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Sensory processing and social participation in children with autism spectrum disorder: A systematic review

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ABSTRACT

Background: Children with autism spectrum disorder experience various challenges, in which difficulties in social participation represent a significant area of concern. Research studies indicate that autistic children who experience more challenges in sensory processing tend to demonstrate lower social competence. Therefore, a comprehensive synthesis of the evidence exploring the link between sensory processing and social participation is needed to develop targeted interventions and support strategies to enhance social functioning in children with autism spectrum disorder.

Objective: This systematic review aimed to investigate the impact of sensory processing on social participation in children with ASD aged 3-18 years.

Materials and methods: The review involved a comprehensive search across electronic databases such as Scopus, PubMed, and OTseeker. The McMaster Critical Review Form for Quantitative Studies was used to evaluate the methodological quality of the included articles.

Results: A total of 4,158 records were identified through database searches and manual searches. Following the title and abstract review, 10 studies were selected for the full-text review, which led to the inclusion of 8 studies in the systematic review that met the predefined criteria. Among the 8 studies, 7 studies reported a significant correlation between sensory processing and social participation in children with ASD. Specifically, sensory over-responsivity, under-responsivity, and seeking behaviors were found to influence the child's ability to comprehend, interpret, and respond to social cues effectively, thereby increasing the social challenges commonly associated with ASD.

Conclusion: This systematic review underscores the evident impact of sensory processing difficulties on social participation among children with ASD. It highlights the critical role of sensory processing in facilitating successful social functioning across diverse contexts and emphasizes its importance in enhancing overall social well-being in children with ASD.

Introduction

Autism Spectrum Disorder (ASD) is a lifelong neurodevelopmental condition that significantly impacts an individual's ability to participate in social activities across various contexts.[1] Children with ASD often face a combination of social communication difficulties, behavioral challenges, and sensory processing (SP) differences that can affect their ability to engage meaningfully in everyday activities.[1] Among the numerous challenges experienced by autistic children, difficulties in social participation represent a significant area of concern. Research studies have found that communication deficits

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and behavioral problems can interfere significantly with social participation in children with ASD.[2-4] Difficulties in verbal and non-verbal communication, such as limited expressive and receptive language skills and problems in understanding social cues, impact the child's ability to engage in social interactions.[2,3] Moreover, behavioral challenges such as repetitive behaviors, restricted interests, and difficulties regulating emotions can further limit a child's participation in various social contexts, including school and community activities.[4] The presence of co-occurring conditions, such as anxiety and depression, can also impact social engagement in children with ASD.[5] While social communication and behavioral challenges are hallmark features of ASD, recent research has increasingly highlighted the importance of sensory processing in shaping the experiences and social participation of children with ASD.[6,7]

Sensory processing refers to the brain's ability to receive, interpret, and respond to sensory information from the environment, facilitating adaptive responses.[8] SP difficulties are highly prevalent in children with ASD, with studies indicating that up to 95% of children diagnosed with ASD experience challenges in this area.[9] SP difficulties can manifest as sensory over-responsivity (SOR), sensory under-responsivity (SUR), and sensory seeking (SS).[10] Children with SOR may exhibit increased responses to sensory inputs, such as sound or touch, while those with SUR may show limited or no response to stimuli that would typically elicit a reaction. On the other hand, children with SS may actively seek out sensory experiences, often in unusual ways.[10] These sensory processing differences can profoundly impact how individuals with ASD engage with their environment, potentially influencing various aspects of their daily functioning.[7,11]

Effective social participation—the ability to engage in social activities and interactions within various environments such as home, school, and community—is crucial for children's emotional, cognitive, and adaptive development. It also plays a vital role in forming meaningful relationships, learning, and overall well-being.[1,12,13] Children with ASD often experience difficulties in navigating social interactions, understanding social cues, and establishing and maintaining relationships.[14] Effective social participation requires individuals to interpret social cues, engage in reciprocal communication, and regulate emotions, which can be challenging when SP challenges are present.[8] For instance, a child hypersensitive to noise may avoid social settings like classrooms or playgrounds. In contrast, another who craves sensory input might engage in behaviors that others find disruptive or inappropriate, further hindering social interaction. Moreover, children with sensory processing differences are linked to challenges in social play and interactions across different developmental stages. In early childhood, sensory processing differences, such as difficulties in processing visual, tactile, proprioceptive, and vestibular information, are associated with challenges in social play activities, including sharing and playing cooperatively.[15] As children progress to middle childhood, those with SI differences are likelier to engage in solitary play and may not shift to organized games with rules as their typically developing peers do.[16] Additionally, children with SI difficulties tend to have more limited social networks and spend less time with friends compared to peers without these difficulties.[17]

Research suggests that children with ASD who experience more significant sensory processing difficulties often demonstrate lower social competence and face more significant barriers to social engagement.[18,19] Therefore, a comprehensive review of the available evidence on how SP influences social participation in individuals with autism is needed. This review will enhance the understanding of the complex relationship between SP and social participation in children with ASD, which helps in developing tailored interventions and support strategies that effectively address the unique needs of individuals with ASD. The aim of this review is to investigate the impact of SP on social participation in children with ASD aged 3-18 years. The age range of 3 to 18 years was selected for this study to include the critical developmental stages where sensory processing and social participation are most relevant and observable. The starting age of 3 was chosen because it is typically when a diagnosis of ASD is first made, allowing for early identification and intervention, which is crucial for improving developmental outcomes. At this age, children also begin engaging in structured social environments, such as preschools, where social participation can be effectively observed. Including children up to age 18 enables a comprehensive analysis of how sensory processing challenges affect social participation across early childhood to adolescence, supporting the development of targeted interventions.

Materials and methods

This systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) reporting guidelines. This systematic review was prospectively registered with PROSPERO under the identification number CRD42023457686. A comprehensive search for relevant studies was conducted across databases, including Scopus, PubMed, and OTseeker. A manual search of printed journals such as the American Journal of Occupational Therapy, the British Journal of Occupational Therapy, the Canadian Journal of Occupational Therapy, and the Australian Journal of Occupational Therapy was undertaken to ensure comprehensive inclusion of the literature.

Search strategy

The following keywords were used during the database searches:

- **Population-Related Terms:** "autism spectrum disorder", "autism", "Asperger syndrome", "pervasive developmental disorder".
- **Social-Related Terms:** "social", "community", "social skills", "social participation", "community participation", "social engagement", "social functioning", "social experience", "social behavior".
- **Sensory processing-Related Terms:** "sensory

processing", "sensory integration", "sensory processing disorder", "sensory integration disorder", "sensory reactivity", "sensory over-responsivity", "sensory under-responsivity", "sensory seeking", "sensory avoiding", "sensory sensitivity", "low registration".

Inclusion and exclusion criteria

The studies included in this review were required to meet specific inclusion criteria: (1) the studies must involve children aged 3 to 18 years diagnosed with Autism Spectrum Disorder (ASD) as the primary population, (2) the studies focused on the relationship between sensory processing/integration and social participation, (3) studies that were published between January 2013 and July 2023, (4) peer-reviewed studies, (5) the full text of the studies had to be available, and (6) studies published in English. Studies were excluded if they presented level 4 evidence (case reports and case series) or level 5 evidence (expert opinions).

Quality assessment

The methodological quality of the included studies was assessed using the McMaster Critical Review Form for Quantitative Studies.[20] This form comprises 16 items that evaluate various aspects of the study's methodology, including its objective, literature review, methodology, results, and conclusion. Each item is assigned a score of "one" if it meets specific criteria and "zero" if it does not. The total score, ranging from 0 to 16, determines the methodological quality classification of the study. Scores between 0-8 are considered poor, 9-10 are deemed fair, 11-12 are considered good, 13-14 are considered very good, and 15-16 are considered excellent.[21] This critical appraisal tool demonstrates good inter-rater reliability, ensuring consistent and reliable assessments.[21]

Data extraction

Eight studies matched the inclusion criteria and were included in the systematic review. Information regarding the author(s), publication year, aims and objectives, study design, sample characteristics, assessments utilized to measure sensory processing and social participation, and findings was extracted from each of the included studies and organized into a tabulated format.

Study selection process

The study selection process was designed to be thorough and minimize bias. First, two authors independently reviewed the titles and abstracts of the studies to determine if they met the inclusion criteria. Studies that appeared eligible were then subjected to a full-text review. At this stage, studies were excluded if they did not focus on the target population, did not address the relationship between sensory processing and social participation, or did not meet other inclusion criteria. If there were disagreements about whether to include or exclude a study, independent reviewers re-evaluated the study to ensure an accurate decision. Following the full-text review, the risk of bias in each included study was assessed using the McMaster Critical Review Form for Quantitative Studies. If there were differences in the risk of bias scores between the two authors, all authors discussed and reached a consensus. Studies with a high risk of bias were carefully reviewed again, and their inclusion was reconsidered. This collaborative approach helped maintain the accuracy and reliability of the review process.

Results

A comprehensive search of the literature in electronic databases resulted in the identification of 4,158 articles. After removing 142 duplicates, 4,016 records were retained for title and abstract review. Among these, 4,006 articles were excluded for reasons such as not including children with ASD aged 3-18 years, not focusing on the relationship between sensory processing and social functioning in children with ASD, and being review articles. Consequently, 10 full-text articles were evaluated for eligibility, with 8 studies fulfilling the inclusion criteria. Two studies were excluded after the full-text review: one study did not have a separate statistical analysis to evaluate the relationship between sensory processing and social functioning, as typically developing children and children with ASD were combined in the statistical analysis. Another study included children with ASD aged 3-18 years but also covered a more comprehensive age range of up to 54 years, with no separate analysis within the age group of 3-18 years. The PRISMA diagram visually represents the review process (Figure 1).

All eight studies were critically appraised using the McMaster Critical Review Form for Quantitative Studies. Four studies yielded a score of 13, two scored 12, while the remaining two scored 11, denoting "very good" and "good" methodological quality, respectively. The critical appraisal is summarized in Table 1.

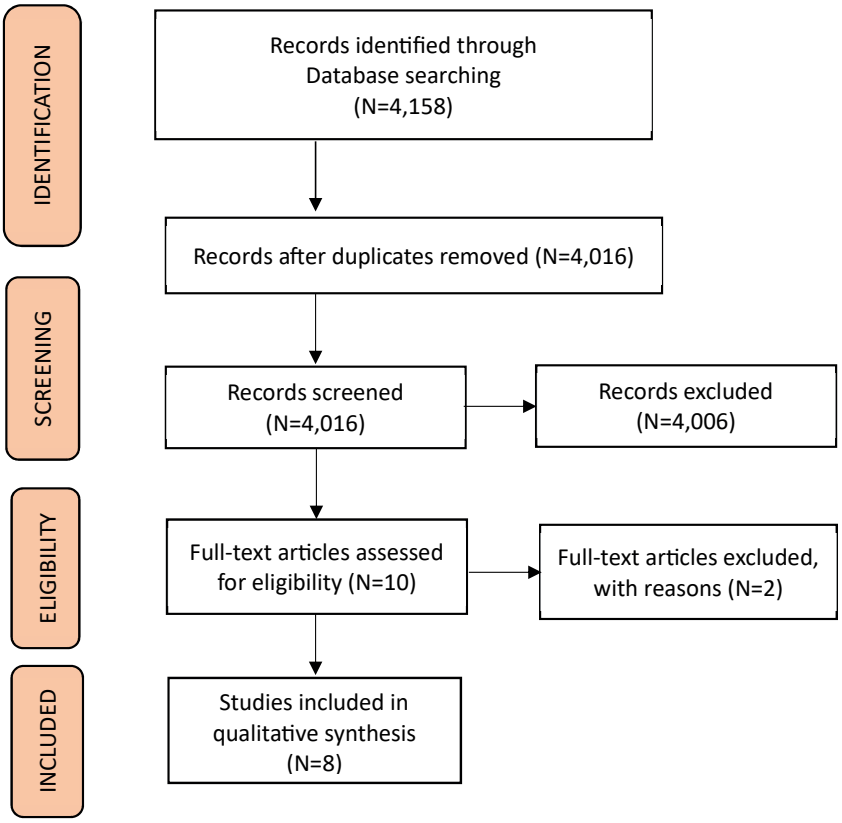

***Figure 1**. PRISMA flow diagram.*

Table 1. Critical appraisal of included studies- McMaster Critical Review Form for Quantitative Studies.

No.	Items	Zhai et al[22]	Kilroy et al.[25]	Pickard et al.[26]	Kojovic et al.[27]	Dakopolos & Jahromi[29]	Linke et al.[23]	Miguel et al.[30]	Matsushima & Kato[24]
1	Purpose	1	1	1	1	1	1	1	1
2	Review of Literature	1	1	1	1	1	1	1	1
3	Study design	1	1	1	1	1	1	1	1
4	Biases	0	0	0	0	0	0	0	0
5	Sample	1	1	1	1	1	1	1	1
6	Sample size justification	0	0	0	0	0	0	0	0
7	Informed consent	1	1	1	1	1	1	1	1
8	Validity of outcome measures	1	1	0	0	0	1	1	1
9	Reliability of outcome measures	1	1	0	0	1	1	1	1
10	Intervention	NA	NA	NA	NA	NA	NA	NA	NA
11	Statistical reporting of results	1	1	1	1	1	1	1	1
12	Statistical analysis	1	1	1	1	1	1	1	1
13	Clinical importance	1	1	1	1	1	1	1	1
14	Conclusions	1	1	1	1	1	1	1	1
15	Clinical implications	1	1	1	1	1	1	1	1
16	Study limitations	0	1	1	1	1	1	1	1
Total Score		**12**	**13**	**11**	**11**	**12**	**13**	**13**	**13**

Measurement of Social Participation

In 3 studies, social participation was measured using the Social Responsiveness Scale,[22-24] whereas 3 studies used the 2nd Edition of the Social Responsiveness Scale.[25-27] The Social Responsiveness Scale is the most reliable measure for social behavior related to ASD based on the Diagnostic and Statistical Manual of Mental Disorders. It is a 65-item rating scale completed by the child's teacher or parents. The assessment tool demonstrates strong internal consistency, test-retest reliability, well-established content validity, and concurrent, construct and predictive validity.[28] In 1 study, social function is measured through social items embedded within the Child Behavior Scale.[29] Pickard *et al*. investigated the role of social anxiety in sensory processing using Liebowitz Social Anxiety Scale.[26] The Social function domain of Autism Diagnostic Interview-Revised, the Social interaction domain of Autism Diagnostic Schedule, the Social Communication Questionnaire- Lifetime, and the Socialization domain of Vineland Adaptive Behavior Scale- 2nd Edition are the other self-report or parent questionnaires used to measure social function in the included studies of the systematic review.

Two studies employed objective measures: Kojovic *et al*.) used an eye-tracking paradigm in which children passively observe three social scenes, each re-enacting everyday situations, allowing for the quantification of visual exploration dynamics and estimation of gaze patterns during naturalistic social interactions.[27] Meanwhile, Dakopolos & Jahromi used an Adapted Early Social Communication Scale in which the experimenter and the child interact using various toys. These interactions are then video recorded and coded to evaluate joint attention.[29]

Measurement of sensory processing

In two studies, sensory processing was measured with the Short Sensory Profile,[22,27] and three studies used the long form of the family of sensory profile assessments such as original Sensory Profile, Child Sensory Profile-2, and Adolescent/Adult Sensory Profile.[26,23,30] The Sensory Profile family of assessments is the most reliable and valid caregiver's questionnaire used to gather information on how an individual responds to various sensory stimuli within different contexts.[31,32] In one study, the Sensory Experience Questionnaire was used to evaluate sensory processing. The Sensory Experience Questionnaire is a caregiver questionnaire that helps to outline the sensory processing difficulties in children with ASD, both in social and non-social contexts.[33] Another study conducted in Japan utilized the Japanese Sensory Inventory-Revised.[24] Finally, only one study investigated the influence of praxis on social participation using the Florida Apraxia Battery (modified for children) and Postural Praxis domain from the Sensory Integration and Praxis Test.[25]

Relation between social participation and sensory processing in children with autism spectrum disorder

Literature suggests a definite relationship between social participation difficulties and atypical SP in children with ASD. Seven studies revealed a statistically significant association between social participation and SP. The eight studies are summarized in Table 2.

Zhai *et al*. suggest a strong association between SP and social dimensions, indicating that children with SP challenges may struggle to engage socially. Additionally, the study found that sensory processing predicts social functioning in individuals with ASD.[22] According to Kilroy *et al.* there is no relationship between praxis and social function.[25] Kojovic *et al*. highlighted the significant influence of SP difficulties on the overall processing of social information in children with autism.[27] This indicates that abnormalities in SP might significantly interfere with the child's capabilities to understand, interpret, and respond to social cues effectively, thereby increasing the social challenges commonly associated with ASD. The impact of SP on social participation in children with ASD is discussed further through two different lenses: sensory threshold and sensory system.

Table 2. Synthesis of studies examining sensory processing and social participation in children with Autism Spectrum Disorder (ASD).

Studies	Aim	Study Design and Sample Characteristics	Assessments used	Findings
Zhai *et al.*[22]	To investigate the relationship between SP and social functioning in children diagnosed with ASD.	**Study design:** Cross-sectional design **Sample:** • The study included 266 children diagnosed with ASD and 223 healthy children. • The average age of children with autism was 5.31 ± 0.102 years, while the control group had an average age of 5.32 ± 0.115 years. • A psychiatrist and clinical psychologist confirmed the diagnosis using the DSM-5 criteria.	**Sensory Processing:** • Short Sensory Profile (SSP) **Social Participation:** • Social Responsiveness Scale • Social function domain of Autism Diagnostic Interview-Revised • Social interaction domain of Autism Diagnostic Schedule	• Spearman correlation analysis revealed inverse associations between the scores of gustatory/olfactory and motor sensitivities from SSP and the social function scores derived from the Autism Diagnostic Interview-Revised. • Additionally, a negative correlation was found between the auditory filtering score and the social interaction score obtained from the Autism Diagnostic Schedule. • The total score of the Social Responsiveness Scale correlated with the tactile, gustation/olfaction, hypo-sensitivity/sensory seeking, auditory filtering, low Strength, and vision/auditory domains of SSP, as well as the total score of SSP. • Also, the study found that sensory characteristics have the potential to act as good predictors of social functioning among children with ASD.
Kilroy *et al*.[25]	To investigate the relationship between social, praxis, and motor skills of children with ASD, Developmental Coordination Disorder, and typically developing individuals.	**Study design:** Cross-sectional design **Sample:** • The study included a total of 96 children aged between 8 and 17 years, comprising 35 typically developing children, 33 children diagnosed with ASD, and 28 children diagnosed with Developmental Coordination Disorder.	**Sensory Processing:** • Florida Apraxia Battery, modified for children. • Postural Praxis domain from the Sensory Integration and Praxis Test **Social Participation** • Social Responsiveness Scale-2	• The study concluded that there were no significant correlations between the Social Responsiveness Scale-2 and praxis measures (Florida Apraxia Battery and Postural Praxis domain from the Sensory Integration and Praxis Test).

Table 2. Synthesis of studies examining sensory processing and social participation in children with Autism Spectrum Disorder (ASD). *(continued)*

Studies	Aim	Study Design and Sample Characteristics	Assessments used	Findings
Pickard *et al*.[26]	To investigate the association between cognitive, emotional, SP, and social anxiety in individuals with autism and neurotypical children.	**Study design:** Cross-sectional design **Sample:** • A total of 61 autistic individuals and 62 neurotypical individuals aged between 11 and 18 years were recruited for the study. • In the autistic group, 46 (75%) received a diagnosis of autism and 15 (25%) received a diagnosis of Asperger's Syndrome.	**Sensory Processing** • Adolescent/Adult Sensory Profile • Porges Body Perception Questionnaire (measures interoception) **Social Participation** • Social Responsiveness Scale- 2 • Liebowitz Social Anxiety Scale • Social Communication Questionnaire- Lifetime	• There was a significant association between the autistic traits (as measured by the Social Responsiveness Scale-2 and the Social Communication Questionnaire - Lifetime) and sensory hypersensitivity in individuals with ASD. • In the autistic group, self-reported social anxiety was significantly associated with increased sensory hypersensitivity. • In children with autism, there was a significant moderate correlation between interoception and social anxiety.
Kojovic *et al*.[27]	To explore the association between SP challenges or differences and social impairments, as well as adaptive functioning, in young children diagnosed with ASD	**Study design:** Cross-sectional design **Sample:** • The study included 64 children diagnosed with ASD, aged 3.0 to 5.9 years, and 36 typically developing children, aged 3.1 to 5.9 years. • All children with ASD were clinically diagnosed using DSM-5 criteria.	**Sensory Processing** • Short Sensory Profile **Social Participation** • Social Responsiveness Scale-2 • Socialization domain of Vineland Adaptive Behavior Scale-2nd edition. • Eye-Tracking Paradigm (objective measure of social attention extracted from the eye-tracking)	• The Short Sensory Profile was negatively correlated with the Social Responsiveness Scale-2 total score and its domain scores in autistic children. Additionally, the correlation analysis of subsections of the Short Sensory Profile-2 and the total score of the Social Responsiveness Scale-2 revealed the strongest correlation between tactile ($P < 0.0010$), under-responsiveness /sensory seeking ($p < 0.0010$), auditory filtering ($p<0.0010$), and social impairment. • A significant correlation was found between the total scores of the Short Sensory Profile and the socialization domain of the Vineland Adaptive Behavior Scale-2nd edition. Additionally, the auditory-filtering subsection of the Short Sensory Profile strongly correlated with socialization ($p < 0.0018$). • Children with ASD and sensory issues significantly impact the processing of social information more than age-matched typically developing peers.

Table 2. Synthesis of studies examining sensory processing and social participation in children with Autism Spectrum Disorder (ASD). *(continued)*

Studies	Aim	Study Design and Sample Characteristics	Assessments used	Findings
Dakopolos & Jahromi [29]	The objective of this study was to assess SP patterns, social competence, and joint attention in children diagnosed with ASD	**Study design:** Cross-sectional design **Sample:** • The study comprised 18 children diagnosed with autism and 20 typically developing children, aged between 2.6 and 6 years. • All children with ASD were clinically diagnosed by developmental pediatricians or clinical psychologists, following the DSM criteria.	**Sensory Processing** • Sensory Experience Questionnaire **Social Participation** • Child Behavior Scale • Adapted version of Early Social Communication Scale (measure joint attention)	• Partial Pearson correlation analysis revealed a significant correlation between sensory hyperresponsiveness, sensory hyporesponsiveness, and social competence in children with autism. Also, the study found that children with atypical sensory responses have problems with joint attention.
Linke *et al.*[23]	To investigate the interhemispheric and thalamocortical connectivity within the auditory network are linked to atypical sound processing and related to social cognition and communication deficits.	**Study design:** Cross-sectional design **Sample:** • The study included 40 children diagnosed with autism and 38 typically developing children, all aged between 8 and 17 years. • Autism Diagnostic Interview-Revised was used to confirm the diagnosis of autism.	**Sensory Processing** • Sensory Profile **Social Participation** • Social Responsiveness Scale	• The severity of social symptoms in children with ASD was linked to auditory abnormalities measured by the sensory profile. Furthermore, the study found that reduced interhemispheric connectivity between the left and right auditory regions was associated with more significant deficits in auditory sensory processing in children with ASD.
Miguel *et al.*[30]	To investigate whether tactile processing predicts social difficulties in children diagnosed with ASD.	**Study design:** Cross-sectional design **Sample:** • The study included 44 children diagnosed with ASD, aged between 6 and 14 years. • All children received the diagnosis from a psychiatrist and met the criteria for ASD.	**Sensory Processing** • Child Sensory profile-2 **Social Participation** • Social Communication Questionnaire	• The study found that tactile hypersensitivity and hyposensitivity were the most significant indicators of social challenges in children with ASD. While tactile seeking did not show a strong predictive relationship with social problems in children with ASD.

Table 2. Synthesis of studies examining sensory processing and social participation in children with Autism Spectrum Disorder (ASD). *(continued)*

Studies	Aim	Study Design and Sample Characteristics	Assessments used	Findings
Matushima & Kato[24]	To examine the relationship between sensory processing disorder and social interaction deficits in Japanese children with ASD aged 4 to 6 years	**Study design:** Cross-sectional design **Sample:** • The study involved 42 children diagnosed with ASD and an equal number of typically developing children, aged between 2.6 and 6 years. • All children with ASD received diagnoses from psychiatrists and confirmed based on the standard diagnostic criteria of the DSM-4.	**Sensory Processing** • Japanese Sensory Inventory- Revised **Social Participation** • Social Responsiveness Scale	• Spearman's rank correlation analysis showed a significant association between the Social Responsiveness Scale and the Japanese Sensory Inventory-Revised, along with its various domains, including vestibular, tactile, proprioception, auditory, visual, and taste.

1. Based on the sensory threshold

Pickard *et al*. (2020) reported that ASD children with sensory hypersensitivity are more prone to experience social anxiety, limiting their ability to engage in social interactions.[26] Kojovic *et al*. found that SUR and SS behaviors were strongly linked to challenges in motivation to interact with each other, which include difficulties in initiating and maintaining social interactions or feeling anxious in social contexts.[27] Dakopolos & Jahromi found that autistic children who are highly responsive to sensory input tend to face more exclusion from peers and exhibit increased hyperactivity and distractibility. Conversely, ASD children who are less sensitive to sensory stimuli show higher levels of aggression towards peers, increased anxiety, and fearfulness, as well as decreased prosocial behavior, all of which contribute to more significant difficulties in establishing and maintaining positive social relationships.[29]

2. Based on the sensory systems

Kojovic *et al*. highlighted the significant role of auditory filtering difficulties in autistic children, especially concerning social communication and motivation.[27] Also, Linke *et al*. suggested a significant connection between atypical auditory processing and social problems in children with autism.[23] Interestingly, Pickard *et al*. found a link between interoceptive sensibility and social anxiety in children with autism.[26] Miguel *et al*. reported that tactile over-responsivity and under-responsivity predict social problems in children with ASD, but not tactile-seeking behavior.[30] Matsushima & Kato found that vestibular, tactile, proprioceptive, auditory, and visual processing are strongly associated with social interaction problems in ASD children aged four to six years.[24]

Discussion

Literature suggests that SP helps children with ASD interpret social cues, regulate emotions, communicate effectively, engage with peers, navigate social settings, and facilitate initiation and maintenance of meaningful relationships.[22-27,29,30] Therefore, SP abnormalities in autistic children act as barriers to effective social participation, limiting their ability to connect with peers and navigate social environments.

Previous studies report that SP dysfunction in children with ASD includes SOR, SUR, and SS. Children under-responsive to sensory input may appear aloof or disinterested in social situations because they fail to notice or respond to social cues appropriately.[27] On the other hand, children who seek sensory input might engage in behaviors aimed at intensifying sensory experiences across various modalities. This leads to socially unacceptable behavior, including constant movement, jumping, crashing, impulsivity, restlessness, and overexpression of affection, which interfere with social interactions and relationships.[6,27] Individuals with sensory over-responsivity may avoid situations that trigger sensory discomfort, such as crowded places or noisy environments. Even when they participate, sensory distractions can hinder their engagement, making it difficult to focus on interactions or follow social cues. Moreover, constant exposure to aversive sensory stimuli can lead to increased social anxiety, resulting in withdrawal or avoidance behaviors, which further impact social participation.[26,29]

Studies have reported various specific sensory domain differences that influence social participation, such as movement, auditory filtering, tactile sensitivity, taste and smell sensitivity, visual/auditory sensitivity, and proprioceptive processing.[22-24,27] According to Linke *et al*., children diagnosed with ASD showed reduced connectivity within their brains' left and right auditory cortices. This lack of interhemispheric connections resulted in impairments in auditory sensory processing, which immediately affected their social functioning.[23] Children with ASD and auditory processing difficulties may have the inability to extract relevant sounds or filter out irrelevant sounds and process appropriate information from the environment.[22]

Emotional recognition during social interaction relies on intact audio-visual processing. Emotional recognition involves the comprehension of facial expressions and emotional rhythms. Facial expressions convey emotions like happiness or sadness, while emotional rhythms include vocal tone and pitch changes. Integrating visual and auditory cues allows for accurate interpretation of others' emotions. Therefore, impairments in audio-visual processing can hinder emotional recognition, affecting social interactions.[22] Also, children with atypical visual processing experience social challenges due to difficulties in learning social behaviors through visual cues, imitation, or feedback.[34,27]

Tactile processing holds significant importance in the social functions of children with ASD. This is underscored by previous studies suggesting that "skin as a social organ" and social touch facilitate the development and neural connectivity of brain areas associated with social cognition.[35,36] Additionally, atypical tactile processing in children with ASD is associated with altered gamma-aminobutyric acid (GABA) levels.[37] Studies also found that a lack of social touch due to atypical tactile processing may lead to an increased risk of mental health problems.[30] Moreover, disruptions in the neural mechanisms that process affective (pleasant) touch have been found in individuals with ASD. These disruptions can further exacerbate difficulties in social relationships.[30] Challenges in processing vestibular and proprioceptive information can disrupt regulating arousal levels, body posture maintenance, and movement coordination during social interactions. This can result in avoiding physical contact, displaying unusual body movements, or experiencing discomfort in crowded or unpredictable environments. The cerebellum is essential for processing vestibular and proprioceptive information, and its interaction with other brain regions is critical for social cognition and interaction. Therefore, it is evident that atypical information processing in the cerebellum leads to problems in social participation.[34] The underlying mechanism of the relationship between SP and social participation is diverse and multifaceted.[34]

Parent-reported measures rather than objective

measures dominate measures for assessing SP in children with ASD. The subjective sensory processing measures include the Sensory Profile, Sensory Profile 2, Adolescent/ Adult Sensory Profile, Short Sensory Profile, and Sensory Experience Questionnaire. While these instruments generally demonstrate acceptable reliability and validity, they must be cautious when applied in diverse contexts or with different demographic groups, as their development and standardization are primarily focused on the US population. Additionally, only one study used the Japanese Sensory Inventory-Revised,[24] highlighting the necessity for cultural adaptation and validation when assessing sensory processing across varied populations.

The primary limitations of this systematic review include the use of only three databases and a focus solely on literature published in English. These constraints may have resulted in the exclusion of relevant studies within our review's scope. The exclusion of non-English studies and studies not indexed in the selected databases might result in missing valuable data or findings. This could limit the comprehensiveness of the review by omitting findings from diverse cultural or regional contexts and reducing the generalizability of the conclusions. Furthermore, the studies included in the review vary widely in methodologies, participant characteristics (such as ASD severity, socio-economic status, etc.), outcome measures, and definitions of social participation, which poses challenges in drawing consistent conclusions.

Beyond sensory processing difficulties, several other factors may interfere with the social participation of children with ASD. These factors include communication challenges, such as verbal and non-verbal communication, and behavioral challenges, such as repetitive behaviors and emotional dysregulation.[14-16] Co-occurring conditions, including anxiety and depression, may further influence social interactions, while cognitive differences, such as impairments in executive functioning, can also affect social participation.[17] Additionally, environmental barriers, such as inadequate support from social settings, social stigma, bullying, or lack of opportunities for social engagement, can also contribute to social problems in children with ASD.[38]

This systematic review will enhance the understanding of how SP impacts social participation in children with ASD, thereby improving assessment protocols for both SP issues and social functions in children with ASD. Additionally, it will aid in the development of tailored interventions and support strategies to manage social participation difficulties in children with ASD.

Conclusion

This systematic review concludes that the difficulty in SP impacts social participation in children with ASD. Therefore, SP is a foundation for successful social function across various contexts and enhances overall social well-being. However, the nature of sensory processing challenges and the specific sensory systems affected are diverse and inconsistent. The majority of included studies were cross-sectional or retrospective; therefore, there is a need for longitudinal research to explain the temporal dynamics of SP and social participation in children with autism. Additionally, more research is needed to thoroughly examine how sensory processing relates to the social involvement, as well as to assess the influence of other factors such as socio-economic status, parent education, cognitive abilities, screen time exposure, and schooling on both typically developing children and those with ASD.

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Conflict of interest

All the authors declare no conflicts of interest

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