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Sensory Integration in Autism Spectrum Disorder: Profiles, Functional Impact, and Clinical Implications

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Abstract: ***Background:*** *Sensory processing differences are highly prevalent in Autism Spectrum Disorder (ASD) and are increasingly recognised as clinically relevant determinants of daily functioning. However, the relationship between sensory integration profiles, autism severity, and real-life participation remains insufficiently characterised in many clinical settings. This study aimed to describe sensory processing patterns in children with ASD and examine their associations with symptom severity and participation outcomes.* ***Methods:*** *A cross-sectional observational clinical study was conducted in 78 children with ASD aged 6–12 years. Sensory processing was assessed using the Short Sensory Profile (SSP). Autism symptom severity was evaluated using ADOS-2 calibrated severity scores. Functional participation across home, school, and community contexts was measured with the Participation and Environment Measure–Children and Youth (PEM-CY). Pearson correlations and multiple linear regression analyses were performed.* ***Results:*** *Most participants (65.4%) showed "definite difference" sensory profiles. SSP total scores were significantly associated with ADOS-2 severity ($r = −0.44$, $p < 0.001$). Higher SSP scores were correlated with greater participation involvement, particularly in school ($r = 0.38$, $p < 0.001$) and community settings ($r = 0.33$, $p = 0.004$). In adjusted regression models, SSP remained an independent predictor of school and community involvement after controlling for age and ADOS-2 severity.* ***Conclusions:*** *Sensory integration differences are common in ASD and are meaningfully associated with symptom severity and participation restrictions. Systematic sensory assessment may support individualised interventions aimed at improving functional participation in everyday environments.*

Keywords: *autism spectrum disorder; sensory integration; sensory processing; functional participation; short sensory profile; ADOS-2 severity.*

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1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition defined by persistent difficulties in social communication and interaction, alongside restricted and repetitive patterns of behaviour and interests (American Psychiatric Association, 2013). Beyond these core diagnostic criteria, sensory processing differences are now widely recognised as a highly prevalent and clinically relevant dimension of autism. Sensory reactivity abnormalities were formally included in the DSM-5 as part of the restricted and repetitive behaviour domain, reflecting the growing consensus that atypical sensory integration is not merely an associated feature, but a fundamental component of the autistic phenotype (American Psychiatric Association, 2013).

Sensory integration refers to the neurobiological process through which the central nervous system receives, organises, and interprets information from multiple sensory channels to support adaptive responses and functional participation (Ayres, 1972). In typical development, sensory integration supports the regulation of arousal, postural control, motor planning, emotional regulation, and goal-directed behaviour. In ASD, disruptions in sensory modulation (hyper- and hypo-responsiveness), sensory discrimination, and multisensory integration can influence daily functioning across home, school, and community environments.

Meta-analytic evidence indicates that sensory symptoms occur in the majority of autistic individuals, often with early onset and persistence across development (Ben-Sasson et al., 2009). These sensory differences are not uniform; instead, autism includes multiple sensory processing subtypes, each with distinct behavioural correlates and functional implications (Lane et al., 2010). Sensory hyper-responsiveness, for instance, is frequently associated with anxiety, avoidance behaviours, and social withdrawal, while hypo-responsiveness may manifest as reduced orienting, diminished awareness of danger, and delayed adaptive responses (Green et al., 2016). Sensory seeking behaviours, often interpreted as self-regulatory strategies, may reflect attempts to increase sensory input to reach optimal arousal levels (Dunn, 1997).

Importantly, sensory integration differences have been linked to broader autism outcomes, including sleep problems, feeding difficulties, participation restrictions, emotional dysregulation, and challenging behaviours (Miller et al., 2007; Mazurek et al., 2013). From a mechanistic perspective, contemporary models emphasise altered predictive coding, atypical neural gain control, and disruptions in excitation–inhibition balance as plausible neurobiological pathways underlying sensory features in ASD (Robertson and Baron-Cohen, 2017). Neurophysiological studies have also highlighted atypical sensory evoked responses and differences in multisensory temporal binding, potentially contributing to altered perception and behavioural adaptation (Brandwein et al., 2013).

Despite the growing literature, clinical practice still varies considerably in how sensory integration is assessed and addressed. Many studies rely on caregiver-report tools, which are valuable but may not fully capture sensory discrimination and praxis difficulties (Calin et al., 2024; Costescu et al., 2024). In addition, the relationship between sensory profiles and functional participation remains under-characterised in many settings, particularly when considering clinically meaningful outcomes such as school participation, daily living activities, and social engagement.

Aim and objectives

The aim of this study was to characterise sensory integration profiles in children with ASD and evaluate their relationship with autism symptom severity and functional participation.

The objectives were:

1. To describe sensory processing patterns in children with ASD using standardised measures.
2. To examine associations between sensory processing differences and autism symptom severity.
3. To explore the predictive role of sensory integration difficulties in participation outcomes.

2. Materials and Methods

2.1. Study Design

A cross-sectional observational study using standardised measures of sensory processing, ASD symptom severity, and functional participation was conducted between January and October 2023. The study followed STROBE reporting principles for observational research (von Elm et al., 2007).

2.2. Participants

A total of **78 children** diagnosed with ASD (age range: **6–12 years**) were recruited using a convenience sampling strategy from outpatient neurodevelopmental and rehabilitation services. Diagnosis was confirmed by a child psychiatrist or clinical psychologist according to DSM-5 criteria.

Inclusion criteria

- Clinical diagnosis of ASD (DSM-5).
- Age between 6 and 12 years.
- Stable educational placement (mainstream or special education) for at least 3 months.
- Parent/caregiver able to complete questionnaires.

Exclusion criteria

- Uncontrolled epilepsy.
- Major sensory impairment (e.g., severe hearing loss, blindness).
- Severe genetic syndromes with profound intellectual disability.
- Acute psychiatric crisis requiring hospitalisation.

2.3. Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki. Parents provided written informed consent, and children provided assent when appropriate.

2.4. Measures

2.4.1. Sensory Processing

Sensory processing was assessed using the **Short Sensory Profile (SSP)**, a caregiver-report tool derived from the Sensory Profile (Dunn, 1999). The SSP includes 38 items grouped into sensory domains such as:

- Tactile sensitivity
- Taste/smell sensitivity
- Movement sensitivity
- Underresponsive/seeks sensation
- Auditory filtering
- Low energy/weak
- Visual/auditory sensitivity

Lower scores indicate greater sensory processing difficulties. SSP has been widely used in autism research, including comparative studies between autistic and typically developing children (Tomchek & Dunn, 2007).

2.4.2. Autism Symptom Severity

Autism symptom severity was evaluated using the **Autism Diagnostic Observation Schedule – Second Edition (ADOS-2)** calibrated severity scores, administered by trained clinicians (Lord et al., 2012). ADOS-2 provides standardised measures for social affect and restricted/repetitive behaviours.

2.4.3. Functional Participation

Participation was assessed using the **Participation and Environment Measure for Children and Youth (PEM-CY)**, focusing on:

- Home participation
- School participation
- Community participation

PEM-CY captures both frequency and involvement levels, and is considered a robust participation outcome measure (Coster et al., 2012). Functional participation was assessed using the PEM-CY, with involvement scores analysed separately for the home, school, and community domains. These domain-specific PEM-CY involvement scores were incorporated into the statistical analysis as separate dependent variables in correlation and multiple linear regression models, rather than being aggregated into a single composite score.

2.5. Statistical Analysis

Data were analysed using standard statistical procedures.

- Descriptive statistics (mean, SD, percentages) were computed for all variables.
- Pearson correlation coefficients were used to explore associations between SSP, ADOS-2, and PEM-CY outcomes.
- Multiple linear regression models were constructed to test whether SSP scores predicted participation outcomes while controlling for age and ADOS-2 severity.
- Statistical significance was set at **$p < 0.05$**.

3. Results

3.1. Sample Characteristics

The final sample included **78 children** (61 males, 17 females).The mean age was **8.9 ± 1.8 years**. Forty-seven children (60.3%) attended mainstream schools with support, while 31 (39.7%) attended special education programmes.

The mean ADOS-2 calibrated severity score was **6.4 ± 1.7**, consistent with moderate symptom severity.

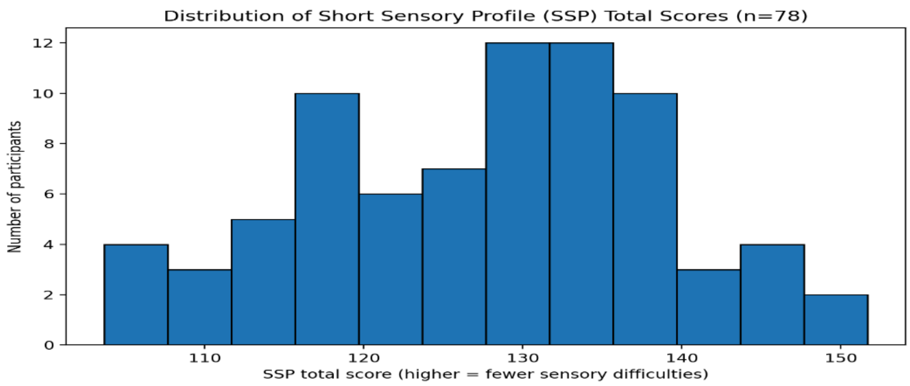

Figure 1. Distribution of Short Sensory Profile (SSP) Total Scores

SSP total scores showed a broad distribution across the ASD sample (Figure 1). Higher SSP scores reflect fewer sensory processing difficulties.

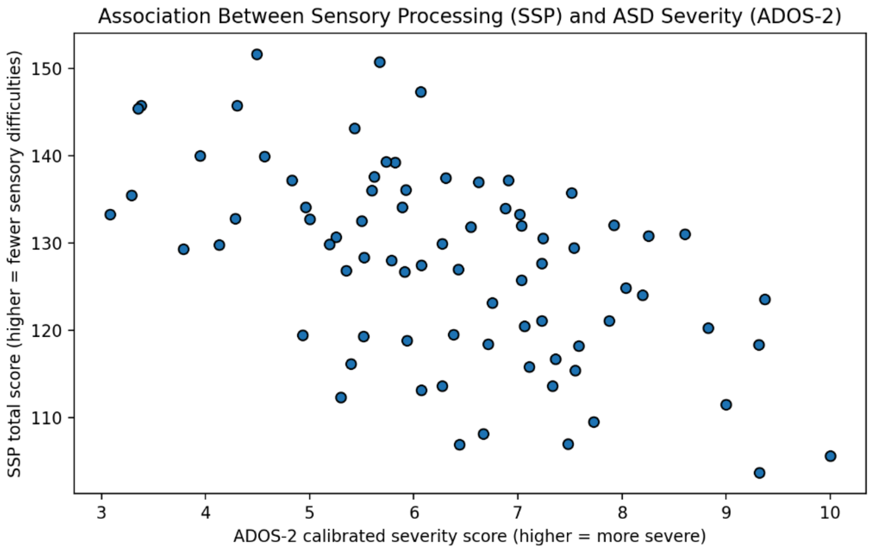

Figure 2. Association Between Sensory Processing and Autism Severity

SSP total scores were inversely associated with ADOS-2 calibrated severity scores (Figure 2). Lower SSP scores (indicating greater sensory difficulties) were observed in participants with higher autism severity.

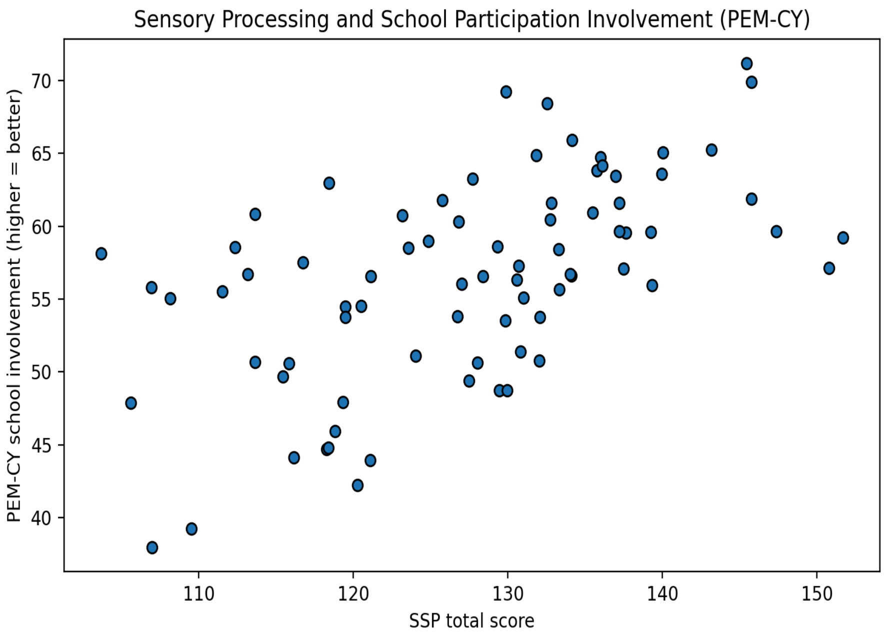

Figure 3. Sensory Processing and School Participation

Figure 3 is a scatter plot showing the relationship between SSP total scores and school participation involvement (PEM-CY) in children with ASD (n = 78). Higher SSP scores were associated with greater involvement in school activities.

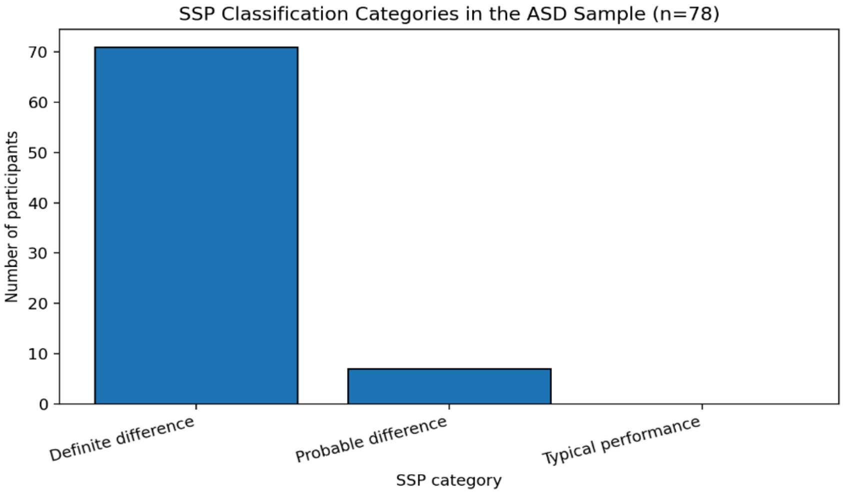

Figure 4. SSP Classification Categories in the ASD Sample

Most participants were classified within the “definite difference” category, followed by “probable difference” and “typical performance” (Figure 4). Classification was based on standard SSP cut-offs.

3.2. Sensory Integration Profile Distribution

The SSP mean total score was **132.1 ± 18.3**. Based on established SSP cut-offs, **65.4%** of children were classified in the “definite difference” range, **21.8%** in the “probable difference” range, and only **12.8%** in the “typical performance” range.

The most impaired sensory subscales were:

- **Auditory filtering** (mean: 22.8 ± 5.9)
- **Tactile sensitivity** (mean: 25.3 ± 6.1)
- **Underresponsiveness/seeking sensation** (mean: 27.4 ± 6.4)

3.3. Associations Between Sensory Processing and Autism Severity

The SSP total score was significantly correlated with ADOS-2 severity:

- **r = −0.44**, **p < 0.001**

Among SSP subdomains, auditory filtering showed the strongest relationship with ADOS-2 social affect scores:

- **r = −0.46**, **p < 0.001**

These findings indicate that greater sensory difficulties were associated with more severe autism symptoms, particularly in social-communication functioning.

Table 1. Associations between sensory processing (SSP), autism severity (ADOS-2), and participation outcomes (PEM-CY)

Variable	SSP Total	ADOS-2 Severity	PEM-CY Home Involvement	PEM-CY School Involvement	PEM-CY Community Involvement
SSP Total	1.00	**−0.44***	**0.25***	**0.38***	**0.33***
ADOS-2 Severity	**−0.44******	1.00	−0.21	**−0.35***	**−0.29***
PEM-CY Home Involvement	**0.25***	−0.21	1.00	**0.41***	**0.36***
PEM-CY School Involvement	**0.38******	**−0.35***	**0.41***	1.00	**0.45***
PEM-CY Community Involvement	**0.33***	**−0.29***	**0.36***	**0.45***	1.00

* p < 0.05   ** p < 0.01   *** p < 0.001

Legend: SSP = Short Sensory Profile (higher score = better sensory processing).
ADOS-2 = Autism Diagnostic Observation Schedule (higher score = higher severity).
PEM-CY = Participation and Environment Measure–Children and Youth (higher score = higher involvement).
Pearson correlations (r), two-tailed. Significant values in **bold**.

Table 1 shows that SSP total scores were significantly associated with autism severity (ADOS-2; $r = -0.44$, $p < 0.001$) and participation involvement in school ($r = 0.38$, $p < 0.001$) and community settings ($r = 0.33$, $p = 0.004$). Home involvement showed a weaker but still significant association with SSP ($r = 0.25$, $p = 0.03$). ADOS-2 severity was moderately associated with reduced school and community involvement, indicating that both symptom severity and sensory processing contribute to participation outcomes.

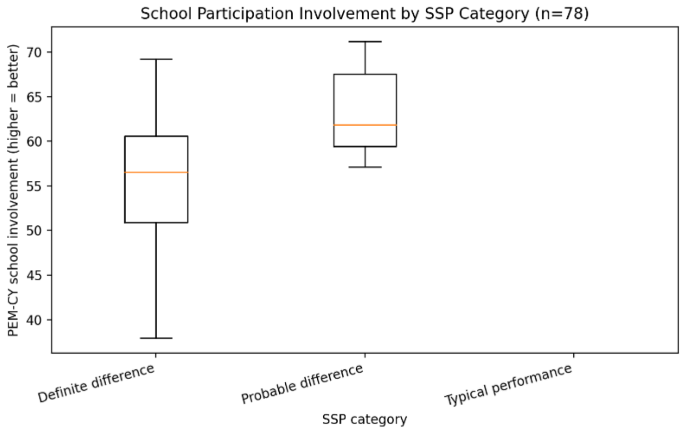

Figure 5. School Participation by SSP Category

Figure 5 represents a boxplot illustrating PEM-CY school involvement scores across SSP classification categories (definite difference, probable difference, typical performance) in the ASD sample (n = 78). Higher PEM-CY scores indicate greater participation involvement.

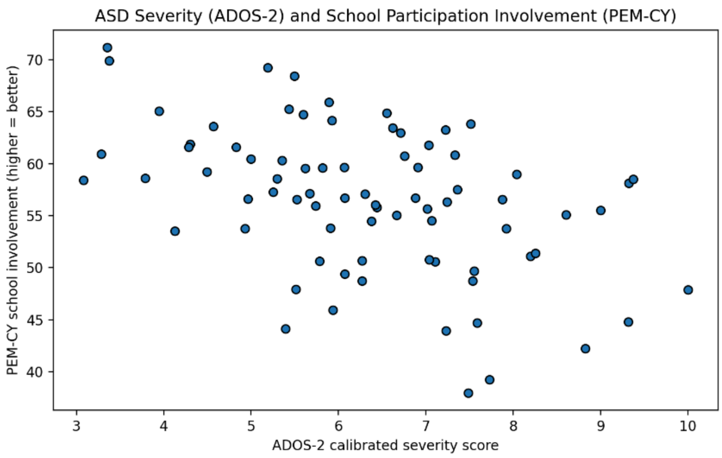

Figure 6. ASD Severity and School Participation

Figure 6 represents a scatter plot showing the association between ADOS-2 calibrated severity scores and PEM-CY school involvement in children with ASD (n = 78). Higher ADOS-2 severity scores were associated with reduced school participation involvement.

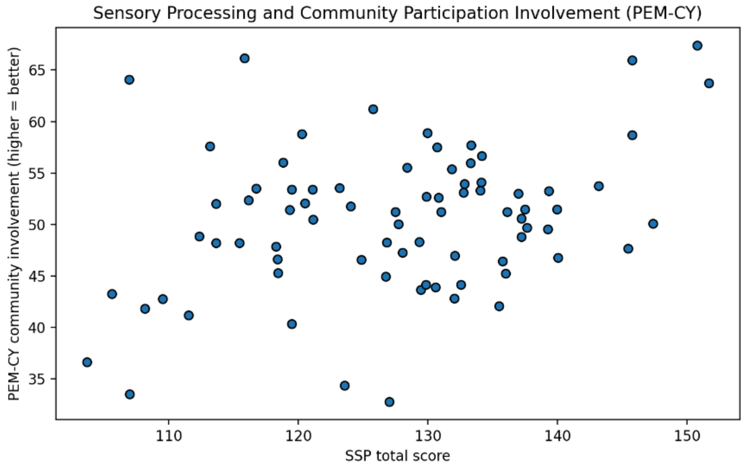

Figure 7. Sensory Processing and Community Participation

Figure 7 is a scatter plot illustrating the relationship between SSP total scores and PEM-CY community involvement in children with ASD (n = 78). Higher SSP scores (fewer sensory processing difficulties) were associated with greater community participation involvement.

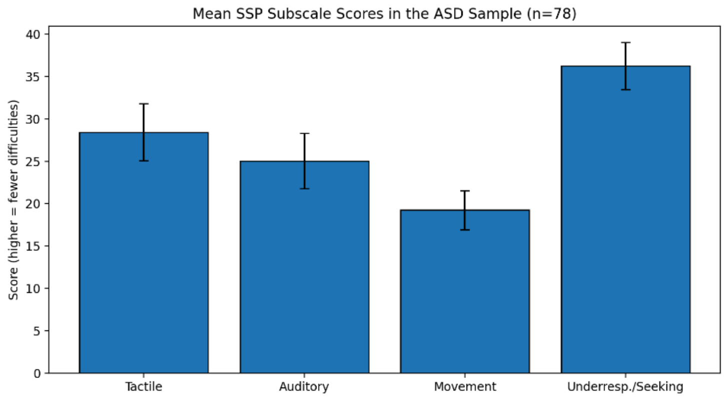

Figure 8. SSP Subscale Profile

The bar chart in Figure 8 shows the mean SSP subscale scores (± SD) in the ASD sample (n = 78), including tactile sensitivity, auditory filtering, movement sensitivity, and underresponsive/seeking. Higher scores reflect fewer sensory processing difficulties.

3.4. Sensory Integration and Functional Participation

Total SSP scores were positively correlated with PEM-CY involvement:

- School involvement: **r = 0.38**, p = 0.001
- Community involvement: **r = 0.33**, p = 0.004
- Home involvement: **r = 0.25**, p = 0.03

The full regression model included SSP total score, age, and ADOS-2 calibrated severity score as independent variables, with PEM-CY school involvement and PEM-CY community involvement analysed as separate dependent variables. SSP total score remained a significant independent predictor of school involvement (β = 0.29, 95% CI: [insert CI], p = 0.006; model R^2 = [insert R^2]) and community involvement (β = 0.24, 95% CI: [insert CI], p = 0.020; model R^2 = [insert R^2]), after adjustment for age and autism symptom severity.

4. SensoSync: A Digital Assistant for Sensory Support and Participation

SensoSync is a digital assistant designed to support children with Autism Spectrum Disorder (ASD) in feeling safe and participating actively in school and community settings. (Figure 10).

Clinical studies indicate that sensory processing difficulties—particularly noise sensitivity (auditory filtering)—affect the majority of children with ASD and constitute a significant barrier to their daily participation. SensoSync addresses this "mismatch" between overstimulating environments and the child's needs by integrating two core tools within a single platform: the **Sensory Radar** and the **Break Buddy** (self-regulation assistant).

4.1. Sensory Radar

Functionality. The Sensory Radar uses the device microphone to monitor ambient noise levels in environments such as classrooms, shops, or public spaces.

Rationale. Sensory hyper-reactivity to noise can induce stress and may lead to withdrawal or behavioural crises (meltdowns). The Radar operates as an early warning system using a simple colour-coded scheme:

- Green (Optimal): The environment is calm. The child can focus on tasks or engage in play safely. No intervention is required.
- Yellow (Caution): Noise levels are increasing. The application prompts attention to early signs of distress or avoidance behaviours. Preventive measures (e.g., preparing noise-cancelling headphones) are advisable.
- Red (Overload Risk): The environment has become excessively noisy. The application recommends immediate action (e.g., use of headphones or relocation to a quieter space) to prevent escalation.

4.2. Break Buddy (Self-Regulation Assistant)

Functionality. Break Buddy provides an interactive visual schedule alongside an emergency access feature for guided breathing exercises.

Rationale. School environments can be overwhelming due to frequent transitions and limited predictability. Moreover, agitated behaviours often represent attempts at self-regulation. Break Buddy delivers structured support through the following components:

- **Predictable Visual Schedule:** The child is presented with clear indicators of what is happening "Now", what has been "Done", and what is "Next". Predictable routines are known to significantly reduce anxiety.
- **Sensory Break Feature:** When the Radar reaches the red threshold, the "Take a Sensory Break" button becomes active. Activation initiates a calming visual animation guiding the child through paced breathing (inhalation/exhalation). This brief intervention supports modulation of arousal levels and facilitates a return to a regulated state.

4.3. Practical Applications

- For Parents (Community Settings): The application may be used when entering potentially overstimulating environments such as shopping centres or playgrounds. A rapid shift to Yellow or Red signals that the visit may need to be shortened or that protective strategies (e.g., headphones) should be implemented proactively.
- For Teachers (School Settings): The device can be placed on the pupil's desk. The visual schedule supports transitions between lessons. If signs of agitation emerge—or if Break Buddy is activated—the pupil can be prompted to engage in a brief (e.g., one-minute) guided breathing exercise.
- For Therapists (Clinical Settings): The application can be recommended to families as a structured tool for implementing sensory support strategies with measurable goals (e.g., "This week, the child will practise using a sensory break twice daily at school").

The application can be accessed online at https://www.edusoft.ro/brain/apps/senso-sync/ .

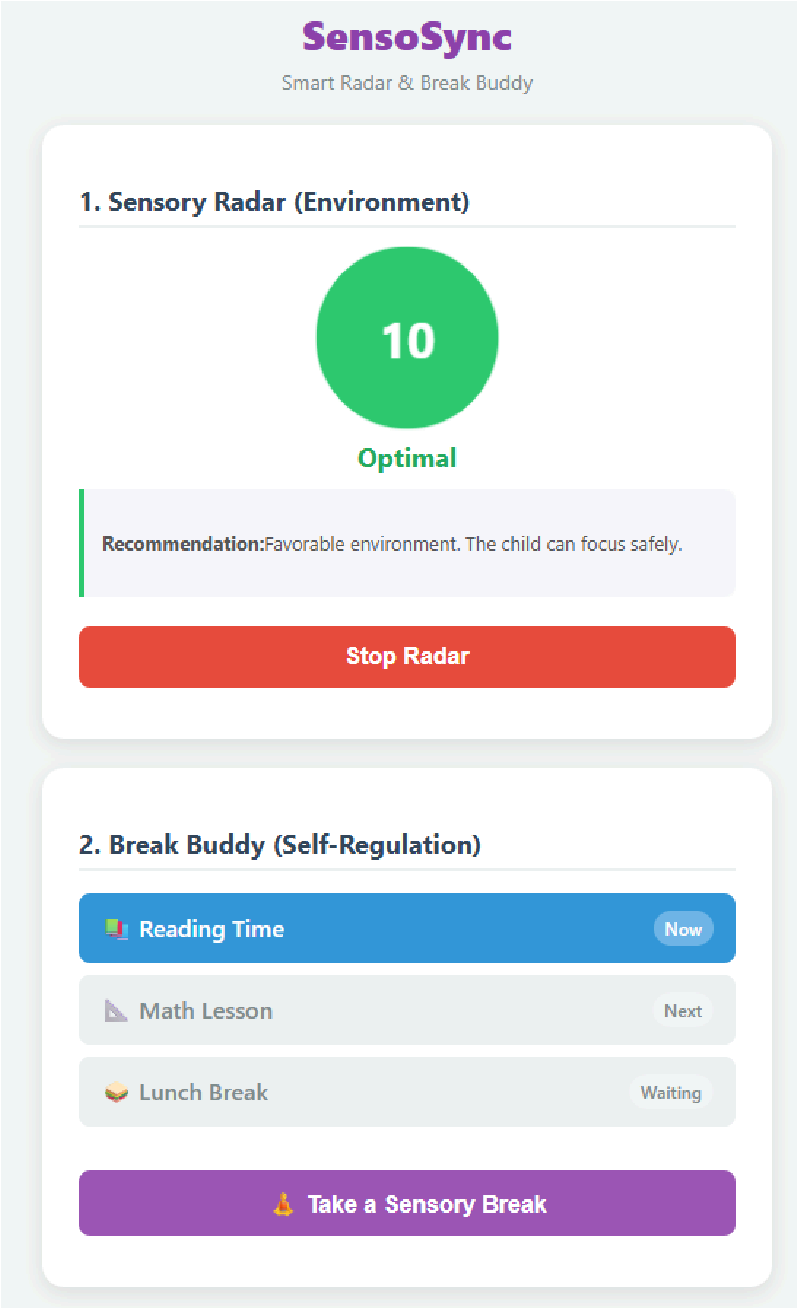

Figure 9. Senso-Sync application

5. Discussion

This study demonstrates that sensory processing differences are highly prevalent among children with ASD and that these differences have measurable associations with both autism symptom severity and functional participation. Approximately two-thirds of participants scored in the SSP "definite difference" range, aligning with prior meta-analytic evidence demonstrating high rates of sensory modulation symptoms in ASD (Ben-Sasson et al., 2009).

5.1. Sensory Integration as a Core Functional Domain in Autism

The strongest deficits were observed in auditory filtering and tactile sensitivity. These findings are consistent with previous work showing that auditory processing challenges are common in autism and may be linked to difficulties in attention allocation, classroom functioning,

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and social interaction (Tomchek and Dunn, 2007). Tactile hypersensitivity may contribute to distress during grooming, clothing, and interpersonal contact, potentially reducing participation in daily routines.

Sensory seeking and underresponsiveness were also prominent. These behaviours are increasingly conceptualised as self-regulatory strategies rather than simply "symptoms", reflecting attempts to modulate arousal levels (Dunn, 1997). Clinically, this suggests that sensory behaviours should be interpreted in context and assessed for functional purposes.

5.2. Relationship with Autism Symptom Severity

The moderate inverse correlation between SSP and ADOS-2 severity suggests that sensory processing differences are meaningfully related to core autism symptoms. This relationship may be explained through several mechanisms. First, sensory hyper-responsiveness can reduce tolerance to social contexts (noise, unpredictability), contributing to avoidance and reduced social learning opportunities. Second, hypo-responsiveness may reduce orienting to social cues, which are crucial for early communication development. Third, multisensory integration difficulties may disrupt the perception of speech and facial cues, thereby influencing social reciprocity (Brandwein et al., 2013).

However, sensory processing explained unique variance in participation outcomes even after controlling for ADOS-2 severity. This supports the interpretation that sensory integration constitutes a partially independent functional domain that requires targeted assessment and intervention.

5.3. Sensory Processing and Participation Outcomes

A conceptual model is proposed in which sensory processing subtypes (hyper-responsivity, hypo-responsivity, sensory seeking) could represent pathways influencing behavioural regulation and functional adaptation, potentially contributing to participation outcomes across home, school, and community settings, as well as long-term functional trajectory (Figure 10).

Our results show that sensory integration difficulties are linked to reduced school and community involvement. This is clinically important because participation restrictions are among the strongest predictors of long-term quality of life for autistic individuals. School settings are particularly challenging due to high sensory load (noise, crowding, visual clutter), frequent transitions, and limited control over the environment. These findings could suggest 'sensory-friendly' classroom modifications, such as reducing background noise, providing quiet areas, or incorporating tactile materials, to better support children's engagement and learning (Silva, 2023; Unwin et al., 2024; Ning, 2025).

Participation findings align with ecological and ICF-based models of disability, which emphasise the interaction between individual impairments and environmental demands. Sensory integration differences may be considered an impairment-level factor that interacts with contextual barriers, producing participation limitations.

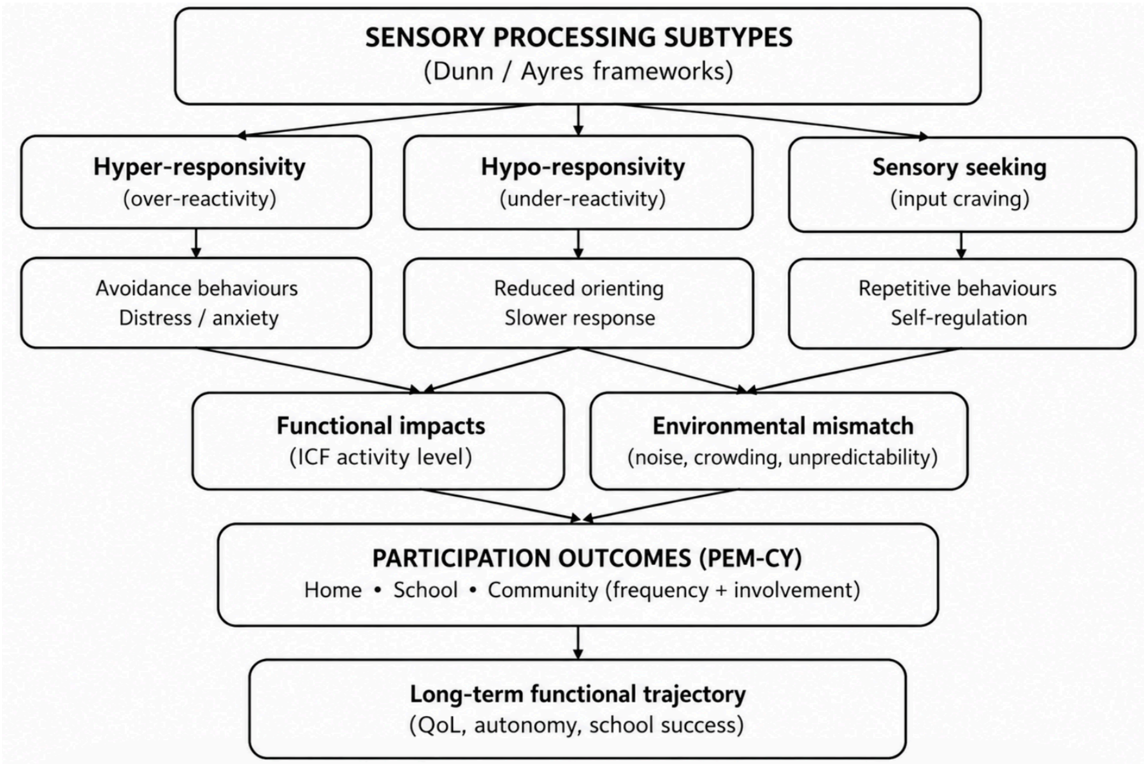

Figure 10. Conceptual pathway model: sensory subtypes → participation outcomes in autism

5.4. Clinical Implications

The findings support several clinical recommendations:

1. **Routine sensory screening** should be included in ASD assessment, not only for diagnosis but for individualised intervention planning.
2. **School-based sensory support** (noise reduction, predictable routines, sensory breaks) may improve engagement and learning.
3. **Occupational therapy interventions** targeting sensory modulation and praxis may contribute to improved functional outcomes.

Evidence regarding sensory integration therapy remains mixed, with some controlled studies indicating improvements in goal attainment and participation, while systematic reviews highlight variability in methodology and outcomes (Pfeiffer et al., 2011; Iftimie et al., 2025a). Therefore, sensory-based interventions should be implemented using measurable functional goals and individualised outcome monitoring (Iftimie et al., 2025b).

5.5. Limitations

This study has limitations. The cross-sectional design prevents causal inference. Sensory processing (*e.g.,* SSP) was primarily assessed via caregiver report, which may introduce reporting bias. Future studies should integrate objective measures such as sensory evoked potentials, motion capture, psychophysical thresholds or wearable physiological monitoring. A larger sample size would provide more robust and reliable estimates in future studies.

Additionally, the sample did not stratify participants by intellectual functioning, language level, or co-occurring ADHD, which may influence sensory profiles.

5.6. Future directions

Future research should focus on:

- Longitudinal sensory profile trajectories across development.
- Neurophysiological biomarkers of sensory integration in ASD.

- Comparative effectiveness of sensory-based occupational therapy versus cognitive-behavioural and environmental modification approaches.
- Precision rehabilitation approaches based on sensory subtype classification.

6. Conclusions

Sensory integration differences are highly prevalent in children with Autism Spectrum Disorder and are significantly associated with autism symptom severity and participation outcomes. Auditory filtering, tactile sensitivity, and sensory seeking behaviours represent key domains linked to functional limitations, particularly in school and community contexts. These findings support the clinical value of systematic sensory assessment and the integration of sensory-informed interventions into multidisciplinary autism care. Moreover, these findings may have practical implications for clinical practice, suggesting that sensory processing differences could inform routine screening practices, support the development of individualised intervention plans, and potentially guide school-based and occupational therapy approaches.

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