

Sensory integration disorders in children with autism spectrum disorder—A review study

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ABSTRACT: In this article, we examine the diagnostic process for children on the autism spectrum, paying particular attention to the importance of sensory diagnosis as a key tool in identifying therapeutic needs and establishing intervention strategies. We discuss the challenges posed to therapists by difficulties in communication, relationship building, and motivation, as well as the need to flexibly adapt diagnostic tools to each child's individual needs. Sensory diagnosis not only helps parents understand their children's behaviors and their underlying causes but also provides concrete knowledge of effective therapeutic strategies that can be used in the day-to-day support of the development of children on the autism spectrum. Our analysis underscores the importance of sensory diagnosis as a tool to help understand and support children in coping with daily challenges and building harmonious relationships with their environment, a key component of effective therapy for children with autism.

KEYWORDS: sensory integration; SI; autism; children; spectrum

1. Introduction

The systematization of autism and its position in the classification of diseases are still in the process of evolution. Although specific behaviors in children with autism resulting from abnormal sensory integration processes have been observed since Kanner's time, it wasn't until 2013 that the DSM-5 (Diagnostic and Statistical Manual of Mental Disorders) classification first included hypersensitivity or sub-sensitivity to sensory stimuli and atypical sensory interests in the diagnostic criteria for ASD (autism spectrum disorder)^[1,2]. The term "holistic developmental disorder" was also replaced with autism spectrum disorder (ASD), which includes autism, Asperger's syndrome, and holistic developmental disorders not otherwise diagnosed. In addition, a three-tiered classification (from L1 to L3) was introduced, depending on the severity of symptoms and their impact on functioning^[3].

The inclusion of sensory disorders in the diagnostic criteria for ASD is an important step in the quest to more fully understand this still incompletely understood neurodevelopmental disorder and to identify potential therapeutic directions^[4].

The literature on the autism spectrum often emphasizes the role of sensory integration disorders as a key element characterizing the functioning of individuals with ASD. This reflects the importance placed on sensory dysfunction in the context of ASD^[1-5].

1.1. Prevalence and type of sensory integration process disorders in children with ASD

According to numerous studies, children on the autism spectrum are observed to have clear manifestations of impaired sensory integration processes. Analyses suggest that about 70%–85% of children with ASD are diagnosed with sensory disorders^[6].

Studies have shown that sensory sensitivities in children and adults with ASD have a more significant impact on their functioning than difficulties in establishing social relationships, regulating emotions, or achieving career success^[7]. People with ASD describe the negative impact of sensory disorders on their emotional, social, and psychophysical aspects^[6].

Sensory deficits in children with autism manifest themselves in a variety of ways and can involve three main areas: problems with the brain's registration of stimuli, dysregulation of sensory information, and difficulties with the initiation of motivational processes^[6,8].

Due to limitations in the registration, modulation, and integration of auditory stimuli, children with ASD face difficulties in the development of both active and passive speech. In addition, due to difficulties in forming a proper body schema, they are unable to develop complete neurodevelopmental models of themselves and their environment, leading to complications in functioning in the environment^[9].

In addition to sensory modulation disorders, abnormal patterns of sensory integration, such as somatodyslexia or vestibule-postural-bilateral disorders, can also have a significant impact on the lives and functioning of people with ASD. Although these disorders are not included as diagnostic criteria in current classifications such as the DSM-5, a growing body of evidence suggests that significant difficulties in the functioning of people with ASD may stem precisely from these abnormal sensory patterns^[10]. Researchers have noted that children with ASD often exhibit deficits in the areas of somatodistracton, postural-oculomotor dysfunction, and bilateral integration and sequencing, as well as in sensory reactivity, which underlies problems with participation in social life, school, and at home^[11].

Therefore, it can be deduced that all types of disorders of sensory integration processes can occur in individuals on the autism spectrum. We now know that autism spectrum disorder manifests in many cases as impaired sensory processing that affects emotional, social, motor, and cognitive development. Sensory integration therapists are receiving more and more patients with a diagnosis of ASD to identify sensory impairments and treat them effectively. A correct diagnosis is crucial to the effectiveness of ongoing therapeutic interventions, so it must be carried out reliably and accurately. Therapists conducting assessments of sensory deficits must be familiar with the functional characteristics of this group of patients^[12].

Given that sensory integration therapy is the only form of therapeutic intervention that addresses sensory deficits, it is important that as many children with ASD as possible can benefit from it^[13].

1.2. Diagnosis of sensory integration processes in a child with ASD

At the outset, it should be emphasized that the diagnosis of sensory integration disorders can only be carried out by a qualified person. The diagnosis of any child, including children with ASD, should consider the typical developmental course. Sensory integration processes follow specific stages, as described by Ayres in the theory of sensory integration (SI). Ayres created diagnostic tools to understand the underlying problems faced by children, both healthy and those with developmental disorders, including autism^[14].

The level of functioning of a child on the autism spectrum determines how the diagnosis is conducted. If the child is cooperative and can participate in standardized tests, such as the Southern

California sensory integration test^[15], sensory integration and practise test^[16], evaluation in ayres sensory integration^[17], the diagnosis process is similar to that of children without ASD, and the results of these tests allow accurate identification of the type of disorder according to the classification of SI disorders. Even partial clinical or standardized testing provides the therapist with important information about the child's functioning. On the other hand, if the child's level of functioning prevents the use of standard diagnostic tools, the diagnosis must be based on available data, but this does not mean that it is insufficient. A key aspect of diagnosing a child with ASD is understanding the behaviors that children may exhibit and their significance in the context of ASD. The therapist must be aware that the child, through his or her behavior, reactions, preferred actions, avoidance of certain stimuli or places, stereotypes, self-stimulations, and challenging behaviors, may signal potential sensory deficits^[18].

It is recommended to use the latest EASI tests. These are the world's first standardized tests that can be used with children between the ages of 3 and 12, and the standards were developed based on studies conducted on children between the ages of 3 and 12 in about 100 countries around the world. EASI tests are used to assess sensory perception, sensory reactivity, postural parameters, visual, and bilateral coordination, sequencing, and praxis. The battery contains 20 tests that assess: sensory perception, sensorimotor abilities, praxia, and sensory reactivity. EASI sensory perception tests assess the ability to detect, perceive, and discriminate between different types of sensory information from the body and environment^[19].

Sensory-motor tests assess how a child uses sensory information to perform various tasks related to body movement, postural control, eye movement control, balance, and coordinated movements involving both sides of the body. They reveal automatisms of actions, such as maintaining the body against the force of gravity^[20].

Praxia tests assess the ability to ideate, that is, imagine how to perform various unfamiliar or unusual body positions, sequences, and interactions with objects. They test children's ability to organize their actions in response to verbal instructions, perform multi-step sequences of actions, imitate unusual positions, and plan movement. Sensory reactivity tests measure a child's tolerance to a range of intensities of sensory experiences^[21].

2. Diagnosis of SI disorders according to age

Making a diagnosis in children using Southern California tests and SIPT tests is feasible from the age of 4. The use of the world's newest EASI tests makes it possible to diagnose children as young as 3 years old. For children under the age of 3, diagnosis is also possible but requires the use of alternative diagnostic tools, such as interviews, questionnaires, free and guided observation, and diagnostic scales. Even infants on the autism spectrum (as well as other children) exhibiting several months of age can present dysregulation, which requires immediate therapeutic intervention. Prompt identification of the problem and initiation of therapy contribute to the effectiveness of these interventions and enable the prevention of potential difficulties in the future. The main goal of the sensory integration (SI) assessment process is to identify the relationship between sensory functioning and functional problems so that the impact of sensory disorders on daily activities can be understood^[14-21].

Components of an AI diagnosis

The diagnosis process includes several elements: interviews, questionnaires, observation of the child's free activity, guided observation, clinical observation of SI, and standardized tests^[22].

Interview with parent/guardian—The first step in the diagnosis process is to conduct an interview, which is the main source of information regarding the child’s development to date. This interview should be comprehensive, including questions about the course of pregnancy, childbirth, and the child’s developmental achievements, such as motor development, language skills, activity level, and self-care skills. During the interview, the parent or caregiver is asked about the child’s observed behaviors, perceived difficulties in the child’s development, and the child’s overall level of functioning in various spheres of life, both inside and outside the home. In the case of an ASD diagnosis, it is important to gather information about characteristic stereotypical and self-stimulatory behaviors, possible aggressive behaviors, and preferences and activities that the child often engages in or avoids. In addition, it is important to know how the child spends his or her time, his or her abilities in self-care activities, sleepiness, and variety of meals. This detailed information is crucial to accurately identifying sensory deficits and enabling us to help parents understand the causes of their child’s behavior. Understanding and accurately recognizing the difficulties that families with children with ASD face daily is important to provide them with appropriate support and assistance^[23].

Questionnaires—A variety of questionnaires can be used to assess a child’s behavior and functioning, which can provide additional information about the child’s development and behavior. Questionnaires are sets of questions used to determine a child’s sensory profile. They usually consist of questions that are answered by the parent by marking a “yes” or “no” answer. For example, a questionnaire on sensorimotor development contains numerous questions and a key that allows preliminary inferences about potential deficits in the registration and modulation of sensory stimuli, as well as deficits related to posture, balance, movement planning, and motor coordination. Another example of a questionnaire is the tactile sensitivity questionnaire, which assesses a child’s risk of developing tactile hyperreactivity or tactile defensiveness. There are also many other questionnaires available online that help assess the level of modulation and registration of sensory stimuli^[24].

Observation of the child’s free activity and guided observation—During observation, both free and guided, the therapist assesses the child’s behavior in a variety of situations and contexts to better understand the child’s functioning. Free observation is the process of monitoring a child’s natural responses to a variety of sensory stimuli in the context of his environment. The therapist prepares an exploratory space where the child can freely explore a variety of activities and toys that provide stimuli from different sensory systems. To this end, the room may include musical instruments, sound toys, containers with sand or masses, items of varying texture, as well as devices providing spatial and proprioceptive stimuli, such as swings or balance boards. During observation, the therapist assesses whether the child responds adequately to various stimuli, observing his or her level of arousal, preferences, and avoidance of certain stimulation. In addition, the therapist monitors for any auto-stimulatory or stereotypic behaviors to understand their sensory basis.

Guided observation is essential because some children with ASD may need more targeted support from the therapist when undertaking activities. In this case, the therapist presents the child with a variety of games and activities tailored to his or her abilities, helping him or her become accustomed to the environment. During guided observation, the therapist ensures that the child feels safe, which encourages the child’s natural responses. In addition, the therapist observes which stimuli the child finds pleasurable and which cause undesirable reactions and analyzes which stimuli affect the child’s level of arousal and stress^[25].

SI clinical observation—This is the systematic observation of a child’s specific behaviors and reactions in the context of his or her response to sensory stimuli. The most commonly used method of

clinical observation is the one based on the samples. During this observation, the therapist evaluates several parameters, including postural responses, co-contractions, muscle tone, balance, motor automatism, the flexibility of movement, the ability to isolate movement, maintenance and transfer of body weight, oculomotor function, praxis, and bilateral motor coordination. In addition, the therapist analyzes sensory modulations such as tactile defenses and gravitational uncertainty^[26].

It should be noted that not all children with ASD will be able to perform clinical trials in the traditional sense. Therefore, the therapist can try to integrate them into natural activities during play, which allows a more natural observation of their behavior and reactions^[27].

Standardized tests—For older children, standardized tests such as the Southern California sensory integration tests (SCSIT) or SIPT tests can be used. However, the world's newest EASI tests, which include standardized clinical samples from clinical observation, allow diagnosis as early as age 3^[28].

3. Interpretation of specific behaviors of the child during the examination

Autostimulations, which are activities during which a child engages in activities that generate sensory stimulation, can manifest themselves in various forms and serve a variety of functions. Autostimulatory or stereotyped behaviors are defined as “repetitive body movements that show no apparent relationship to the environment.” One of the functions of these behaviors is to regulate the level of arousal in the nervous system to maintain an optimal state, which is necessary for carrying out daily activities and focusing attention. Another important function of self-stimulatory behavior is to reduce over-stimulation, satisfy sensory needs, protect against nervous overload, relieve tension, cope with stress, maintain a sense of control over the environment, and obtain satisfaction. However, there is a risk that the latter function can lead to sensory addiction, which in turn can result in autostimulatory behavior turning into compulsive behavior. Autostimulatory behaviors can also take the form of self-aggression, such as biting, scratching, or hitting. They are particularly common in people experiencing sensory subreactivity^[29,30].

The common denominator of many studies on the etiology of stereotypic behavior is sensory processing dysfunction, expressed in sensory deficits or excesses. One behavior, such as jumping, may be rooted both in an inadequate response of the vestibulo-proprioceptive system and in problems with sensory planning and attempts to regulate arousal levels^[31].

Research suggests that identifying the correct cause of self-stimulatory behavior, including self-injurious behavior, and adjusting therapy, accordingly, can effectively reduce the incidence of these behaviors.

4. Methods for recognizing symptoms of stimulus modulation and registration disorders

To evaluate disorders of modulation and registration of sensory stimuli, it is essential to know the symptoms of these disorders^[32].

The therapist gathers information on potential symptoms by interviewing the parent/guardian, analyzing the caregiver's responses to questionnaires, and observing the child's behavior during the examination^[33].

Sensory integration testing is a process stretching over several hours to establish a diagnosis and

develop an overall therapeutic plan (**Tabel 1**). According to guidelines, the examination report should include the reason for the referral to the examination, a description of the examination tools used, a discussion of the results of the trials and tests conducted, a summary including the relationships between the disorders found, conclusions and suggestions for therapy, and a detailed therapeutic plan. Recommendations for parents on a “sensory diet” are also an important aspect of the diagnosis, as well as possible suggestions for teachers and caregivers^[26].

Table 1. The sensory processing disorders of children with autism^[34–36].

Layout	Overactivity	Subreactivity
Previous	Gravity insecurity is the fear of body movement and displacement, the anxiety associated with getting one’s feet off the ground, and experiencing discomfort, especially when tilting one’s head back, such as when performing Bo bath ball exercises. People with the disorder often avoid swinging, preferring a seated position during activities, experience a fear of falling, and avoid playground activities and climbing to avoid losing their balance. Motion intolerance manifests itself through negative somatic sensations in response to rapid movements and rotations, which manifests as an unwillingness to participate in such activities. Symptoms can also include motion sickness symptoms and a feeling of nausea even when observing rotating objects.	Reduced response to movement, frequent loss of balance, stumbling, and lack of defensive reactions to falls may indicate reduced sensitivity to motor stimuli. The affected person may exhibit characteristics typical of a sensation-seeking profile, characterized by constant activity, a preference for head-down positions, exploration of heights, a lack of response to potential threats, and a tendency to spin around one’s axis, rocking and swaying. Alternatively, it may manifest behaviors typical of the passive profile, which does not actively seek movement, but responds to intense motor stimuli through activation and difficulty in terminating the action.
Proprioce	Proprioceptive hyperreactivity in children with ASD manifests as hypersensitivity to tactile and pressure stimuli, leading them to avoid touching or wearing certain clothing. They may also react excessively to pressure or touch, manifesting soreness, or discomfort. This can limit their range of motion and desire for physical activities, negatively affecting motor development. Therapy is based on an individualized approach, tailoring exercises, and strategies to help the child regulate proprioceptive sensations and improve function.	Insufficient response to movement, frequent loss of balance, stumbling, and lack of instinctive defensive reactions when falling are common observations in people with such disorders. There are two possible forms of behavior: the sensation-seeking type, which is characterized by constant movement, assuming head-down positions, exploring heights and often failing to notice potential danger, and the passive type, where the person inactively seeks movement, but can be stimulated by strong motor stimuli, but finds it difficult to complete the activity.
Touch	Activities such as rubbing affected areas, avoiding playing with materials of different textures such as sand, foam, or plush toys, and avoiding close physical contact such as hugging may be observed. In addition, there may be difficulty performing daily hygiene tasks, such as brushing teeth or caring for hair and nails. Children may also avoid touching certain textures or materials, such as when eating meals, and prefer to avoid walking barefoot.	Ignoring tactile stimuli, failing to recognize dirt or wetness, insufficient response to touch, exploring stimuli by rubbing hands on different surfaces, taking food by touch, excessive physical contact, preferring dirt-related play, and destroying clothes.
Listen	Covering one’s ears in response to certain sounds; stress reactions to sudden, unexpected sounds that others do not regard as bothersome, such as the sound of bells in a distant church; exceptional auditory sensitivity—picking up sounds that others do not notice, masking sounds by generating their sounds.	Shielding the ears in response to certain sounds; reactions to sudden, unexpected stress-inducing sounds that are not offensive to others, such as the sound of bells in a distant church; extraordinary auditory sensitivity - detecting sounds that escape others, masking sounds by making their sounds.

Table 1. (Continued).

Layout	Overactivity	Subreactivity
Sight	Covering eyes from bright lights, avoiding sources of flickering and shining lights, avoiding approaching objects, avoiding eye contact, blinking frequently, eye fatigue, tearing and rubbing eyes, not wanting to look in mirrors, paying attention to details such as specks and pollen; high ability to puzzle and create complex patterns.	Prolonged staring at light sources, preference for intense and flashing toys, repetitive head waving, tendency to look at different angles, and use of peripheral vision. Interest in mirrors and reflective toys, fascination with rotating objects; difficulty in picking out a picture from the background, exploration by moving fingers in the field of vision, failure to notice changes, and unawareness of approaching objects, such as a ball.
Sense	Feeling nausea and vomiting reactions in response to the odors of one's stool or urine—trying to stop these reactions if possible; avoiding eating certain foods and frequently communicating that certain odors are considered unpleasant.	Lack of reaction to intense odors, ignoring their presence, dealing with fecal matter, sniffing every object and person, touching them, drooling on their hands, and touching them, and having no choice about food.
Taste	Limited acceptance of a variety of tastes, preference for foods with a particular flavor or texture, avoidance of foods containing spices and carbonated beverages. In addition, food selectivity can lead to inadequate nutrient intake and make it difficult to maintain a balanced diet. It is worth noting that aversion to spices and carbonated beverages may be related to sensitivity to intense taste stimuli or feelings of discomfort after consuming such products.	Accepting all available objects as a potential snack, including inedible objects, and showing a preference toward intense, sharp-tasting substances. Such behaviors can lead to the risk of ingesting items that are hazardous to health and affect the composition and quality of a child's diet. Additionally, a preference for pungent tastes may be related to a search for strong sensory stimuli or a preference to engage in activities that provide intense taste sensations.

The diagnostic process ends with the identification of a specific type of disorder and the identification of the main problem that represents the greatest obstacle to the child's development, along with the determination of the direction of therapy. The diagnosis of children on the autism spectrum requires flexibility and the ability to adapt diagnostic methods to the individual needs of the child. Problems with communication and building a common field of attention and motivation pose a challenge to the therapist, who must modify the approach during the diagnosis.

The child's sensory diagnosis is designed to help parents understand their child's behavior and explain why he or she reacts in certain ways and how difficult behaviors, self-stimulations, and problems with emotions, sleep, or eating arise. In addition, the diagnosis is intended to provide knowledge on how to support the child in dealing with difficulties, build a relationship with the child, spend time together, and help the child with daily challenges.

Author contributions

Conceptualization, KKK; methodology, MK; resources, MK and KKK; writing—original draft preparation, KB and KKK; writing—review and editing, KB; supervision, MG; project administration, MG. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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