Sensory Processing Sensitivity and Children Development in the Context of Environmental Sensitivity

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Abstract. Studies proved that people vary greatly in their sensitivity to the environment, and some are more sensitive than others. Aron et al. proposed the Sensory Processing Sensitivity (SPS) model to explain individual differences in sensitivity from the perspective of environmental information processing depth, which has recently been incorporated within a meta-framework of Environmental Sensitivity. In the field of children development research, children's SPS is gradually understood as an important marker of children's environmental sensitivity, and about 30% of children have a high-sensitive trait characterized by deeper processing of environmental information, increased emotional and physiological reactivity, greater awareness of environmental subtleties, and ease to be overstimulated. Recently, SPS and the highly sensitive child have gained great popularity in public and academia. This article reviews the theoretical framework and measurements of SPS of children, summarizing the relationship between SPS and children's development outcomes and the moderating role SPS plays in children's development. Future research needs to focus on the prevention and intervention of negative effects related to SPS and harness its positive potential to promote children's well-being.

Keywords: Environmental sensitivity; Sensory processing sensitivity; Children development; Interventions.

1. Introduction

In our daily life, it is easy to find that some individuals are more sensitive than others. Those who are highly sensitive seem to be easily offended or upset, have or display a quick and delicate appreciation of others' feelings, and have a rich inner world. Indeed, the notion "highly sensitive person" has been discussed widely in public, and some simple discoveries and opinions about this group of people have been spread by media, including their advantages, disadvantages, and behavior guidelines for them to improve well-being.

Although the public show great interest in a highly sensitive person and sensitivity, relevant academic studies are lagging, leading to a gap between society's need for knowledge and scientific findings [1]. The concept of the highly sensitive person was first formally proposed by Aron and colleagues in 1997. Meanwhile, they provided a Sensory Processing Sensitivity (SPS) model to depict a phenotypic personality trait of highly sensitive people [2]. In fact, several traditional models were also proposed to address the individual difference in sensitivity to the environment since the 1990s, including Diathesis-Stress [3], Differential Susceptibility [4], Biological Sensitivity to Context [5], Vantage Sensitivity [6]. Although different concepts and theoretical perspectives are selected, these models all contribute to describing variability in sensitivity to the environment of people. Therefore, Pluess [7] integrated these models into a single overarching meta-framework of Environmental Sensitivity for its potential benefits to both research and practical application. Recently, SPS has become a compelling aspect of Environmental Sensitivity. In 2019, some experts in the field of sensitivity jointly published a systematic review of the latest scientific discoveries on SPS in the context of Environmental Sensitivity [1].

Studies proved that sensitivity is moderately heritable, with about 50% of the variance explained by genetic factors and the residual 50% interpreted by environmental influences [8]. In the field of children development research, SPS is an important model to elaborate the interactive effects of individual factors (e.g., genes) and environmental factors (e.g., family) on children's development

[9]. Scientific research on sensitivity in children has abounded in recent years. However, a review to summarize the relationship between SPS and children's development is lacking. To remedy the deficit, this review aims to figure out how children's sensitivity affects their performance and developmental outcomes by summarizing the existing research. To better understand the meaning and the characteristic of SPS, this review illustrates the role of SPS in the context of Environmental Sensitivity framework.

2. Method

In this review, child, childhood, adolescent, children development, environmental sensitivity, sensory processing sensitivity, and sensitivity were searched on Web of Science, Scopus and Elsevier. Literature backtracking was used for the supplementary search. A total of 79 articles are retrieved from 2007 to 2022. After screening, 27 articles are included in the analysis. Studies included in this review need to meet the following criteria: (1) the research was carried out in the framework of environmental sensitivity theory; (2) the research examined children's performance or children's developmental outcomes as dependent variables and demonstrated their relationship with sensory processing sensitivity or revealed the role it plays.

3. Literature Review

3.1 Definition and Theories

Aron and colleagues proposed the model of Sensory Processing Sensitivity (SPS) to describe a relatively stable human trait that depicts the capacity to perceive and process information from the environment, and more sensitive individuals tend to deal with environmental stimuli more deeply than non-sensitive counterparts. A highly sensitive person is characterized by higher emotional and physiological reactivity, greater awareness of environmental subtleties, and is easier to be over-stimulated [2, 8]. SPS defined the environments broadly to contain any prominent conditioned and unconditioned stimuli from internal or external, such as physical environments (e.g., food consumption, caffeine intake), sensory environments (e.g., visual, tactile stimuli), and social environments (e.g., parenting quality in childhood). SPS emerges at the beginning of every life and is further shaped by the environmental condition's children experience as they grow up [8].

SPS has been included in a family of theoretical frameworks of Environmental Sensitivity [7]. which has been adopted in the field of children development. Environmental Sensitivity also comprises the following theories.

The earliest Diathesis-Stress model regarded sensitivity as vulnerability, with which children are more likely to be influenced by adversity, resulting in multiple mental or behavior problems. Secondly, Belsky's Differential Susceptibility Theory use the notion of "susceptibility" to describe sensitivity to environment, which is rooted in the perspective of evolution. Individual differences in susceptibility represent two alternative developmental strategies resulting from natural selection: high-susceptibility individuals adopted plastic strategy featured adaptation to the environment, whereas low-susceptibility individuals used the fixed strategy reflecting relative inertia in response to environment [4, 11]. Besides, Boyce and Ellis's Biological Sensitivity to Context theory concentrates on individual variations in physiological reactivity in response to environment, which reflects the neurobiological susceptibility or sensitivity of individuals [5]. Finally, according to Vantage Sensitivity model, people react differently to positive stimuli based on their intrinsic traits. When exposed to a supportive and protective environment, those of high sensitivity are more likely to benefit from it, while those of low sensitivity are more resistant to the potential positive effects [6].

Notably, SPS owns unique theoretical and applied implications because it first proposed that sensitivity can be measured as a phenotypic trait in children and adults directly, and psychometric tools have been developed based on it, with important theoretical and applied implications. Multiple studies provide evidence that SPS is a proximal and potent marker of environmental sensitivity [1].

3.2 Measurements of Environmental Sensitivity in Children

3.2.1 Highly Sensitive Child Scale (HSC)

Based on the SPS model and the Highly Sensitive Person Scale (HSP, a self-reported questionnaire to measure sensitivity in adults published in 1997), researchers have developed scales from different perspectives to assess children' sensitivity.

A 23-item parent-report questionnaire for children was first published in Aron's book The Highly Sensitive Child [12]. The questionnaire's reliability, distribution, and dimensionality were examined in a Dutch sample [13], which showed excellent internal consistency, a normal distribution, and a two-factor structure. The first factor is "Overreaction to Stimuli" (OS), and the second factor is "Depth of Processing" (DP).

Pluess and colleagues developed a 12-item self-report questionnaire Highly Sensitive Child (HSC) Scale [14]. Psychometric data suggests that the scale contains three components: Low Sensory Threshold (LST), Ease of Excitation (EOE), Aesthetic Sensitivity (AES). The factorial structure analysis suggested that the scale has adequate reliability and validity across various samples. Since the same three components were found susceptibility in the HSP, this three-factor structure is more acceptable to researchers.

Overall, studies indicated that SPS is a normally distributed continuum and individuals are divided into three sensitivity groups: a low (approx. 30%), medium (approx. 40%), and high (approx. 30%) sensitive group, while the HSC scales have been validated to have good psychometric properties [15,16], the scales need to be optimized further. Primarily, the sub-scales of the HSC scale were not designed but emerged when analyzing the collected data, so the underlying meaning of these components is not explicit when taken respectively, which needs to be investigated in the future, especially with the help of relevant neurobiological studies.

3.2.2 SPS Behavior Observation: the HSC Rating-System

The HSC Rating-System, a behavioral observation measurement of SPS in children between the ages of three and five, was developed by Lionetti et al. [17]. Currently, the HSC Rating System has been validated in a single study which only covers American children from middle-class families. Although its psychometric features will need to be thoroughly tested in the future, it has the potential to be a useful tool for future studies on SPS in children because it gives a more objective behavioral assessment. Obviously, the combined use of Behavior Observation and one version of the questionnaires may be a more reliable method to assess SPS.

3.3 SPS: a Double-edged Sword for children's development

A large number of correlational studies have documented that the three sub-scales of HSC (LST, EOE, and AES) are associated with children's performances and developmental outcomes in two inverse directions, which shows that the bright side and dark side exist in HSC at the same time.

On the one hand, EOE and LST seem to be the dark side of SPS. In adolescents, they were both found to be connected with negative emotionality, anxiety, and depression in a moderate effect size, and LST has been found to be associated with self-reported sensory discomfort [16]. The combination of EOE/LST, which was named negative affect in Evans and Rothbart's study, was reported to have a substantial positive correlation with negative affect, and the relevance with the sensory discomfort was particularly strong. It is also worth noting that there is a fairly minor negative correlation between SPS and positive affection [18].

On the other hand, AES performs to be the bright side. It has been found to be connected with positive emotionalities, including positive affect and self-esteem, and has nothing to do with negative emotions in children [10]. Moreover, it was reported to have a low to modest positive correlation with positive affection and affirmative motivation [18].

In conclusion, SPS seems to contain two opposite dimensions, which display different correlational patterns with negative or positive performances and outcomes.

3.4 The Moderating Role of SPS in Children Development

3.4.1 SPS acting as a vulnerability factor

An early study discovered an interaction between SPS and a destructive childhood environment, showing that high SPS adults who reported unhappy childhoods scored higher on negative emotionality and social introversion, whereas high SPS adults who reported happy childhoods did not significantly differ from the non-highly sensitive adults on these performances [2]. Additionally, a similar relationship was found between SPS and parental care in childhood when predicting adult depressive symptoms [19]. More specifically, when parental care was poor, people with high SPS reported the highest levels of depression, whereas depression scores did not correlate with SPS when parental care was excellent [20]. When childhood experiences were extremely unfavorable, people with high SPS scores reported reduced life satisfaction in adulthood; however, no evidence was found to support a differential effect of positive experiences [20]. These findings imply that SPS reflects children's vulnerability to the adverse impact in environments of growth, which seems to hamper children's development and is likely to predict unfavorable consequences in adulthood. Note that all these findings provided evidence for Diathesis-Stress model.

3.4.2 SPS acting as a susceptibility factor

A paper involving three investigations by Aron et al. reported an interaction between SPS and supportive experiences in childhood, which showed the positive potential of high SPS for the first time [21]. According to their research, individuals with high SPS but not non-sensitive group performed particularly poorly on negative affect measures in adulthood if they reported having troubled childhood, and they also scored especially low if they didn't experience such childhood. Since then, a wealth of research has demonstrated that SPS is capable of predicting behavioral and mental developmental trajectories for children with different levels of SPS when facing both destructive and supportive environments, rather than limited in amplifying the negative consequence brought by poor experiences in their early age, which follows the differential susceptibility model.

According to an important longitudinal research examining SPS in kindergartners, SPS interacted with changes in both positive and negative parenting styles, which predicts changes in externalizing difficulties, including conduct problems and attention problems. [22]. As for externalizing problems, a similar result has also been reported by Lionetti et al. [17]. Besides, their study also examined the developmental outcomes of children's internalizing problems and social competence, and they found that children who scored high in behaviorally observed SPS were more susceptible to parenting behavior in both positive and negative ways, predicting more serious internalizing difficulties and greater social competence when parenting got worse as well as slighter internalizing issues and poorer socioemotional functioning when parenting became better for children aged at three and six.

More recently, a wider range of developmental outcomes of children have been investigated further. Scrimin et al. found a negative correlation between family adversity and children's health (emotional and physical comfort) together with academic performance and a positive association between family support and children's well-being, but children's SPS moderated these relationships, magnifying the negative impacts of stressful environments on physical and social performances and heightening the positive impacts of a supportive environment on children's social functioning [23].

A novel study first investigated individual differences in SPS at the physiological level in 101 youth adolescents who engaged in a standardized social stress task (Trier Social Stress Task-Modified version for children and adolescents (TSST-M)) [24]. Eight cortisol samples and a series of Autonomic Nervous System activity indications (e.g., heart rate, heart rate variability, skin conductance, cortisol) were collected during the experiment. Self-reported SPS and perceived stress were also measured before, during, and after TSST-M. The Results showed that more sensitive individuals reported perceiving more negative affect and less positive affect from perceived stress. More importantly, participants scoring high on SPS displayed higher recovery rates of heart rate and stronger cortisol responses in high-quality environments, which seems to offer preliminary evidence for Biological Sensitivity to Context theory.

Overall, studies suggest that SPS moderates' children's reactivity and developmental consequences to what they have gone through both in a negative and positive environment. Specifically, high sensitivity increases environmental influences, while low sensitivity seems to play a role as a buffer for both positive and negative experiences.

3.5 Interventions for Highly Sensitive Child

The potential positive side of SPS has been found in the following three intervention studies, in line with Vantage Sensitivity model. The earliest research conducted a school-based depression prevention program in highly sensitive adolescent girls from an at-risk population together with a control group consisting of girls scoring low in SPS [25]. The research found that girls high in SPS experienced a significant reduction in depression scores, but girls low in SPS showed no salient change. Another large randomized controlled trial [26] tested whether SPS could predict children's treatment response to an anti-bullying intervention. Results showed that the changes in victimization and internalizing symptoms were all moderated by SPS as measured by HSC. Specifically, intervention worked effectively, mainly among children scoring high in HSC. On the contrary, no significant effect was found for children with low HSC scores.

The latest intervention study [27] checked the role of SPS plays in the change of socioemotional well-being during their high school transition by using the Japanese version of the Highly Sensitive Child Scale for Adolescence (J-HSCS). The results showed that highly sensitive adolescents reported a greater increase in their well-being corresponding to their perceived environmental change after the school transition. However, this well-being enhancement did not occur in their peers with low SPS.

In conclusion, different intervention effects were found in children and adolescents with different levels of SPS. Positive psychological intervention programs are proven to be effective for children who are highly sensitive but not for low-sensitive children. According to these findings, personalized intervention and therapy methods should be applied for children of different levels of sensitivity.

4. Implications

Children with high SPS are regarded as "Orchids" who need more considerable care but are particularly brilliant when thriving. Children with low SPS have been seen as "Dandelions" because they tend to be relatively robust and can grow up anywhere. Another 40% fall in the middle group are described as "Tulips" since they are not as fragile as "Orchids" nor as strong as "Dandelions" [15]. These findings suggest the importance of considering the moderating role of SPS under Person-Environment interactions for psychologists. Specifically, for clinical psychologists, studying treatment heterogeneity and developing positive intervention programs for high SPS individuals are valuable. Also, caregivers of highly-sensitive children should pay greater attention to offering a supportive and protective environment for children's growth.

Besides, considering that more sensitive individuals have gained the majority of concerns in the field of SPS, future research should also pay attention to children in the medium- and low-sensitive groups. Although less sensitive individuals can be more resilient and robust under adversity and stress, they also pay the price of being more resistant to the beneficial impacts of positive interventions. Therefore, a better understanding and further insights into low SPS individuals may be helpful when explaining individual examining individual variations in treatment response.

Finally, it's significant to note that the etiology and biological foundation of SPS are still in their initial phase [1]. Large-scale brain networks should be the focus of further fMRI research in humans and animals. It is important to clarify if SPS is associated with modifications in physiological responses and pinpoint the objective and biological markers of SPS, which may be determined by heart rate variability, basal, and stress-induced glucocorticoid levels. It is also anticipated to evaluate the epigenetic mechanisms underpinning the interactions between SPS and environment.

5. Conclusion

SPS catches sensitivity to environment straightly as a phenotypic temperament or personality, and provides measurement and physiological understanding of individual differences in response to what they have experienced. In the field of children development research, SPS is an important model to state the interactive effects of individual factors and environmental factors on children's development. Empirical data support that SPS contains three components (LST, EOE, and AES), in which AES seems to be the bright side of SPS, while LST and EOE seem to be the dark side. As children grow up, SPS plays a moderating role between childhood environment and their developmental outcomes. In some cases, it acts as a vulnerability factor, and children with high SPS are more likely to generate worse performances or consequences when facing a negative environment but differ little in response to a positive experience. Meanwhile, a wide variety of studies suggest that children with high SPS not only more easily suffer internal and external problems after going through stressful environments but also benefit more strongly from positive experiences. Sometimes, SPS can be an advantage factor, leading to greater benefits from a supportive environment. Overall, SPS measured by questionnaires or behavior observation provides multiple pieces of evidences for other sub-theories in Environmental Sensitivity framework.

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