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Types and Frequency of Dysfunction of Sensory Integration in Children with Autism Spectrum Disorder

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To determine the frequency and the types of dysfunctions in sensory integration in children with Autism Spectrum Disorder (ASD).
Study Design: Quantitative study.
Place and Duration of Study: Centre for rehabilitation of pathology of verbal communication – Skopje, between January and December 2022.
Methodology: We surveyed 40 patients (32 boys, 8 girls; age range 3 – 7 years) with ASD. The research method used was qualitative description. Content analysis and documentation analysis

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were used as research tools. Sensory Profile Caregiver Questionnaire was used as an instrument.
Results: Out of 40 patients, 33 patients displayed definite differences at least in one of the Sensory Profile sections. The most frequent differences in Sensory Processing section were observed in Vestibular and Multi-Sensory Processing (39,4% in each of both sections, out of the total number of children with total score in definite differences range). In Modulation score pattern, definite differences were most frequent in Modulation of Sensory Input affecting Emotional Responses (48,5% of the total number of children in the definite differences range). In Behavior and Emotional Responses score pattern, the most frequent were the definite differences in Behavioral Outcomes of Sensory Processing (45,5% of children with total score in definite differences range). Referring to the Factors section, most of the participants had definite differences in Emotionally Reactive and Fine Motor/Perceptual factors (39,4% in each of both sections) Regarding the Quadrants section, 54,5% out of the total number of children with total score in definite differences range had definite differences in Sensory Avoiding.
Conclusion: Sensory abnormalities in children with ASD may be the key to understand many of their challenging behaviors, and thus it is a relevant aspect to be taken into account in their management. A formal evaluation of sensory integration processes should be performed in these children.

Keywords: Dysfunction of sensory integration; sensory processing; children; autism spectrum disorder.

1. INTRODUCTION

"Autism spectrum disorder (ASD) refers to any one of a group of disorders with an onset typically occurring during the preschool years and characterized by difficulties with social communication and social interaction and restricted and repetitive patterns in behaviours, interests, and activities" [1]. "ASD are complex neurodevelopmental disorders that affects all aspects of the child's personality: communication, motor skills, behavior and learning. Autism is not a disease or illness; it is a condition that the individual lives with throughout the entire life" [2,3].

"Sensory processing disorder (SPD) refers to the difficulties in ability to register, organize, and interpret information from our senses and the environment" [4]. "In order to better understand sensory integration disorders it is necessary to know how the central nervous system (CNS) processes, interprets and uses the sensory information. It is assumed that the CNS modulates information by creating a continuous exchange between habituation and sensitization" [5,6]. The various sensory modalities from the environment each follow specific pathways to the brain that process and store information. Children overreact to certain types of stimuli, react poorly to other, and to some types of stimuli they do not react at all [7]. Biological predispositions largely determine child's sensitivity to various sensory information, so that some children experience better hearing or sight, others are more agile, while third have refined sense of smell, taste or touch [8]. When the information that child receives is not adequately organized, it cannot be well integrated, which may affect the way a child behaves [9]. When the sensory threshold is too low or too high it can cause problems in child's experience. Sensory integration disorder occurs when the individual experiences problems in the ability to register and integrate various sensory information [10,8].

"Sensory integration focuses primarily on three basic senses: tactile, vestibular, and proprioceptive. The second level of sensory integration is established with the inter-relationship among these three senses, which is complex and enables development of body awareness, bilateral coordination, motor planning, focused attention and emotion regulation. In the third phase each of the different senses develop and coordinate with each other. Auditory information integrates with the vestibular functions, so hearing becomes more refined and the child can understand language when it is heard and can communicate through speech. Vision becomes more precise and the child can interpret visual information more accurately. Visual information integrate with tactile and proprioceptive and hand-eye coordination improves. This level strengthens basic cognitive skills and motor skills that propel the child into a world of learning" [11]. "When the senses, motor skills and cognitive progression have coordinated accurately, academic skills and complex motor skills start to shine. All of these abilities become

increasingly sophisticated in this fourth level" [7]. This is where body and brain lateralization take place, and the ability for concentration, self-confidence, self-control, self-esteem, abstract thinking and reasoning, as well as the functional specialization take the stage [12].

Evidence obtained by neurological studies indicate that the patterns of disrupted connectivity found in ASD might relate to abnormal sensory processing [13]. According to May-Benson, Koomar, Teasdale (2009) SPD is strongly associated with certain prenatal, perinatal and postnatal birth and developmental problems of children [14].

Shimatani, Sekiya, Tanaka, et al. (2009) state that children with developmental disorders, including children with ASD, experience difficulties in sensory integration and motor functions [15]. Atypical responses to sensory stimuli are a new criterion in DSM-5 for the diagnosis of an autism spectrum disorder (American Psychiatric Association), which supports the fact that the prevalence of sensory issues in this population is very high [1].

The brain processes all the signals that it takes from the external environment through the sensory organs, make sense of those signals and respond appropriately. That is the way we communicate with and fully understand the world around [2]. In children exhibiting sensory processing dysfunctions, the brain cannot differentiate between relevant and irrelevant information, so children cannot filter out background noise, they feel the clothes touching their skin, tend to notice all the details and even the slightest changes [2]. The room may appear strange or cause fear and anxiety. Sometimes children with ASD experience delayed processing and have trouble tuning out distractions (background sounds, clothes sensations, etc.). These children tend to process sensory information differently than other children. Sometimes you may have the impression that some of their senses are "shut down" [16]. That's the way how the children cope with own sensory overstimulation and overload. For example, when a child is overstimulated with auditory stimuli he may appear "deaf" because it actually helps other senses work better. Some children may use the other senses to compensate "the switched off" one, so they smell, lick or touch objects [2,17-19].

Dysfunction in sensory integration (DSI) is "the inability to modulate, discriminate, coordinate, or organize sensation adaptively" [20]. Sensory integration disorder symptoms often involve: excessive irritability, anxiety, temper tantrums, social isolation, unpredictable behaviour, rigidity, inattention, distractibility, reduced processing abilities, and difficulties in following instructions [21-24]. There are two main types of sensory processing issues: hypersensitivity and hyposensitivity. Hypersensitivity leads to fear, anxiety and avoidance of particular stimuli. Hyposenstivity leads to seeking out any sensory stimulation [4]. For example, if children are hyposensitive to touch they will seek out strong tactile feedback; when they are hyposensitive to smell, children will crave certain smells; in case of auditory hyposensitivity children make repetitive sounds; when children seek vestibular stimuli they will spin or rock all the time, and if they seek visual stimuli they will often make unusual movements with their hands in front of the eyes [2].

According to Miller et al. (2000) sensory processing disorders are subdivided into 3 specific patterns:

1. Sensory modulation disorder, subdivided into overresponsive, underresponsive, and sensory seeking/craving subtypes.
2. Sensory discrimination disorder, which applies individually to each sensory system (vestibular, proprioceptive, tactile, visual, auditory, olfactory, gustatory, and interoceptive).
3. Sensory-based motor disability, subdivided into postural disorder and dyspraxia [4].

Sensory integration dysfunctions may affect a child's ability to focus on tasks, perform coordinated motor activities, plan and sequence new tasks, develop social relationships, perform tasks related to self-care, participate in family activities and fulfil school requirements. Referring to school, sensory integration issues may affect students' sitting up straight during classes, attention, gross and fine motor skills, writing, autonomous tasks execution, eye-hand coordination, peer play and relations, etc. [25].

1.1 Research Objective

"Inclusion of sensory difficulties in the DSM-5 criteria has led to an increasing interest in this emerging research area. Children with developmental disorders often exhibit sensory integration challenges which may interfere with age-appropriate life activities" [26,15].

"Greenspan and Weider (1997) reported that 100% of the participants diagnosed with autism in their study demonstrated difficulties with auditory responding. In a comparative study, Tomchek and Dunn (2007) reported that difficulties with the processing of auditory, taste, and olfactory stimuli are the most common sensory processing dysfunctions" [27,28]. Gillberg and Coleman (2000), and Baranek, Foster and Berkson (1997) in their studies have found dysfunctions in tactile and visual sensory processing in children with ASD [29,30]. Other studies (Dunn, 1997; Joosten, Bundy, 2010) also revealed different forms of sensory processing difficulties (sensory seeking, low registration, sensory avoidance, sensory sensitivity) in children with ASD [5,31,32]. In this context, the aim of this paper was to determine the frequency and the types of dysfunctions in sensory processing and integration in children with ASD. This research constitutes a starting point for the development of new hypotheses and further examination of associations between sensory features and demographics, parental styles and other aspects of family functioning, co-occurring problems in other areas, etc., as well as starting point for further surveys in order to analyze the evolution of sensory features in children with ASD some years later, to compare the sensory profile characteristics of the children with ASD and children with typical development, and so on.

2. METHODOLOGY

2.1 Study Population

The research was conducted on a sample of 40 children with ASD receiving services in the Intensive Rehabilitation Programme in PHI Institute for rehabilitation of hearing, speech and voice - Skopje. All the participants included in the sample met all the diagnostic criteria for ASD according to DSM-5 and had relevant diagnosis documentation issued by a doctor (i.e. child psychiatrist), which actually was the inclusion criterion. The study excluded children with ASD already undergoing sensory integration treatment. Of the total number of participants, 32 (80%) were boys and 8 (20%) were girls. The age range of participants was 3 to 7 years. Most participants were at the age of 4 years (35%) and 6 years (27,5%). Regarding the ethnicity of study participants, 31 (77,5%) were Macedonians, 4 (10%) Bosniaks, 3 (7,5%) Albanians, 1 (2,5%) Turk and 1 (2,5%) Serbian. When it comes to the parental styles, 29 (72,5%) of parents reported that they were overprotective and permissive. More than 60% of parents reported their children were excessively exposed to screens.

2.2 Sampling Method

The research method used is qualitative description. Content analysis and documentation analysis were adopted as research tools. The instrument used was the Sensory Profile Caregiver Questionnaire (SP, Dunn, 1999). It is an assessment tool that helps professionals measure the possible contributions of sensory processing to children's daily performance patterns. It comprises 125 items divided in 14 categories in three sections: Sensory Processing, Modulation and Behavior and Emotional Responses. It also includes Quadrant and Factor Analysis sections.

2.3 Data Analysis

Obtained quantitative data were presented using tables and/or graphs. The type of applied descriptive statistics is frequency distribution and the data are summarized in numbers and percentages.

3. RESULTS AND DISCUSSION

The results obtained with analysis of the sensory profiles are shown below.

3.1 Presence of Differences in sections, Factors and/or Quadrants of the Sensory Profile

Table 1 shows that 82,5% of participants displayed definite differences at least in one of the sections, factors and/or quadrants. The rest of the participants displayed either possible difference or typical performance.

Table 1. Presence of differences in sections, factors and/or quadrants of the sensory profile

Presence of differences in sections	Number	%
Definite differences	33	82,5%
Possible difference or Typical Performance	7	17,5%
Total	40	100%

3.2 Scores in Sections Sensory Processing, Modulation, Behavior and Emotional Responses

Table 2 shows the results referring to differences in Sensory Processing section. As shown, the most frequent differences in the Sensory Processing section are observed in Vestibular and Multi-Sensory Processing (39,4% in each of the both sections, out of the total number of children with total score in definite differences range). Typical performance is most frequent in visual processing section. A possible reason for this outcome might be the self-reported over-protective parental style, as well as the screen exposure, which altogether results with restricted opportunities for movement activities and sensorimotor exploration of the environment. This could be one of the issues for further investigation.

In the Modulation score pattern, definite differences are most frequent in Modulation of Sensory Input affecting Emotional Responses (48,5% of the total number of children with total score in definite differences range). Typical performance is most frequent in Modulation of Movement affecting Activity Level (60% of the total number of participants).

In the Behavior and Emotional Responses score pattern, the most frequent are the definite differences in Behavioral Outcomes of Sensory Processing (45,5% of the total number of children with total score in definite differences range). This might be related to the self-reported permissive parenting characteristics and more research is needed to better understand this issue.

3.3 Factor Scores of the Sensory Profile

Table 3 shows the obtained results referring to the Factors section of the sensory profile. Most of the participants had definite differences in Emotionally Reactive and Fine Motor/Perceptual factors (39,4% in each of the both sections, out of the total number of children with total score in definite differences range). Typical performance is most frequent in the Low Endurance/Tone section (77,5% of the total number of participants).

3.4 The Quadrant Scores of the Sensory Profile

Table 4 shows the obtained results referring to the Quadrants section of the sensory profile. The most frequent definite differences are those in Sensation Avoiding (54,5% out of the total number of children with total score in definite differences range) and Sensation Seeking (42,4% out of the total number of children with total score in definite differences range). Possible explanation regarding the results in Sensory Processing section (referring to the over-protective parenting style and excessive exposure to screens) might apply here as well, and it also requires further research.

Similar results were obtained by Mohammed, Al-Heizan et al. (2015). They investigated the manifestation of sensory processing dysfunction in autism and compared the functional components of sensory processing between Saudi Arabian children with and without autism. The overall findings indicated that the prevalence of sensory dysfunctions in children with autism was significantly higher than in the children without autism. The most common sensory processing dysfunctions in children with autism involve the under-responsive/seeks sensation, auditory filtering, tactile sensitivity, and low energy/weak domains. These authors assume that cultural and community lifestyles have some degree of effect on the severity and percentage of involvement of sensory processing dysfunctions in children with autism. The parenting style of Saudi Arabian parents tends toward the protection and nurturing of their children. This parenting style could decrease the child's opportunity for vestibular/ proprioceptive/ motor stimulation [33].

Tzischinsky O, Meiri G, et al. (2018) examined the relationship between sensory abnormalities and sleep disturbances in children with autism. Hypersensitivity towards touch, in particular, exhibited the strongest relationship with sleep disturbances in the autism group. The conclusion was that hypersensitivity towards touch interferes with sleep onset and maintenance in a considerable number of children with autism who exhibit severe sleep disturbances [34].

Table 2. Scores in sections Sensory Processing, Modulation, Behavior and Emotional Responses

Section	Definite Difference			Possible Difference		Typical Performance	
	f	% out of the total number of participants with definite differences	% out of the total number of participants	f	% out of the total number of participants	f	% out of the total number of participants
Auditory processing	10	30,3	25	7	17,5	23	57,5
Visual processing	2	6,1	5	7	17,5	31	77,5
Vestibular processing	13	39,4	32,5	8	20	19	47,5
Touch processing	4	12,1	10	13	32,5	23	57,5
Multi-sensory processing	13	39,4	32,5	14	35	13	32,5
Oral sensory processing	10	30,3	25	10	25	20	50
Modulation							
Sensory processing related to Endurance/Tone	8	24,2	20	3	7,5	29	72,5
Modulation related to Body Position and Movement	11	33,3	27,5	18	45	11	27,5
Modulation of Movement affecting Activity Level	1	3	2,5	15	37,5	24	60
Modulation of Sensory Input affecting Emotional Responses	16	48,5	40	13	32,5	11	27,5
Modulation of Visual Input affecting Emotional Responses	3	9,1	7,5	19	47,5	18	45
Emotional/Social Responses	13	39,4	32,5	9	22,5	18	45
Behavioral Outcomes of Sensory Processing	15	45,5	37,5	11	27,5	14	35
Thresholds for Response	8	24,2	20	11	27,5	21	52,5

**Note: one study participant may exhibit deviations in more than one category, so the sum of the percentages per column cannot amount 100*

Table 3. Factor Scores of the Sensory Profile

Factor	Definite Difference			Possible Difference		Typical Performance	
	f	% out of the total number of participants with definite differences	% out of the total number of participants	f	% out of the total number of participants	f	% out of the total number of participants
Sensory Seeking	10	30,3	25	13	32,5	17	42,5
Emotionally Reactive	13	39,4	32,5	10	25	17	42,5
Low Endurance/Tone	7	21,2	17,5	2	5	31	77,5
Oral sensory Sensitivity	4	12,1	10	15	37,5	11	27,5
Inattention / Distractibility	10	30,3	25	8	20	12	30
Poor Registration	5	15,1	12,5	12	30	23	57,5
Sensory Sensitivity	4	12,1	10	8	20	28	70
Sedentary	2	6,1	5	14	35	24	60
Fine Motor/Perceptual	13	39,4	32,5	5	12,5	22	55

Table 4. Quadrant Scores of the Sensory Profile

Quadrant	Definite Difference			Possible Difference		Typical Performance	
	f	% out of the total number of participants with definite differences	% out of the total number of participants	f	% out of the total number of participants	f	% out of the total number of participants
Low Registration	9	27,3	22,5	12	30	19	47,5
Sensation Seeking	14	42,4	35	13	32,5	13	32,5
Sensory Sensitivity	6	18,2	15	17	42,5	17	42,5
Sensation Avoiding	18	54,5	45	9	22,5	13	32,5

According to Castro and Monteiroments (2022), impairments may arise at different steps along the auditory pathway. Multiple defects are observed, such as decreased tonotopicity, altered thresholds to sound stimuli, and abnormal spectral and temporal processing (especially in the auditory regions of the brainstem and cortex) [35].

Our findings are consistent with prior research indicating that abnormal sensory-based behaviors are a defining feature of autism spectrum disorders. The results of this study will be of interest to multiple audiences, including patients, their families, caregivers, healthcare professionals, researchers, scientists and decision makers. The knowledge of atypical sensory patterns in children with ASD may be of fundamental importance for individualizing psychoeducational interventions in preschool- and school-aged children and later developmental stages. We believe that effort should be made to ensure early recognition and management of these sensory features to improve children's functional and psychosocial outcomes and to identify family-oriented supportive interventions with more optimal long-term effects.

4. CONCLUSION AND RECOMENDATION

Atypical responses to sensory stimuli are highly prevalent in children with ASD. The underlying mechanisms of these symptoms are unclear, but several theories have been proposed linking sensory dysfunction with known abnormalities in brain structure and function that are associated with ASD.

Sensory abnormalities in children with autism spectrum disorder may be the key to understand many of their challenging behaviors, and thus it is a relevant aspect to be taken into account in their management. A formal evaluation of sensory integration processes should be performed in these children.

Aside from classical knowledge that the ASD population suffers from sensory processing disorders, there is a need to identify homogenous groups of children with ASD based on sensory features (i.e., sensory subtypes) to inform research and treatment. Characterizing the nature of homogeneous sensory subtypes may facilitate assessment and intervention, as well as potentially inform biological mechanisms. Sensory features can affect the everyday experiences of both children and caregivers. What is unknown, however, is the extent to which sensory features affect family functioning over time, as well as the influence of received services on these relationships. Additional research has the potential to shed more light on the nature and underlying mechanisms of these disorders and to open new avenues of effective treatments.

CONSENT

As per international standard, parental written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

This research was approved by the Experts Council and the Ethics Committee of the Institute for Rehabilitation of Hearing, Speech and Voice - Skopje.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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