines of Arksey and O' Malley (2005) and following the PRISMA-ScR checklist. 671 studies were screened and 63 studies were included in the final review.

Results: Thematic analysis indicated the environments most studied were sensory, occupational, and social environments, particularly parenting and childhood circumstances. Negative psychological outcomes were most represented. Paradigms included surveys,

experimental tasks and little qualitative research. The quality of the studies was generally good with potential for methodological improvements.

Conclusions: The SPS-environment association for each type of environment needs to be more systematically investigated, lifespan studies are missing and studies are lacking on underlying mechanisms and positive environments allowing high SPS to thrive.

Keywords: highly sensitive person, sensory processing sensitivity, environment, wellbeing.

1. Introduction

Mental health is an important public concern, with mental health disorders affecting around 10.7% of people around the world (Ritchie & Roser, 2018). Two of the most common mental health issues are anxiety disorders and depression, affecting 3.6% and 4.4% of the world's population respectively and contributing significantly to global disability (WHO, 2017). Importantly, a recent systematic review on the impact of COVID-19 on mental health suggests the global prevalence of depression and anxiety to have risen to 28% and 26.9% respectively (Nochaiwong et al., 2021). Different models aiming to explain the aetiology of mental health issues, some focusing on specific disorders and others which take a broader focus on mental health, have been proposed, for example the biopsychosocial model (Engel, 1977).

The biopsychosocial model posits health and illness are a result of interactions between biological factors, psychological factors, social factors, and context. Research suggests the environmental context of an individual has a role, alongside individual factors, in determining their mental health outcomes (Schmidt, 2007).

One research area which examines this interplay between the individual and their environment, and its subsequent effects, is that of Environmental Sensitivity (ES). ES is an umbrella term, covering theories aiming to explain the role of the individual-environment interplay in adjusting to environmental circumstances, as well as a term to reflect the differences in individuals' abilities in the registration and processing of environmental stimuli (Pluess, 2015). Theories and models falling under this umbrella include; the Diathesis-Stress model (Gottesman & Shields, 1967) also known as the dual-risk or transactional model which posits mental and physical disorders develop from genetic or biological predispositions combined with stressful conditions; Biological Sensitivity to Context (BSC) theory (Boyce & Ellis, 2005) which suggests depending on one's psychobiologic reactivity to stress individuals differ in their susceptibility to environmental influence in a "for better or for worse" way; Differential Susceptibility (DS) theory (Belsky & Pluess, 2009) which suggests highly sensitive individuals have greater susceptibility to the environment and assumes an evolutionary point of view, and Vantage Sensitivity (VS) theory (Pluess & Belsky, 2013) which speaks to vantage resistance in positive environments without reference to negative environments. Another theory residing under this umbrella, and the focus of the current review, is that of Sensory Processing Sensitivity (SPS) (Aron & Aron, 1997). SPS specifically defines ES as resulting from a deeper perception and processing of stimuli. It has been extensively studied in relation to mental health outcomes.

SPS refers to an individual trait capturing individual differences in ES. Increased SPS is driven by a greater sensitivity of the central nervous system which in turn is associated with greater levels of sensitivity and responsivity to both social and environmental stimuli, which are processed more deeply (Acevedo et al., 2018). SPS is different from Sensory Processing Disorder (SPD). SPS refers to normal variations in the levels of a temperamental trait,

whereas SPD refers to a disorder of sensory processing difficulties which impair an individual's functioning (Miller et al., 2007).

SPS is a continuously distributed trait, existing in individuals at different levels throughout the population (Greven et al., 2019). Those high in the trait are known as Highly Sensitive Persons (HSPs) and the Highly Sensitive Person Scale (HSPS; Aron & Aron, 1997) is used to measure the trait. Research on the percentage of HSPs in the population has it ranging between 20% to 30% (Aron et al., 2012; Lionetti et al., 2018; Pluess et al., 2018). HSPs are characterized by high levels of sensitivity to stimulation offered by the environment and are identifiable by their heightened emotionality, their empathy, and their depth of processing i.e., HSPs are able to absorb more information from their surroundings than others can, and they analyse it more deeply (Aron et al., 2012).

While the HSP scale has been designed to capture a unique individual trait, other investigations reported the existence of three components (Smolewska et al., 2006); Ease of excitation (EOE) i.e. feeling overwhelmed by internal and external demands, aesthetic sensitivity (AES) i.e. awareness of aesthetics in one's surroundings, and low sensory threshold (LST) i.e. unpleasant sensory arousal. These factors resulted post-hoc from analysis, but considered altogether still capture increased sensitivity for both negative and positive stimuli, that is, they are consistent with the theoretical definition of an overarching SPS construct.

Research has found HSPs tend to struggle more with mental health related issues, such as anxiety and depression, than their non-HSP counterparts, (e.g. Ahadi & Basharpour, 2010; Benham, 2006; Jagiellowicz et al., 2019; Liss et al., 2005, 2008). Furthermore, SPS has been found to correlate positively with neuroticism in children and adults, and is moderately associated with negative affect in adults (Lionetti et al., 2019), defined by the authors as an

amalgamation of anxiety, depression, stress, complaints and negative affect/emotions. Aron (2011) notes HSPs are overrepresented in clinical practices, suggesting they represent close to 50% of clients in most psychotherapy practices, compared to 20-30% of the general population (Lionetti et al., 2018; Pluess et al., 2018), highlighting the psychological needs of this cohort. One possible link between SPS and poorer psychological outcomes is dysfunctional cognitive responses to environmental stimuli, such as rumination i.e., cognitive reactivity (Wyller et al., 2017). SPS has also been found to impact on cognitive tasks, for example in Rigby et al. (2020), where EOE was a negative predictor of accuracy in classification of positive scenes in an evaluation of emotional scenes task.

While the possible disadvantages of having high levels of SPS have been discussed, research has also found SPS to be a marker of behavioural plasticity in response to the environment and can, in the right conditions, confer benefits such as better emotional wellbeing and fewer issues with behavioural problems. This has been shown in intervention studies (e.g., Nocentini et al., 2018; Pluess & Boniwell, 2015) and longitudinal studies (e.g., Slagt et al., 2018). For example, Lionetti et al. (2018) found those higher in SPS had increased positive affect and were more susceptible to positive mood induction compared with those lower in SPS in a study utilising mood induction video clips.

The term ‘environment’ differs in meaning across research areas; in the realm of SPS research, the term is used to refer to any salient conditioned or unconditioned stimuli, be they internal or external, including; physical environments, social environments, sensory environments, and internal events both physiological and psychological (Greven et al., 2019). Many of the environments studied in SPS research contain combinations of these elements. Examples of environments studied in SPS to date include; the work environment (e.g., Andresen & Goldmann, 2016; Evers et al., 2008), the parenting environment (e.g., Aron et

al., 2019; Slagt et al., 2018; Su et al., 2018), and intervention studies which impact on an individual's environment (e.g., Amemiya et al., 2020; Nocentini et al., 2018).

The environment clearly plays a large role in outcomes for those high in the trait of SPS; thus, identifying the specific environmental variables which could impact on the adjustment and functioning of those high in SPS is crucial, especially considering the sizable minority of the population who have high levels of SPS. While there is interest in SPS from media and the public, and the research in the area has grown in recent years, applied scientific research is lagging behind in some areas (Greven et al., 2019). Research into the area has grown globally, with studies from, for example, Kibe et al. (2020) in Japan, Tillmann et al. (2018) in Germany, Grinapol et al. (2022) in Israel, and Weyn et al., (2019) in Belgium.

The aim of this scoping review is to identify what types of environmental variables have been explored in relation to HSP, the kinds of psychological outcomes found in HSPs, the research design of the studies in the area, and to identify future directions of research. Psychological outcomes include mental health itself, mood state, and cognitive functioning.

1.1 Key definitions

Environment: In the context of this review, 'environment' refers to any salient conditioned or unconditioned stimuli; internal or external, including but not limited to: physical environments, social environments, sensory environments, and internal events both physiological and psychological – as per Greven et al. (2019).

Psychological outcomes: In the context of this review, psychological outcomes encapsulate three different constructs, including psychological measures assessing (i) indicators of poor mental health, (ii) indicators of positive mental health/wellbeing, and (iii) cognitive functioning.

1.2 Aims and objectives

The overall aim of the scoping review is to both systematically and comprehensively scope the extent, nature, and range of evidence currently available around the impact of environment on the psychological outcomes of those high in SPS.

The objectives of the current review are as follows:

- Objective 1: Document the nature (e.g., qualitative, quantitative, paradigms used) of the existing research examining the effect of different environments on the psychological outcomes of HSPs.
- Objective 2: Identify and describe specific environments which have been found to be beneficial for psychological outcomes in those with high levels of SPS, and those which have been found to be detrimental.
- Objective 3:Identify any gaps in the literature with regards the psychological outcomes of HSPs and the relationship of these with the environment.
- Objective 4: Identify the major theoretical frameworks used in the literature in understanding the relationship between HSPs, and the impact of environment on their psychological outcomes.

This review will summarise the existing evidence in the area and map it out systematically. Through this process, gaps in the literature can be identified as areas for possible future research (Arksey & O'Malley, 2005). The scope of this review has been kept deliberately broad to allow for the collection, summarisation, and mapping of all currently available research in the field.

2. Materials and Methods

Given the diverse nature of the existing literature in the field, a scoping review was selected as the preferred method. Scoping reviews differ from systematic reviews, in that they have a less focused research question, include differing study designs and methods, and attempt to describe the whole literature broadly (Arksey & O'Malley, 2005). The current review is a systematic scoping review, as a systematic approach has been used to identify, include, and extract data from the literature (Oswald et al., 2020). The scoping review process was guided by the methodology outlined by Arksey & O'Malley (2005), as well as by the PRISMA Scoping Review Checklist (Tricco et al., 2018) to enhance the quality of the methodology and reporting. Thus, the five framework stages of a scoping review as outlined by Arksey & O'Malley (2005) were followed, namely: (1) identifying the research question, (2) identifying relevant studies, (3) selecting studies, (4) charting the data, and (5) collating, summarizing, and reporting the results. A protocol presenting the project's objective and planned procedures was registered via the Open Science Framework platform (OSF) on September 7th, 2021 (available online: <https://osf.io/aehtb>).

2.1 Identifying the research question

Given the diverse nature of research into SPS, and significance of mental health issues globally, the research question which was the focus of the current scoping review is: what evidence is available in the literature around the kinds of effects of environment on the psychological outcomes of those high in SPS, with psychological outcomes including both psychological wellbeing and cognitive functioning.

The research question was purposely kept broad to allow for the mapping of the literature across the many different types of environments and across all age groups.

2.2 Identifying relevant studies

The search strategy was developed, and search terms were selected through discussions between all authors, with the first author (EC) conducting literature searches relevant to the research question to aid in identifying key terms. The different terms identified and used in searches can be seen in Table 1, with search strategies, with specific terms used, including Boolean operators for each database available in Appendix A.

Table 1

Search Terms for Scoping Review

“Highly Sensitive Person” OR “Highly Sensitive Child*” OR “Sensory Processing Sensitivity” OR “Environmental Sensitivity”

AND “Wellbeing” OR “Well-being” OR “well being” OR “Anxi*” OR “Depress*” OR “Mental Health” OR “Cognit*” OR “Psychia*” OR “Psychol*” OR “Happ*” OR “Flourish*” OR “Perception” OR “Processing” OR “Internalising Beh*” OR “Internalising Prob*” OR “Internalizing Beh*” OR “Internalizing Prob*” OR “Externalising Beh*” OR “Externalising Prob*” OR “Externalizing Beh*” OR “Externalizing Prob*” OR “social competence” OR “life satisfaction” OR “satisfaction with life” OR “positive affect” OR “negative affect”

The following six databases were searched from 8th September 2021 to the 16th of September 2021: Scopus, Web of Science, Academic Search Complete, APA PsycInfo, PubMed, and Google Scholar. The first 200 results from Google Scholar were considered as these are likely to be the most relevant to the current review (Bramer et al., 2017). The reference lists of relevant papers were also hand-searched to identify relevant papers which may not have been identified on these scholarly databases i.e., backwards search. The hand-search was completed by examining the reference lists of the identified papers and contacting

relevant authors in the field when studies were identified as possibly relevant to the review but could not be accessed. See PRISMA flow diagram below for numbers.

2.3 Selecting studies

The titles and abstracts of articles returned by the search engines were screened for relevance by the first author, and those deemed as relevant selected for full text review. The first author conducted the primary screening of the full texts, with the fourth author screening in cases where there was uncertainty (n=48), and screening 10% of all identified articles. In cases where uncertainty remained (n=7 studies), the relevant studies were presented to all authors, discussed, and majority decision taken. The “Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)” flow diagram in Figure 1. outlines how papers were selected for the review. The inclusion and exclusion criteria can be seen in Table 2. They were intentionally kept broad and both peer-reviewed and grey literature were included in the search. As noted previously, study quality was assessed in the current review, however, it was not used as a criterion for inclusion in the review as it aimed to cover the literature as broadly as possible. Quality was assessed to allow possible gaps in the literature due to poorer quality of studies in the area to be identified. Zotero and Microsoft Excel were used to assist with the screening process and to remove duplicates.

Table 2

Inclusion Criteria

-
- Articles in English language
 - Articles published any time up to 16th September 2021 (this was indicated at 31st of July in OSF but updated.)
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- Articles relating to HSPs/HSC and SPS, where there is an environmental factor and psychological outcome

Exclusion Criteria

- Articles in a language other than English
 - Articles not in relation to the concepts of HSP or SPS, or concerning other types of sensitivities or SPD
 - Articles containing no psychological outcome
 - Articles with no environmental factor
-

2.4 Charting the data and collating, summarising, and reporting results

Once exclusion criteria were applied and the final articles for inclusion were identified, the data were charted – see Appendix B. To ensure the data was being systematically mapped, the chart was pre-tested, with the first author charting the first five studies and then meeting with the fourth author to ensure there was consistency and accuracy in the charting of data.

Quality of the studies included was also assessed at this stage, using the Mixed Methods Appraisal Tool (MMAT) 2018 version (Hong et al., 2018), which assesses study quality across five different methodological categories; qualitative, quantitative randomised control trials, quantitative non-randomised, quantitative descriptive, and mixed methods. While a scoping review does not require quality appraisal, whether this step should be included remains controversial in the literature, with quality assessment reported to be present in

22.38% of scoping reviews in a scoping review of scoping reviews (Bieber et al., 2019; Pham et al., 2014). The MMAT was utilised as it is both a reliable and practical instrument which can be utilised with studies of various designs (Pace et al., 2012). Results will be reported as per guidance document from the creators (*Reporting the Results of the MMAT*, 2020), such that studies which meet all five criteria receive five stars, four of five criteria receive four stars etc. The first and fourth authors met and discussed the quality review process. The initial quality review was carried out by the first author. The fourth author then reviewed 20% of the studies, including all studies with ratings of 1 and 2 stars. Consensus was reached for these studies, and revisions to the criteria applied when needed.

An optional step for scoping reviews identified by Arksey and O'Malley (2005) is consultation. In the current review, researchers consisted of an interdisciplinary team of researchers with experience in environment and SPS. Preliminary findings from the scoping review chart were presented to the third author, a researcher working in the area of SPS. An in-press paper was identified and added at this stage.

Data were summarised, collated, and presented in the results section. In line with the first aim of the review, numerical summary analysis was utilised to provide an overview of the literature in the area, looking at the different geographical areas of studies, the characteristics of participants, the range of environments, and the research methodology. The findings from the review are also presented in a descriptive narrative summary form.

The data were analysed using an inductive thematic analysis approach (Braun & Clarke, 2006) in order to summarise findings and identify recurring themes. The aim of the qualitative analysis is to identify and describe patterns in the data, which is an appropriate fit for thematic analysis as per the advice of Braun and Clarke (2021). The data consisted of the results of the charting process. Conducting the thematic analysis was an iterative process,

moving between the data and research question. As the data had been extracted from the source material and categorised prior to analysis to make sense of the variety of research, this in turn guided the analysis. The chart can be seen in Appendix B.

At this stage of the scoping review process there was a high level of familiarity with the dataset. The table was scrutinised by the first author and then coded systematically. Following the coding of the initial studies in the dataset, the first author consulted with the fourth author to ensure codes were based on the data, and relevant to the current work, with codes checked by the fourth author for the first five papers. The rest of the dataset was then coded. Based on these codes, themes and subthemes were generated in a systematic, iterative process. The fit of the generated themes to the extracted data and assigned codes were then assessed by the fourth author.

3. Results

The database searches returned a total of 1442 records. Before the screening process was begun, 771 duplicates were removed. 671 titles and abstracts were then reviewed, and 384 were removed as the papers were deemed not relevant to the current review. Full texts were reviewed for 287 records, and irrelevant records removed at this stage. This resulted in 61 records to be included. One record was added based on hand-searching the relevant records' reference lists and one record added through identification by the third author. This resulted in a total of 63 records. During this process, four relevant review articles/posters were identified. These were not included in the main analysis to avoid duplication in the results as they contain many of the records already identified and included in the scoping review. They are Aron et al., 2012; Castellano & Dascalu, n.d.; Costa-López et al., 2021; and Greven et al., 2019. A flow diagram of this process is presented in Figure 1. A summary of the studies included is presented in Table 3.

Figure 1

PRISMA Flow Diagram

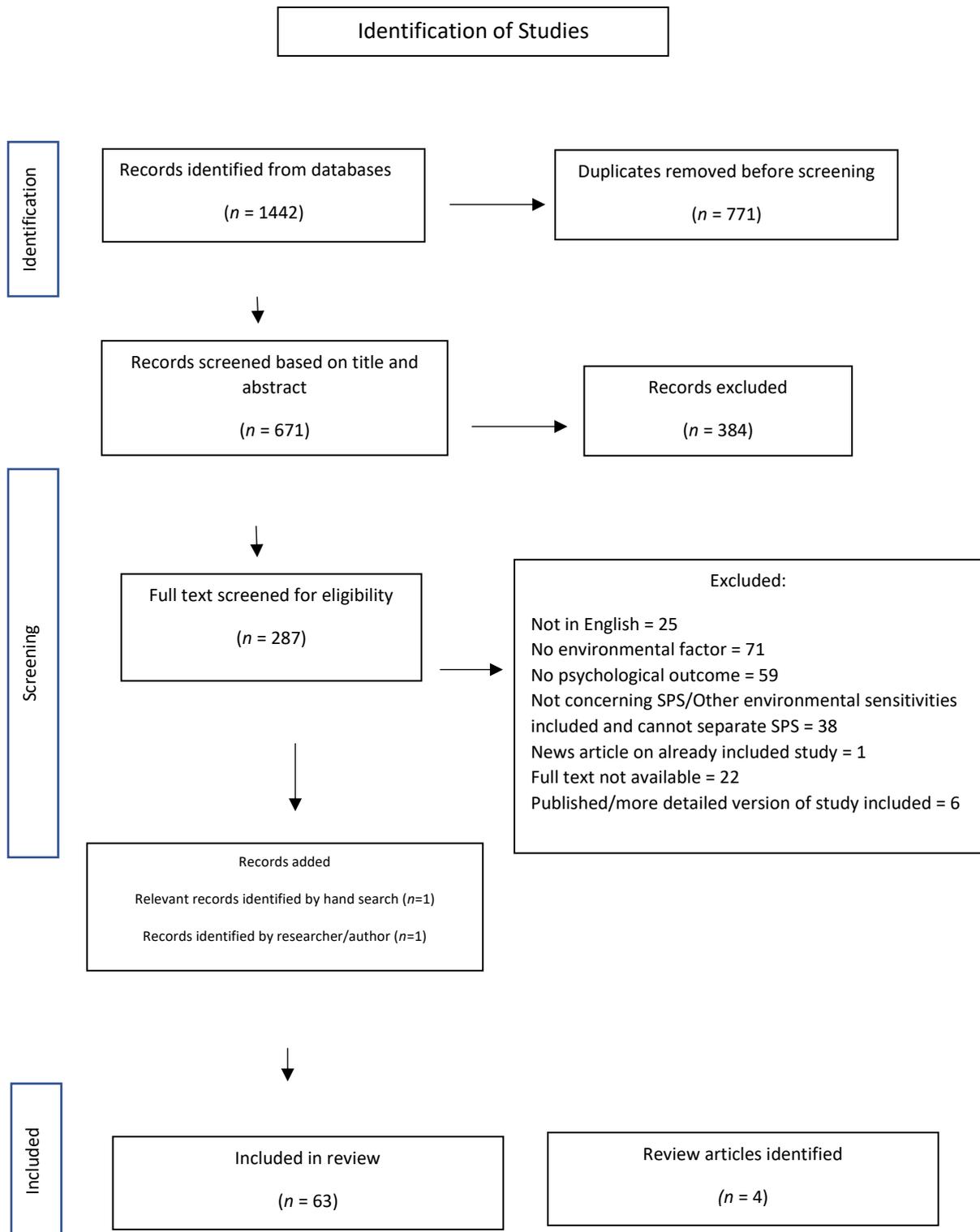


Table 3

Characteristics of the included studies

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Aron, E.N. & Aron, A.	1997	USA	Studies 2-4: To assess the extent to which original themes constituted a core pattern, relation of core items to social introversion and emotionality, the existence of subgroups of HSPs, whether sensitivity moderated the relation of family environment to how childhood was experienced.	Multiple	Family environment in childhood	Study 2: When parental environment was optimal, there was little difference between HSPs and non HSPs, but when the parental environment was poor, the highly sensitive scored higher on unhappy childhood. Study 3: Three-way interaction found with gender, such that when parental environment was optimal, there was little difference between men regardless of sensitivity; when the parental environment was poor, highly sensitive men reported having a much less happy childhood.	SPS	Study 2: ***** Study 3: ***** Study 4: ****
Meyer, B., & Carver, C. S.	2000	USA	To test a model that memories of negative childhood experiences, SPS, and pessimistic expectancies are associated with Avoidant Personality Disorder (APD) features.	Multiple	Childhood Environment	APD features were found to be negatively correlated with optimism, and positively correlated with negative childhood memory valence, and SPS. A significant negative interaction between optimism/pessimism and SPS was found. A significant negative correlation emerged between optimism and APD features among those scoring highly in SPS. The combination of pessimistic expectancies and high levels of SPS yielded higher levels of APD features.	SPS, theories of APD e.g., Beck and colleagues (1990), Carver and Scheier's (1981, 1998) self-regulation theory	**

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Aron, E. N., Aron, A., & Davies, K. M.	2005	USA	Examining the relationship between adult shyness and SPS. Positing new model where the interaction of sensitivity and adverse childhood environments lead to negative affectivity and in turn shyness.	Social	Studies 1-3 Childhood Environments / Study 4. Manipulated negative event i.e. frustrating survey completion	SPS and childhood environment interact predicting adult trait negative affectivity. SPS interacts with a manipulated negative experience to predict greater state negative affect.	SPS	Study 1 - **** Study 2 - **** Study 3 - **** Study 4 - ***
Liss, M., Timmel, L., Baxley, K., & Killingsworth, P.	2005	USA	To explore the relationship between SPS, parenting style, anxiety, and depression. To determine how knowledge of an individual's SPS contributes to predicting if someone is anxious or depressed above parenting style. To look at interaction effects between negative parental environment and negative affect separately in anxiety and depression and looking separately at parental care and overprotection.	Relational	Parenting environment	SPS was strongly related to depression and to anxiety. It contributed unique variance above parenting factors for both depression and anxiety. SPS was particularly strongly related to anxiety. SPS was correlated with parental-overprotection. For depression there was a small but significant interaction between parental care and SPS, such that HSPs were more depressed in the context of low parental care. This interaction was not found for anxiety. No interaction effects found for parental overprotection.	SPS	****
Kemler, D.S.	2006	USA	To investigate how differences between athletes with varying levels of SPS apply self-discrepancies and emotional reactions to competitive sports.	Multiple	Competitive sports event	Participants high in SPS responded to competition with greater anxiety and shame than low SPS counterparts. Participants high in SPS also reported having greater stress related to actual to ideal and actual to ought self-discrepancies than those low SPS.	SPS , Self-discrepancy Theory (Higgins, 1987)	****

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Evers, A., Rasche, J., & Schabracq, M. J.	2008	Netherlands*	To examine the construct validity of the HSPS, to introduce the concept into the field of work stress, and to adapt the user-friendliness of the HSPS without affecting reliability and validity.	Multiple	Work environment	SPS (and its subscales) are negatively correlated with sense of coherence, comprehensibility, manageability, meaningfulness and self-efficacy. SPS (and its subscales) are positive correlated with negative affectivity, work displeasure and need for recovery.	Organisational Psychology, SPS	****
Jagiellowicz, J., Xu, X., Aron, A., Aron, E., Cao, G., Feng, T., & Weng, X.	2011	China	Investigate the relationship between perceptual and cognitive processes underlying tendency of pausing before acting and SPS.	Sensory/Perceptual	Change detection task using images	No significant associations between accuracy and SPS. Significant correlation between SPS and minor-minus-major difference in response time, such that the higher a participant was on SPS the longer time they spent before responding to minor changes, relative to major changes.	SPS	***
Gerstenberg, F.X.	2012	Germany	To investigate potential differences in SPS with regard to the HSPS subscales, to further investigate whether individuals high in SPS process information more carefully and correctly using a larger sample size, and to use a behavioural task that allowed for differentiation between reaction times and error rates.	Sensory	Visual detection task	SPS was found to predict performance on a visual detection task (both reaction times and error rates) and increased perceived stress. Only the LST subscale led to these results however. Results were independent of Big-5. Individuals high in SPS perceived more stress after taking the test than individuals low in SPS.	SPS	*****
Sobocko, K.	2012	Canada	To assess whether continuous self-regulation among people showing higher levels of sensitivity accelerates states of ego-depletion, in turn explaining poor cognitive and social performances. To show SPS is distinct from yet related to neuroticism and introversion.	Sensory	Exposure to noise similar to that of a busy I or restaurant	No significant difference found between participants in cognitive performance in noise vs control. This indicates the impact of the environmental stimulus was not affected by SPS. Though results null, more sensitive participants showed slowest response time in Stroop task.	SPS	*****

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Gearhart, C.G.	2014	USA	To investigate the multiple effects of SPS on nonverbal decoding. Specifically, on identifying emotions from paralinguistic cues.	Multiple	Audio stimulation	HSPs were found to be no worse or no better at recognizing vocal expressions of emotion than non-HSPs. This was regardless of whether they were exposed to conditions of stimulation or not. When neuroticism was controlled for, HSPs did not report being more distracted by moderate or high intensity audio stimulation than non-HSP counterparts.	SPS, Information processing	****
Booth, C., Standage, H., & Fox, E.	2015	UK	To assess a continuous predictor and outcome variable, that is capable of differentiating positive and negative extremes. Assessing for possible plasticity effects for SPS's three factors. While using a heterogeneous adult community sample. Assess would SPS moderate association between current life satisfaction and childhood experiences.	Social	Childhood experiences with caregiver	Those scoring more highly in SPS were found to be more affected by negative childhood experiences than those scoring low in terms of adult life satisfaction levels. No differential effects under positive childhood experiences were found for high or low SPS scorers. LST and EOE produced the same significant interaction.	Differential susceptibility	***
Pluess, M., & Boniwell, I.	2015	UK	To investigate whether SPS moderates the efficacy of a school-based intervention aimed towards preventing depression.	Intervention	SPARK Resilience programme	SPS was a significant predictor of treatment response. The intervention was successful in reducing depression in girls scoring highly in SPS, though not effective at all in those scoring lowly in SPS.	SPS , Vantage sensitivity framework	****

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Valojää, A.	2015	Finland	To investigate whether SPS can explain social preference for interacting online, and if the internet should be considered as a beneficial and alternative channel for communication for HSPs.	Multiple	Internet	No difference was found in the psychological wellbeing of those HSPs who preferred online interaction and those who preferred face-to-face interaction. When comparing the psychological wellbeing in the HSPs who belonged to online and Face to face groups, no difference was found. HSPs were found to be somewhat more distressed than non-HSP counterparts.	SPS, Computer mediated communication	***
Jagiellowicz, J., Aron, A., & Aron, E. N.	2016	USA	To examine the greater subjective emotional responses to both negative and positive stimuli which is thought to be characteristic of SPS.	Multiple	IAPS picture presentation/parenting environment from childhood	Those high in SPS tend to rate standard pictorial stimuli, and especially positive ones, as more intensely valanced, perhaps respond more quickly than others, but do not differ in their rating of the level of arousal caused by the pictures. Evidence found for an interaction between SPS with quality of parenting in predicting how they rated arousal, such that those high in SPS with high-quality parenting reported having greater arousal to positive pictures.	SPS	*****
Jaswetz, L.	2016	Netherlands	To answer the question of what are the combined effects and individual effects of SPS and childhood environment on social anxiety.	Multiple	Childhood environment	No significant interaction effect found. Main effect of SPS on social anxiety found.	SPS	***

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Meredith, P. J., Bailey, K. J., Strong, J., & Rappel, G.	2016	Australia	To gain understanding of the interrelation of adult attachment, sensory processing, and distress in healthy adults	Sensory	Cold-pressor pain inducement task used to activate attachment system	Attachment anxiety was related to sensory sensitivity as measured by the HSP-SV. This association was not retained when controlling for stress, indicating the association was largely accounted for by stress. Sensory sensitivity as measured by HSP-SV was positively linked with distress.	Attachment theory	*****
Uljarević, M., Carrington, S., & Leekam, S.	2016	UK	Study aimed to further characterize the nature of the specific Sensory Sensitivity – Intolerance of Uncertainty - anxiety inter-relationship to determine whether the pattern was evident in a sample of adults.	Relational	Parenting child with ASD diagnosis	A three-way inter-relationship between SPS, Intolerance of Uncertainty and anxiety was found. High sensitivity and a susceptibility to being overwhelmed by environmental stimulation may lead to an experience of the world as being highly unpredictable, which in turn could make even simple situations and events uncertain and difficult for the HSP, thus provoking anxiety.	SPS, Intolerance of Uncertainty	***

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Rothenbucher, F. U.	2017	Belgium	Aimed to explore if HSPs and those scoring highly in SPS differ in the manner in which they attend to incoming visual stimuli.	Sensory	Posner exogenous cueing task and cued attention task	A significantly higher levels of attentional engagement was found for the high SPS group for happy cues at the 100ms duration, which indicates a continuous direction of attention at the positive stimuli and deeper processing of this material. High SPS participants had self-reported higher negative affect and lower levels of extraversion. They also diverted attention away from neutral cues at 100ms, possibly to prevent sensory overload.	Attentional bias research	*****
Stefan Lindsay, J.	2017	USA	To describe how teachers who may be highly sensitive interpreted professional stressors and cognitively appraised work events to develop successful coping skills, and to make clear successful coping strategies from teachers who may be highly sensitive and have committed to help others who are highly sensitive sustain their profession.	Multiple	Teaching environment	SPS significantly and positively correlated with risk of burnout. However, stress fully mediated this relationship when introduced into this model. At increased risk of presenting with SPS, teachers tended to have a greater risk of burning out due to emotional exhaustion. They also reported experiencing more stress at work. Qualitative results indicated time demands and colleagues as primary sources of stress, and both daily and systematic coping strategies were utilised.	Teacher self-efficacy and cognitive appraisal theory	****
Andresen, M., Goldmann, P., & Volodina, A.	2018	Germany*	To explore the role of resources (such as SPS and social capital) in explaining the perceived stress of expatriates and their turnover intention.	Multiple	Expatriation – working in a foreign country	Perceived stress fully mediated the effects of SPS and bonding social capital on expatriates' turnover intention. 26.4% of expatriates scored highly in SPS. Significant differences were found such that 30.7% of organisational expatriates were highly sensitive compared to 19.3% of external expatriates.	Hobföll's (1989) conservation-of-resources (COR) theory	****

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Campbell, T., & Moore, K.	2018	Australia*	To better understand the relationship between SPS and social anxiety through investigating relevant factors thought pertinent to the onset and maintenance of the relationship.	Relational	Parenting environment	Those higher in SPS were found to be more prone to experiencing social anxiety than others. SPS also associated with avoidant coping, irrespective of the quality of parental bond experienced in childhood.	SPS, Differential susceptibility	****
Lionetti, F., Aron, A., Aron, E. N., Burns, G. L., Jagiellowicz, J., & Pluess, M.	2018	USA & UK	<u>Study 2.</u> To investigate whether the detected groups in levels of SPS differ significantly regarding common personality traits and emotional reactivity.	Sensory	Viewing happy and sad video clips	HSP mean score and EOE subscale were positively associated with positive emotional reactivity, and a marginally significant positive association between HSP and EOE subscale and negative emotional reactivity. Difference between three sensitivity groups in positive emotional reactivity approached significance, though groups did not differ significantly regarding negative emotional reactivity.	Environmental Sensitivity	*****
Nocentini, A., Menesini, E., & Pluess, M.	2018	Italy	To test whether individual differences in environmental sensitivity predict treatment response to an antibullying intervention in a large randomised control trial.	Intervention	KiVa antibullying programme	Significant intervention effects on victimisation and internalising symptoms were moderated by Highly Sensitive Child (HSC) scale score and gender. Boys scoring higher on HSC benefitted significantly more than lower scoring counterparts with reduced victimisation and internalising symptoms.	Environmental sensitivity	*****

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Rubaltelli, E., Scrimin, S., Moscardino, U., Priolo, G., & Buodo, G.	2018	Italy	To examine whether exposure to terrorism-related pictures interacted with individual differences in environmental sensitivity and psychophysiological response to stress in explaining people's risk perception.	Sensory	Exposure to terror-related or neutral pictures and Manneheim multi-component stress task	Sensitivity and reactivity were not significantly correlated. Sensitivity and likelihood of attack were correlated such that those scoring higher in HSPS estimated future attacks were more likely. The relationship between HSPS score and experimental condition was not significant. Those scoring higher in HSPS in the terrorism-related pictures condition were more willing to trade off privacy than those in neutral condition.	Risk-perception, environmental sensitivity	***
Scrimin, S., Osler, G., Pozzoli, T., & Moscardino, U.	2018	Italy	To investigate how adversities experienced by families and the supportive resources within the family itself are linked to children's perceptions about a number of factors. Namely: their own health status, their emotional wellbeing, as well as their academic and social performance. Furthermore looked at whether expected associations were moderated by the levels of environmental sensitivity in the children.	Multiple	Early adversities in family environment e.g. death in family, discontent in relations	HSCS score moderated the association between both family adversities and supportive resources provided by families on children's physical comfort and their perceived academic and social performance.	SPS	*****

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Slagt, M., Dubas, J. S., van Aken, M. A., Ellis, B. J., & Deković, M.	2018	Netherlands	To compare SPS and negative emotionality as markers of individual differences in susceptibility to parenting among children.	Relational	Parenting environment	SPS interacted with both changes in negative and positive parenting in predicting externalising, though not prosocial, behaviours. Sensitive children decreased the most in externalising behaviour when negative parenting decreased, but increased in it the most when negative parenting increased. Likewise, sensitive children decreased the most in externalizing behaviour when high levels of positive parenting were maintained, however they increased the most in externalizing behaviour when positive parenting decreased. Sensitive children decreased in externalising behaviours more than less-sensitive counterparts when receiving low levels of negative parenting. Sensitive children had the lowest levels of externalizing behaviour when high levels of positive parenting were maintained, but similar levels when positive parenting decreased.	Differential susceptibility	****

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Strand, J. F., Brown, V. A., Merchant, M. B., Brown, H. E., & Smith, J.	2018	USA	To evaluate the convergent validity and sensitivity of commonly used measures of Listening effort. To assess how scores on the tasks relate to cognitive and personality variables.	Multiple	A number of lab-based tasks	Those with higher HSPS scores rated the tasks as more difficult and had slower complex dual-task (CDT) latencies. A marginally significant HSPS × Noise interaction was found, indicating that the relationship between HSPS score and CDT latency is stronger in the hard than in the easy condition. Individuals who score higher in SPS showed increased effort as measured by some LE tasks.	Listening Effort, SPS	****
Su, X., Cai, R. Y., & Uljarević, M.	2018	China	To explore the influence of different factors on the mental health of Chinese parents of children diagnosed with autism spectrum disorder (ASD). Namely; Intolerance of uncertainty, sensory sensitivity, broader autism phenotype, and the severity of the child's ASD symptoms and comorbid symptoms.	Multiple	Parenting a child with ASD diagnosis	Higher levels of parental sensory sensitivity were associated with higher DASS-21 total score. Sensory sensitivity had an indirect effect through intolerance of uncertainty on parental mental health.	Intolerance of uncertainty, SPS	***
Tillmann, T., El Matany, K., & Duttweiler, H.	2018	Germany	Study 2: Exploring relationship of newly developed German SPS scale for children with additional school related variables.	Multiple	School environment	The highest positive significant correlation found between negative affect and the SPS sub-facet Overexcitability and the total SPS scale. Significant negative relationships between physical well-being, psychological well-being, functional capacity, and SPS.	SPS, Environmental sensitivity	*****

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Hjordt, L. V., & Stenbæk, D. S.	2019	Denmark	To investigate the cross-seasonal group differences in trait SPS and the association between trait SPS in remitted phase, and depression severity in symptomatic phase in those with Seasonal Affective Disorder (SAD)	Physical	Seasons – summer/winter	Participants with SAD exhibited higher scores on trait SPS compared to healthy controls in both summer and winter. Their scores on trait SPS increase from summer to winter, i.e. individuals with SAD displayed a cross-seasonal pattern of high sensitivity. Higher trait SPS in summer was found to be associated with more severe SAD symptoms in winter.	SPS	****
Holm, S. E. H., Hansen, B., Kvale, G., Eilertsen, T., Hagen, K., & Solem, S.	2019	Norway	To examine whether SPS affects treatment outcome in patients with OCD.	Intervention	Bergen concentrated 4-day exposure treatment (B4DT)	No significant relationship between SPS and treatment outcome was found after controlling for pre-treatment levels of OCD, depression, and anxiety. HSPS scores were significantly reduced after treatment.	SPS, cognitive behavioural therapy	****
Karam, E. G., Fayyad, J. A., Farhat, C., Pluess, M., Haddad, Y. C., Tabet, C. C., ... & Kessler, R. C.	2019	Lebanon	Aimed to evaluate the relative roles of war, childhood adversities and sensitivity in the development of PTSD.	Multiple	Exposure to war environment	While sensitivity was significantly related to PTSD, childhood adversities were the most important variable in predicting PTSD. The effect of war on PTSD was dependent on the interplay between adversities and sensitivity and was most prominent in highly sensitive children with lower adversities levels, and less pronounced in those experiencing high adversities levels.	Ecological framework	****

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Lionetti, F., Aron, E. N., Aron, A., Klein, D. N., & Pluess, M.	2019	USA	Developing an observational rating system of environmental sensitivity suitable for pre-schoolers and testing whether this predicts individual differences in response to negative and positive parenting aspects.	Relational	Parenting environment	Children who scored highly in the HSC-RS were more affected by the influence of parenting quality compared to those scoring low. Children in the highly sensitive group were found to be more sensitive to negative influences of high levels of permissive parenting when considering externalizing behaviour problems aged three and internalizing behaviour problems aged 3 and 6. They were also more sensitive to positive effects of high levels of authoritative parenting in predicting social competence at aged 3 and 6. Those scoring low in sensitivity were generally less sensitive to the influence of parenting.	Environmental sensitivity	*****
Slagt, M., Dubas, J. S., Ellis, B. J., Van Aken, M. A., & Deković, M.	2019	Netherlands	To investigate whether children who show stronger immediate reactions to their mothers during observed parent-child interactions are those whose development across one year is more strongly predicted by parenting at the beginning of that year.	Multiple	Parenting	SPS was related to neither externalising nor prosocial behaviour. Highly Reactive children did not score more highly on SPS than other children. Authors suggest it may be unlikely for children who are identified as susceptible for better and for worse using SPS to be the same ones who are also reactive for better and for worse within parent-child interactions.	Differential susceptibility	*****

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Tillmann, T.	2019	Germany	To differentiate SPS from other variables of psychological wellbeing. To examine whether highly sensitive teachers perceived characteristics of their professional lives in a different way than non-highly sensitive counterparts, and how SPS relates to perceived stress. Examine how SPS relates to different symptoms of mental disorders. Explore how highly sensitive teachers differ among each other in SPS and other variables, and if an overarching model of teacher stress including SPS be supported.	Multiple	Teaching environment	Highly sensitive teachers, while more attuned to students in need, do not demonstrate enhanced processing in teaching related aspects. SPS can explain the relationship between some work characteristics and perceived stress through coping and cognitive processes. SPS was found to relate to teachers depression, anxiety, and some psychosomatic disorders. Teachers who were highly sensitive benefited more from therapeutic interventions than non-highly sensitive counterparts. SPS can contribute significantly to development of stress in teachers.	SPS	*****
Vander Elst, T., Sercu, M., Van den Broeck, A., Van Hoof, E., Baillien, E., & Godderis, L.	2019	Belgium	Investigate assumptions that those with higher or lower levels of SPS develop differential susceptibility for the work environment, which is characterised by demands of the job and resources.	Multiple	Work environment	EOE and LST were found to amplify the relationship between job demands and emotional exhaustion.	SPS , Job Demands-Resources model (JD-R model; Bakker & Demerouti, 2007)	****
Yano, K., Kase, T., & Oishi, K.	2019	Japan	To investigate the associations of SPS, sense of coherence, and the interaction between these and depressive symptoms in university students.	Multiple	University environment	Strong Sense Of Coherence prevented high-SPS students from experiencing over-arousability and dysfunctional cognition, and consequently decreased the severity of depressive symptoms.	SPS, Sense of coherence	****

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Amemiya, R., Takahashi, G., Rakwal, R., Kahata, M., Isono, K., & Sakairi, Y.	2020	Japan	To examine the impact of yoga on mood states and attentional control in graduate students with varying levels of SPS in a physical education course setting.	Multiple	Yoga course	Students higher in SPS had lower Attentional Control and higher negative mood states before the course, however, a significant improvement in scores was observed. Differences between the two groups after the yoga course were not statistically significant. A positive correlation was found between SPS and variation in AC, however, a negative correlation was found between variation in AC and mood states.	SPS	**
Baldwin, E. D.	2020	USA	To examine if in college students with high SPS, there is a relationship between watching ASMR videos and change in emotional response.	Sensory	Viewing ASMR videos/non ASMR controls	Negative affectivity was not correlated with high SPS. Increase in positive affect between pre and post-test when viewing no voice control video in high SPS participants. Data did not support the hypothesis of significant improved positive affect after watching ASMR type videos. Decrease in negative affect found after watching ASMR videos and control video in those with higher HSPS score.	SPS,ASMR	**

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Black, B. A., & Kern, M. L.	2020	Australia	To investigate how those high in SPS who live within an extravert-dominant social context conceive of and experience wellbeing.	Multiple	Extravert-dominant social context	HSPs perceived wellbeing arises from harmony across different dimensions. A number of valued practices were noted for wellbeing: self-acceptance, having positive social relationships but this being balanced by times of solitude, connecting with nature, contemplative practices, emotional self-regulation, practicing self-compassion. Emotional experiences were also valued: low-intensity positive emotion, self-awareness, having a sense of meaning, and hope/optimism. Barriers to wellbeing were identified as physical health issues and saying no to others.	Idiographic	*****
Carr, M., Summers, R., Bradshaw, C., Newton, C., Ellis, L., Johnston, E., & Blagrove, M.	2020	UK*	Aimed to contrast predictions of diathesis-stress and differential susceptibility frameworks by assessing nightmare sufferers on a range of questionnaire, dream diary, task and neuroimaging measures.	Sensory	Emotional Picture Viewing	Nightmare sufferers scored more highly on the HSPS than control participants.	Diathesis-stress, Differential susceptibility	*****

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Fikkers, K. M., & Piotrowski, J. T.	2020	Netherlands	To explore individual differences in responses to media through investigating how four theoretically relevant variables (including SPS) affect responses to positively and negatively valanced media entertainment.	Social	Viewing positive and negative media video clips	Results showed that more variation in responses to media was due to differences between the participants rather than difference between stimuli, however SPS did not significantly explain this between-participant variation as a predictor or moderator.	Models of interactions between content and person e.g. Differential Susceptibility to Media effects model	****
Goldberg, A., & Scharf, M.	2020	Israel	To examine parenting practices regarding adolescent children of parents high in SPS. To examine whether attachment insecurity mediated this relationship.	Relational	Parenting environment	Attachment anxiety was positively associated to SPS. Attachment anxiety mediated the relationship between parents' SPS levels and harsh parenting, and partially mediated the relationship between parents' SPS levels and use of psychological intrusiveness.	Attachment theory	****
Iimura, S., & Kibe, C.	2020	Japan	Aims to clarify the mechanism of adolescents' differential adjustments. Investigates the role of SPS using the Japanese version of Highly Sensitive Child Scale for Adolescence (J-HSCS), and tests whether the diathesis-stress model or the differential susceptibility model best describes the socioemotional adjustment of students across the transition to high school.	Multiple	Transition to high school environment	Adolescents higher in SPS reported a greater increase in their well-being after the transition to high school, corresponding to their perceived environmental change, whilst low sensitivity peers did not show such well-being enhancement. Evidence found for vantage sensitivity over diathesis-stress or differential susceptibility models.	Environmental Sensitivity	*****

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Kibe, C., Suzuki, M., Hirano, M., & Boniwell, I.	2020	Japan	To develop a culturally suitable intervention in prevention and evaluate its efficacy, and to investigate moderation effects of SPS and gender of Japanese young people's wellbeing from a diathesis stress perspective.	Intervention	Modified version of the SPARK resilience program	Student scoring higher in SPS, who scored significantly lower in wellbeing than counterparts at baseline, responded more positively to the intervention, and had greater levels of reduction in depression and more promotion of self-esteem.	Differential susceptibility	*****
Meyerson, J., Gelkopf, M., Eli, I., & Uziel, N.	2020	Israel	Analyse the influence of SPS on burnout and professional quality of life in Israeli dentists.	Multiple	Work as dentist in Israel	Found that burnout can be predicted by the three aspects of SPS (ease of excitation, low sensory threshold and aesthetic sensitivity). These also predicted dentists satisfaction at work. Positive correlation between SPS and secondary traumatic stress. EOE and LST but not AES predicted dentists' reactions to patient's stress and trauma.	SPS, Occupational health	****
Onursal Özer, B.	2020	Turkey	To investigate the association between internalizing behaviours and perceived maternal and paternal rejection. To test whether this association is moderated by SPS and further moderated by child's gender.	Relational	Parenting environment	Higher levels of SPS predicted higher levels of internalizing problems when controlling for parental rejection, however this effect was not there when interaction between SPS and gender was included in the model. Highly sensitive girls were more inclined to experience internalizing problems.	Environmental Sensitivity, Parental Acceptance – Rejection Theory (PARTheory, contemporarily called IPARTheory)	****

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Pernot, L.	2020	Netherlands	To examine if depression can be explained by the amount of mismatch factors i.e., the different way of living in present time compared with ancestral world, and if SPS plays a role in this relationship. To gain more understanding about the onset of student depression, considering SPS and the timeline of mismatch factors.	Multiple	University environment	SPS was found to have a moderating effect on the positive correlation between mismatch factors and depression. SPS was found to correlate with mismatch factors, depression, and neuroticism. In the interviews, HSPs noted their sensitivity to environmental stimuli, feeling different compared to others, and having more difficulty coping with mismatch factors in their daily life.	SPS, Evolutionary mismatch hypothesis	****
Pluess, M., Lionetti, F., Aron, E. N., & Aron, A.	2020	UK	Study 3: To test individual differences in sensitivity to negative experiences. Study 4: To test individual differences in response to positive experiences.	Multiple	Study 3: Teaching environment as a teacher-trainee Study 4: Exposure to mood induction video.	Study 3: HSP-12 was a significant predictor of changes in well-being across 10 months, with teacher trainees who were more sensitive showing a significant decline in well-being followed by a full recovery. Those low in sensitivity appeared unaffected by the experience. Study 4: HSP-12 score significantly moderated short-term effects of positive mood induction using video clip on pre-post changes in positive mood. Change in positive mood was more pronounced in the high sensitivity group.	Environmental sensitivity	Study 3: *** Study 4: *****
Redfeam, R. A., van Ittersum, K. W., & Stenmark, C. K.	2020	USA	To explore major nursing stressors and burnout levels in nurses that are considered highly sensitive by nature compared to their less sensitive peers.	Multiple	Working in nursing currently in the USA	SPS was found to correlate overall with nursing stress, burnout, five nursing subscales of stress, and two subscales of burnout. SPS was shown to be a predictor for overall nursing stress, overall burnout, of two nursing stress subdimensions, and one burnout subdimension.	SPS, Occupational health	****

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Rigby, S. N., Jakobson, L. S., Pearson, P. M., & Stoesz, B. M.	2020	Canada	Investigate the links between alexithymia and the evaluation of emotional scenes, and whether viewer's evaluations of these scenes were better predicted by specific alexythymic traits or individual differences in SPS.	Sensory	Emotional scenes task	Strong positive correlations were observed between difficulties identifying and describing feelings scores and scores on the EOE subscale of the HSPS. Authors suggest this indicates that problems with emotional appraisal are most evident in those who are easily overwhelmed by busy sensory environments. EOE was a negative predictor of accuracy in classification of positive scenes.	SPS, Alexithymia	****
Bordarie, Jimmy; Aguerre, Colette; Bolteau, Laëtitia	2021	France	Investigate the effects of confinement using a longitudinal reflection framework on quality of life and anxiety/depressive symptoms in individuals with different levels of SPS.	Multiple	Confinement during COVID-19 pandemic	SPS related to levels of anxiety and depression, with depression increasing with higher levels of SPS. For those with average SPS, lockdown had a significant positive effect in reducing anxiety disorders. In terms of quality of life, lockdown appeared to play a positive role for entire sample regardless of SPS level.	SPS	**
Hellwig, S., & Roth, M.	2021	Germany	Study 2: To test if SPS is an ability construct, with regards perceiving and processing environmental stimuli.	Multiple	Geneva Emotion Recognition Test (GERT; Schlegel et al., 2014)	Any potential relation between the factors of SPS and emotional recognition ability can be fully explained by the Big-5 personality traits. Low sensory threshold (LST) was found to be unrelated to emotional recognition ability.	SPS , Big 5 personality framework	***

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Imura, S.	2021	Japan	Aims to provide new evidence on whether adolescents' SPS moderates the relationship between current life events and current socioemotional well-being and what shape of interaction SPS and current life events exhibit.	Multiple	Current life environment	Adolescents with high SPS were more likely to be affected by both negative and positive life events, which resulted in an increase in their socioemotional well-being. However, their SPS functioned as vulnerability when they experienced many negative life events. Lower SPS adolescents showed resilience regardless of the quality of their life events.	Environmental Sensitivity	*****
Lionetti, F., Klein, D. N., Pastore, M., Aron, E. N., Aron, A., & Pluess, M.	2021	USA	Investigate the interactions between early parenting styles and children's ES on symptoms of rumination and depression in middle childhood and early adolescence.	Multiple	Early parenting environment	Children's sensitivity interacted with permissive parenting to predict rumination at age 9, which in turn predicted higher levels of depression.	Environmental Sensitivity	*****
Lionetti, Spinelli, Moscardino, Ponzetti, Garito, Dellagiulia, Aureli, Fasolo, & Pluess	2021	Italy	Study 2: Explore changes in externalising and internalising behaviours in children during the COVID-19 pandemic.	Relational	Parenting environment during COVID-19 Pandemic	High levels of parent-child closeness was protective for HSCs for internalising and externalising behaviours. HSCs showed overall slightly higher levels of internalizing behaviours before and during the lockdown. Low levels of parent-child closeness was associated with a small increase in internalizing behaviours during the lockdown in both low and highly sensitive children.	Environmental sensitivity	****

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May, A.K. & Pitman, M.M.	2021	South Africa	To examine university adjustment differences between students scoring high and low on SPS, and test whether these effects were independent of the five-factor model of personality, and moderated by early parental care levels.	Multiple	Early parenting experiences/Adjustment to university	Students with high levels of SPS reported significantly worse adjustment to university. Moderating effect for parental care for students low on SPS. Poor adjustment to university was driven by a propensity towards negative affect, but carefully and deeply processing stimulation by those with high SPS levels partially offset adjustment difficulties.	SPS, Big 5 Personality Framework	***
Moscardino, U., Scrimin, S., Lionetti, F., & Pluess, M.	2021	Italy	To investigate behaviourally observed environmental sensitivity in children from low Socio Economic Status families to explore the existence of sensitivity groups. To assess whether the aforementioned groups differ in terms of physiological self-regulation.	Relational	Family support	Three sensitivity groups identified: "Low sensitive" (43%), "Moderately sensitive" (33%), and "Highly sensitive" (24%). No difference between groups at baseline cardiac vagal tone (CVT). At low and average levels of family support, highly sensitive children with higher resting CVT reported better wellbeing than those with low resting CVT, this was not observed in other sensitivity groups.	Socioecological, risk- and resilience-oriented framework (Bronfenbrenner & Morris, 1998; Masten, 2018)	*****

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Pérez-Chacón, M., Chacón, A., Borda-Mas, M., & Avargues-Navarro, M. L.	2021	Spain	This study's objectives were to find out the extent to which both healthcare and educational professionals showed burnout at the beginning of COVID-19 pandemic, to determine if there were differences in SPS, burnout, compassion fatigue/compassion satisfaction depending on sector, and to find out to what extent these variables influenced experience of these syndromes as risk or protective factors.	Multiple	Working in education or healthcare fields at beginning of COVID-19 pandemic	Relationship between emotional exhaustion and SPS were significant in healthcare workers and educators. Relationship between DP and SPS was significant in educators. Increase in EOE would contribute to increasing emotional exhaustion. Being a healthcare worker and scoring high on EOE acted as a risk factor for personal realization. Low sensorial threshold and compassion satisfaction acted as protective factors in this area. EOE and EAS increased compassion fatigue regardless of sector.	SPS, Occupational health	****
Sklar, A. Y., Goldstein, A. Y., Abir, Y., Goldstein, A., Dotsch, R., Todorov, A., & Hassin, R. R.	2021	Israel	<u>Experiment 8:</u> To examine whether differences in non-conscious visual prioritization speed (NVPS) are echoed in individuals' conscious everyday experiences, and to examine correlate of SPS.	Sensory	bCFS task	Significant correlation found between NVPS and self-reported SPS using the HSFS short version.	SPS, Cognitive neuroscience	***

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Weyn, S., Van Leeuwen, K., Pluess, M., Lionetti, F., Goossens, L., Bosmans, G., ... & Bijttebier, P.	2021	Belgium & Netherlands	To improve the HSC scale by including new items, to allow more variation and capture underlying construct. To examine psychometric properties of this scale and run a validity check. Assess whether scores on the HSC scale are a moderator in the relationship between negative and positive environmental factors (in this case negative and positive parenting) and outcomes (here internalizing and externalizing problem behaviours)	Multiple	Parenting environment	Results did not support evidence for HSC Scale as a moderator for relationship between parenting internalising or externalising problems.	Environmental Sensitivity	*****
Yano, K., Kase, T., & Oishi, K.	2021	Japan	To investigate the relationship between life skills and depressive tendencies in Japanese university students, as well as how this relationship may be moderated by individuals' levels of SPS.	Multiple	University environment	Association between SPS and depressive tendencies even when controlling for neuroticism. Emotional coping skills were found to be negatively associated with depressive tendencies only when SPS was high. Decision-making skills were found to be negatively associated with depressive tendencies only when SPS was low. Interpersonal relationship skills were negatively associated with depressive tendencies, without SPS interaction.	Life-skills training, SPS	*****

Authors	Year	Country Study was Conducted In/ Or Lead Author Affiliated	Objectives of the Study	Environment Type	Specific Environment	Relevant Key Findings	Theoretical Framework/Area of study	MMAT Result
Iimura, S.	2022	Japan	To examine how SPS and resilience in those aged 18-24 relate to COVID-19 induced distress.	Multiple	COVID-19 pandemic in Japan	Higher levels of SPS were associated with higher levels of COVID-19 stress. Resilience buffered the negative association between SPS and COVID-19 stress.	Environmental sensitivity	*****

*Note. * indicates that the country listed was the listed country of first author*

Most records were from peer reviewed journal articles ($n = 52$), followed by college theses/dissertations ($n = 8$). Most studies were quantitative ($n = 66$), cross-sectional ($n = 52$), and observational (i.e., the independent variable not manipulated) ($n = 48$). Most studies included only adults ($n = 31$), and participants of both sexes/genders ($n = 61$). Most environment types contained multiple facets ($n = 35$). The methodological characteristics of the different articles included are summarized in Table 4.

Table 4
Methodological Characteristics of the included articles

Characteristics	Categories	<i>N</i>
Source	Peer reviewed journal article	52
	Preprint journal article	2
	College thesis/Dissertation	8
	Poster presentation	1
Country Study was Conducted In/ Or Lead Author Affiliated	Australia	3
	Belgium	3
	Canada	2
	China	2
	Denmark	1
	Finland	1
	France	1
	Germany	5
	Israel	3
	Italy	5
	Japan	7
	Lebanon	1
	Netherlands	7
	Norway	1
	South Africa	1
	Spain	1
	Turkey	1
	UK	6
USA	14	
Study Type	Observational	48
	Experimental	15
	Quasi-experimental	4
	Outcome Research	1

	Two-cohort treatment/control design	1
	Randomised-control design	1
Study Design	Cross-sectional	52
	Longitudinal	13
	Longitudinal seasonally counter-balanced design	1
	Initial measures of longer study	1
	Pre-post design	2
Methodological Approach	Quantitative	66
	Qualitative	1
	Mixed-Methods	1
	Explanatory sequential mixed methods	1
Environment type	Intervention	4
	Multiple	35
	Physical	1
	Sensory	11
	Social	3
	Relational	9
	Sensory/Perceptual	1
Participants Gender/Sex	Males only	0
	Females only	2
	Males and Females	61
Participants Age Group	Adults (18+)	31
	Children (0-17)	8
	Adults and Children	14
	Not specified	10
Theoretical Framework/Area of study	Alexithymia	1
	ASMR	1
	Attachment theory	2
	Attentional bias research	1
	Big 5 Personality Framework	2
	Cognitive appraisal theory	1
	Cognitive behavioural therapy	1
	Cognitive neuroscience	1
	Diathesis-stress	1

Differential susceptibility	6
Ecological framework	1
Environmental sensitivity	13
Evolutionary mismatch hypothesis	1
Theories of APD e.g., Beck and Freeman (1990), Carver and Scheier (1981, 1998) self- regulation theory	1
Hobfoll's (1989) conservation-of- resources (COR) theory	1
Idiographic	1
Information processing	1
Job Demands-Resources model (JD-R model; Bakker & Demerouti, 2007)	1
Life-skills training	1
Listening Effort	1
Occupational health	3
Organisational Psychology	1
Parental Acceptance – Rejection Theory (PARTheory, contemporarily called IPARTheory)	1
Risk-perception	1
Self-discrepancy Theory (Higgins, 1987)	1
Sense of coherence	1
Socioecological, risk- and resilience-oriented framework (Bronfenbrenner & Morris, 1998; Masten, 2018)	1
SPS	37
Teacher self-efficacy	1
Vantage sensitivity framework	1

Note: Some studies applied multiple study designs or were carried out across several countries. Thus, it is possible that the sum of the categories exceeds the number of included articles. Children were defined as participants up to and including 17 years old.

Most studies were conducted in, or if data was not available had a first author from, the USA ($n = 14$), Japan ($n = 7$), the Netherlands ($n = 7$), the UK ($n = 6$), and Germany ($n = 5$).

3.1 Quality assessment

A detailed presentation of the ratings of each of the included studies, across the five criteria, is available in Table 3. MMAT resulted in the identification 4 studies meeting two of the criteria, and 12 studies meeting three of the criteria. Most studies complied with the quality criteria with 24 studies meeting all five criteria and 29 studies meeting four of five criteria. As noted previously, this assessment was not an inclusion or exclusion criterion, and all studies are included in the analysis regardless of their MMAT quality.

3.2 Theoretical frameworks

It was noted during the process of identifying theoretical frameworks in the included studies very few papers explicitly stated the theoretical framework they were using; thus, for some studies where this was not clear it was decided to add in the area of study, as this too would provide useful information in terms of the studies' background.

As can be seen in Table 4, we could identify several different theoretical frameworks and areas of research across the included studies, the most prevalent being SPS.

Several sensitivity models were identified in the theoretical discussions of the studies: vantage sensitivity, diathesis-stress, and differential susceptibility.

The area of Occupational Health also appeared in a number of papers, while other papers focused more on specific theories, e.g., Hobfoll's (1989) conservation-of-resources (COR) theory, Interpersonal Acceptance-Rejection Theory (IPARTheory; Rohner, 2014).

3.3 Themes identified

Three primary themes were identified through the analysis: 1) Studied environments, 2) Outcomes for SPS in environments, and 3) Different aspects of sensitivity and SPS. A

summary of the included studies is presented in Table 3, and a table with a detailed description and coding, and a coding table can be found in Appendix C.

Studied Environments. The theme of “studied environments” included the subthemes of “early years for child and caregiver”, “the senses, perception, and cognitive modification”, “occupational environment”, and “multi-faceted environment”.

The area of childhood and the effects of the parenting environment appeared frequently in the literature, including areas such as parenting a child with additional needs (e.g., ASD).

Other environmental areas included the use of different sensory and cognitive tasks, manipulating the visual or auditory input, presenting different kinds of emotional stimuli, and attention tasks. Several longer-term intervention environments were also identified ranging from those targeted towards mental health, to yoga courses, and school-based interventions.

Occupational environments also appeared frequently. This included working environments such as in healthcare and teaching, as well as school and university environments i.e., the occupation of younger people.

Finally, the subtheme of multifaceted environments comprised of those environments which contained a multitude of different features; for example, the environment of war, the COVID-19 pandemic, and competitive sporting environments.

Psychological outcomes for SPS in different environments. The larger of the three overarching themes, this contained the subthemes of “Mental Health and Wellbeing”, “Cognition”, and “Relationships with Other Internal and External Factors”.

In terms of mental health and wellbeing, several different facets were studied in the literature, with some having a positive impact, others negative, and some null findings.

Benefits appeared in areas such as emotional and social wellbeing, decreases in negative affect, and increases in self-esteem. In general, high levels of SPS appeared to be beneficial in intervention studies, with reductions in depression and greater changes in positive mood noted in different studies. However, higher levels of SPS were also associated with higher levels of distress, negative affect, work displeasure, declines in wellbeing, higher negative affect, anxiety, psychosomatic disorders, and rumination. In different environments, SPS can confer both vulnerabilities and more positive opportunities in this area.

In the area of cognition, outcomes pertaining to processing, affect, and behaviour were examined. High levels of SPS were related to difficulties in emotional identification, reduced comprehensibility i.e., comprehension of internal and external stimuli as understandable, a negative impact on CDT latencies, difficulties with emotional description, a negative relationship with functional capacity, and lower Stroop response times. However, other studies found faster reaction times for rating positive valence of images, greater attention engagement, more attunement to students' needs, using coping strategies, and deeper processing of material were related to higher levels of SPS. Self-perception such as in the areas of academia and socially, and perception of the external world, such as in work and safety, also appear to be related to individuals' levels of SPS.

Relationships between SPS and other factors, both internal and external, appear to relate to the connections between SPS and outcomes. Factors such as coping styles, intolerance of uncertainty, optimism/pessimism, sense of coherence, parenting quality, and lockdown, amongst others, all appear to interact with environments and SPS in creating the outcomes.

Different aspects of sensitivity and SPS. The final theme, “Different aspects of sensitivity and SPS”, was the least represented of the three themes, and contained the subthemes of “SPS Groupings” and “Other sensitivities”.

SPS groupings captured the finding that SPS tends to be broken down into either two or three groupings in the literature, that is low, and highly sensitive or low, medium, and highly sensitive. Furthermore, individual factors of SPS are often used in analysis in the literature. These factors of EOE, AES, and LST are used in some, but not all studies.

Other sensitivities appeared alongside SPS in research papers. Theories such as vantage sensitivity, diathesis-stress, and differential susceptibility are all linked with SPS, and in the research in the area.

4. Discussion

This systematic scoping review examined the current research on environmental variables explored in relation to SPS, the types of psychological outcomes investigated, the impact of these environments on psychological outcomes of HSP, and the methodological approaches adopted. The overall trend of the literature included in the scoping review suggests the relationships between SPS, the environments, and psychological outcomes are complex, and vary regarding specific population types and levels of exposure. A wide variety was found amongst the studies in terms of the types of environments investigated and methodologies used in research.

Having extracted descriptive characteristics and key results of the included studies, a thematic analysis approach was applied as per the guidelines of Braun and Clarke (2006) to identify patterns in the data. This resulted in three overarching themes; Studied environments, Outcomes for SPS in environments, and Different aspects of sensitivity and SPS. Numerical analysis was also applied to identify key descriptive trends.

In terms of our Objective 1, the descriptive analysis of the study characteristics found most studies applied a cross-sectional design. Most studies are quantitative utilising experimental or survey designs. Most studies were carried out in Western countries, with adult populations. However, there were some studies carried out in Asia. This highlights a gap in the research into this area in areas such as Africa, South America, and South Asia. As noted by Black and Kern (2020), Western Educated Industrialised Rich and Democratic (WEIRD) countries have been found in research to differ from non-WEIRD countries across different behavioural and cognitive indices. Thus, investigating the trait of SPS in non-WEIRD populations is a necessity when considering generalisability of the construct and findings from SPS research worldwide. However, as can be seen from the dates of the included studies, this is an area of research which is rapidly expanding, with 50 of the 63 included papers being published in the last 5 years.

In terms of our Objective 2, considering the first overarching theme found in this review, it appears research in SPS has taken place across a multitude of different environments. One area which is widely researched is that of the family environment, specifically parenting (e.g., Lionetti et al., 2019; Moscardino et al., 2021; Onursal Özer, 2020; Slagt et al., 2018; Uljarević et al., 2016). Research into the impact of parenting took place both at the time of child/parent interactions in the present (e.g., Lionetti et al., 2021), or in the participants' past (e.g., Liss et al., 2005).

A number of different sensory environments were researched, with participants exposed to different audio stimuli (e.g. Hellwig & Roth, 2021; Strand et al., 2018), visual stimuli (e.g. Jagiellowicz et al., 2016; Sklar et al., 2021), and cognitive tasks (e.g. Gerstenberg, 2012; Rigby et al., 2020). Environmental manipulations through interventions

were also popular in the literature, with a number of school-based interventions identified (e.g. Nocentini et al., 2018; Pluess & Boniwell, 2015). The interaction between the working environment, SPS, and psychological outcomes has been investigated in a number of working environments, from healthcare (Redfearn et al., 2020), to teaching (Tillmann et al., 2018), and working as an expatriate (Andresen et al., 2018). Throughout the qualitative analysis, it became apparent that there were several multi-faceted environments which resulted in the construction of the subtheme of the same name. Environments like the seasons changing (Hjordt & Stenbæk, 2019), and competitive sports (Kemler, 2006), contain a multitude of factors which make them complex.

Areas that could be of relevance for SPS but are not directly and systematically investigated are natural environments and social relationships, such as friendships and romantic relationships. This is surprising given the growth in this research area over the past decade, and the fact that HSPs note nature to be an important enabler of wellbeing (Black & Kern, 2020). Furthermore, research around social environments in relation to SPS was limited to specific areas e.g., work, parenting. Given the importance of relationships in psychological wellbeing, and the growing evidence for the role of nature, these could possibly be important areas for research in the area going forward.

In relation to Objective 3, the second theme helps elucidate this point, “Outcomes for SPS in environments”. In terms of mental health and wellbeing in the school environment, the two available interventions had a positive effect for those higher in SPS, with greater benefits from school-based interventions in reducing internalising symptoms and victimisation for boys (Nocentini et al., 2018), and reductions in depression in girls (Pluess & Boniwell, 2015). Considering cognitive tasks, in some situations SPS can confer benefits, such as a deeper processing of material in a Posner exogenous cueing task and cued attention

task (Rothenbücher, 2017), and faster reaction times in responding to pictorial emotional stimuli (Jagiellowicz et al., 2016). However, it was also found to have a negative impact on Stroop performance (Sobocko, 2012), and a negative impact on complex dual-task (CDT) latencies.

The work environment presents some difficulties for the HSP in terms of burnout (Meyerson et al., 2020; Redfearn et al., 2020; Stefan Lindsay, 2018), and aspects such as manageability i.e., extent of belief that necessary resources to cope with problems are available, comprehensivity i.e., extent of belief that problem being faced is clear, and meaningfulness i.e., the extent of belief that one wishes to cope with the problem (Evers et al., 2008). The parenting environment appeared to have an impact on the HSP's psychological outcomes, dependent on the quality of the parenting, with positive parenting predicting better outcomes and lower quality parenting having a negative impact (e.g., Lionetti et al., 2019; Liss et al., 2005). This is in line with the parenting research in the general population (Tabak & Zawadzka, 2017). Areas of psychological outcomes investigated were diverse, though few focused on the area of mental health disorders. Given the noted prevalence of those higher in SPS in therapy (Aron, 2011), it is surprising the impact of the environment on this cohort and on these disorders is not as prevalent in the current review. Future studies might examine the relationship between SPS and mental health disorders, as opposed to symptoms alone.

An additional important point became apparent from the thematic analysis. As identified in the theme "Different aspects of sensitivity and SPS", the use of different conceptualisations of SPS and sensitivity in the literature is widespread. This is in line with the literature, as while initial analysis suggested SPS was a unitary factor (Aron & Aron, 1997), later research suggested it contains a bifactor solution including the three constructs of

EOE, LST, and AES and a general SPS factor (Lionetti et al., 2018). In terms of measurement, as can be seen in Appendix B, all studies used some form of SPS scale based on Aron and Aron's (1997) original HSP scale. Most scales were in a questionnaire format, including the HSC child-report (Pluess et al., 2018) and its parent-report version (Slagt et al., 2018), apart from the HSC-rating system specifically developed for pre-schoolers which is based on observation of child behaviours (Lionetti et al., 2019). This allows for comparison across studies; however, as the scales are generally self-report, apart from studies in which parents report for children, there is likely to be some self-reporting bias. As noted by Greven et al. (2019), more objective assessment procedures could be a beneficial addition to the research in this area. Furthermore, the HSP/HSC scales were at times used in studies as a measure of SPS, though at times noted to be measuring ES. It could be helpful for future research in the area to be careful to clarify the concepts of sensitivity they are utilising, what the sensitivity scale one is using has been designed to measure, and place results within the greater sensitivity literature framework – for example the framework suggested by Pluess (2015).

As to Objective 4, the theoretical framework of ES was popular across studies, as can be seen in Table 3. As noted in the results, many studies did not note the theoretical framework from which they were working in their articles. From examining those noted and the general areas of research, there appears to be a plethora of different theories and research areas, from cognitive to social and mental health-based research. However, given the relative spread and the high levels of speciality of the studies, it suggests that SPS is a concept which at times gets included in studies rather than being the focus. Thus, building a foundation of research into different common environments, e.g., nature, home environment, educational, could be beneficial in terms of identifying the areas which are more likely to impact on the mental health of those high in SPS alongside the examination of the more niche areas which

have been examined already in the literature. Future research should also consider focusing on more experimental work around the cognitive dimensions of the construct. This would be pertinent as from this review it is clear there is a larger body of applied research with few studies examining quantifying the characteristics of the trait e.g., depth of processing.

4.1 Strengths and Limitations of the Current Scoping Review

This is the first scoping review summarising the available research on the impact of different environments on the psychological outcomes of those high in SPS. However, there are several limitations which need to be considered in relation to this review. Only articles published in English were included in the review, thus relevant studies published in other languages were not included. As can be seen in Figure 1, 25 studies identified were not published in English which is a substantial number. Thus, the countries and cultures of these papers were not included in the analysis leading to a WEIRD-leaning review.

Another limitation is that due to the heterogeneity of the studies, there were difficulties in summarising the findings of the studies, and in turn difficulty in drawing conclusions.

This review also has strengths. The definitions of environment and psychological outcomes were kept broad to include as much research as possible to allow it to be mapped. The study also included quality review, adding to the descriptions of the studies, and aids in identifying what areas may need further investigation. Many theses completed around the area of SPS were identified throughout the process of the review, with the majority of these not appearing in published form. This speaks to a possible “file drawer” problem in the area. As much of this research may not be returned in traditional searches, it is a strength of this review to include the results of such studies.

5. Conclusions

SPS is a trait interacting with a wide variety of environments, which can have an impact, for better or worse, on an individual's psychological outcomes. Research into sensitivity is burgeoning and is being carried out in many regions of the world, although primarily in WEIRD participants. This review synthesised the available evidence regarding the relationship of SPS with the environment on psychological outcomes. In sum, research gaps were identified in terms of non-WEIRD populations, research into mental health disorders interacting with SPS and environments, research quantifying the characteristics of the trait and sub-dimensions (e.g. EOE, AS, LST), and nature environments. In terms of paradigms, future research should apply longitudinal designs to investigate psychological outcomes for those high in SPS, and follow-up to investigate possible long-term associations, as well as adopting a systematic approach where each environment is studied both with quantitative and qualitative approaches. Further intervention studies should also be considered, especially around mental health. Finally the main outcomes studied are negative mental health outcomes, apart from the area of cognition, therefore there is a need to focus on positive mental health outcomes and related environments in relation to SPS.

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7.0 Disclosure Statement

The authors report there are no competing interests to declare.

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