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Review

Sensory Processing in Autism Spectrum Disorder (ASD)

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ABSTRACT

Sensory processing in humans involves reception of a physical stimulus, transduction of the stimulus into a neural impulse, and perception, or, the conscious experience of sensation. These sensory disorders can negatively affect development and functional abilities in behavioral, emotional, motoric, and cognitive domains. Sensory processing is an important stage in performance during which the organization and interpretation of received messages is done, and finally the final decision is made. Development in an efficient sensory-perceptual-motor processing system plays an essential role in the successful execution of a task and learning, and a defect in skills may be related to one of the sensory systems and lead to functional problems. The aim of this study was to review the studies related to Sensory Processing Disorder in autism disorders, attention deficit hyperactivity disorder and learning disabilities. Using keywords (Sensory Processing Disorder, Autism Spectrum Disorder, Attention Deficiency Hyperactivity Disorder, Developmental Coordination Disorder, Learning Disability), articles were searched in Elsevier, Science Direct and Google Scholar databases between 2000 and 2020.

Results: According to an inclusion and exclusion criterion, 41 articles focusing on Sensory Processing Disorder in Autism Spectrum Disorders, attention deficit hyperactivity disorder, Developmental Coordination Disorder and learning disorder were examined. This disorder is caused by damage to areas of the brain, including the white matter, and Sensory Modulation Disorder (SMD (is the most common type. In these people, usually, skills deficits make it difficult for the child to play the role, and the most common interventions among them are based on sensory integration.

Conclusion: Among the four groups, Sensory Processing Disorder is very common and can be the cause of many problems in their perceptual, motor, behavioral and academic skills.

***Keywords**: Sensory Processing Disorder; Autism Spectrum Disorder; Attention Deficiency Hyperactivity Disorder; Developmental Coordination Disorder; Learning Disability.*

INTRODUCTION

Mental health has always been a critical component of overall health, drawing attention from various medical branches for its treatment, and it is specifically evaluated and addressed in occupational therapy as a core focus. In recent years, it has become evident that technological advances, the emergence of artificial intelligence, and stressful conditions such as warfare and economic difficulties have adversely affected human quality of life. Consequently, occupational therapy sees an influx of clients from various backgrounds, including regular schools and counseling centers, aiming to improve quality of life and promote health. This demand has prompted numerous studies.[1-3]

Autism Spectrum Disorder (ASD) is a multifaceted neurodevelopmental condition marked by enduring challenges in social communication and interaction, paired with restricted and repetitive patterns of behavior, interests, or activities.[4] This "*spectrum*" characterization underscores the significant diversity in challenges, strengths, and manifestations among individuals with ASD, ranging from subtle social difficulties to more profound impairments affecting daily functioning.[5,6]

The prevalence of ASD has been rising in recent years, with current estimates suggesting that approximately 1 in 36 children receive an ASD diagnosis.[7] This trend reflects not only an increase in awareness and diagnostic precision but also highlights the pressing need for supportive and targeted interventions. ASD typically becomes evident in early childhood, though diagnoses can occur later, especially for those with milder symptoms or who develop compensatory skills that mask early signs. Essential diagnostic criteria for ASD include persistent deficits in

social communication and interaction, as well as repetitive behaviors or interests, which manifest early in development. These symptoms are sufficiently impactful to interfere with daily life, and they cannot be attributed solely to intellectual disability or developmental delays, distinguishing ASD as a unique neurodevelopmental condition.[8]

Sensory processing is emphasized as a personality variable and perhaps the most fundamental psychological element influencing how individuals perceive and react to their environment. This construct is a general concept referring to how the nervous system is employed to receive, organize, and interpret sensory inputs.[9]

Sensory processing is also viewed as an internal neurological process that, based on sensory information gathered from the surrounding environment (e.g., auditory and visual inputs) and within the body (e.g., vestibular and proprioceptive receptors), makes the individual aware of events around them and enables them to respond appropriately to contextual demands. A deficit in sensory processing can lead to Sensory Processing Disorder (SPD), which is marked by difficulties in modulating and organizing responses to sensory inputs to meet environmental needs. Individuals with this disorder often show exaggerated (avoidance and defensiveness) or inappropriate responses to sensory inputs. This disorder is a long-term condition that affects a child's life in family, school, and community contexts. Disabilities resulting from this disorder, such as deficits in social skills, play participation, reduced self-confidence and self-esteem, compromised adaptive responses, weaknesses in gross and fine motor skills, struggles in motor planning and coordination, delays in learning and language, and disruptions in executive functioning and self-regulation can persist into adulthood without effective interventions and potentially lead to social issues in later life.[10]

Sensory processing sensitivity is a neurobiological trait present in about 10 to 20 percent of the population and significantly greater in more than 50 percent of psychiatric patients compared to others. This heightened or diminished sensitivity affects individual lives, social relationships, and work. For instance, highly sensitive individuals (HSP) are more easily stimulated by stressors such as loud noises, bright lights, strong odors, and chaotic environments, and they process cognitive, social, and emotional information more deeply. Problems arising from sensory processing sensitivity include weak parent-child interactions during childhood, poor peer relationships during youth, strained marital communications in adulthood, poor stress management, depression, and anxiety, low self-esteem, panic disorder, negative affect, severe shyness, avoidant personality disorder, lower job satisfaction, and reduced quality of life. However, research shows that sensory processing sensitivity is more of a diversity in information processing than a disorder, with only partial overlap with personality traits and mental health issues. In fact, although individuals with high sensory processing sensitivity are at greater risk for maladaptation in negative environments, they also respond intensely to positive stimuli. Hence, sensory processing sensitivity has bright aspects as well and is correlated with better perception, creativity, and imagination. With insights into individuals' sensory processing sensitivities, healthcare providers and public health interventions can design more suitable programs for affected populations in crisis situations.[11]

Based on clinical experiences, the prevalence of sensory processing disorders in children and adults is notably significant, potentially exerting considerable impact on their social interactions and level of participation. Dunn proposed a four-factor model of sensory processing in 2001. Dunn's Sensory Processing Theory posits that each individual has a unique way of processing sensory inputs; in other words, individuals react differently and sometimes oppositely to the same stimulus. The sensory processing process focuses on the fact that all individuals occupy a position on two continua: (1) high neurological threshold—low neurological threshold and (2) active—passive, which classifies them into one of four sensory processing patterns: sensory seeking, low registration, sensory avoiding, and sensory sensitivity, through which they regulate their sensory inputs.[11,12]

Sensory processing disorder, defined as issues in regulating and organizing the type and intensity of responses to sensory inputs to adapt to environmental needs, usually prompts individuals to exhibit exaggerated (avoidance and defensiveness) or inappropriate responses to sensory inputs. The disorder affects sensory modulation across various sensory systems, such as auditory, visual, tactile, proprioceptive, and vestibular systems, impacting a child's developmental processes, effective interaction with the physical and human environment, optimal function, and participation in life's daily challenges.[12]

It remains inconclusive whether children who manifest sensory processing issues have an actual "*disorder*" in sensory neural pathways or if these deficits represent variations associated with other developmental and behavioral disorders. The observed behavioral differences in children with Autism Spectrum Disorders (ASD), Attention Deficit Hyperactivity Disorder (ADHD), and Developmental Coordination Disorders have overlaps with symptoms described in children with sensory processing disorders. To date, studies have not demonstrated that sensory integration dysfunction exists as a distinct disorder from these other developmental disabilities. Moreover, there are significant challenges in evaluating the efficacy of sensory integration therapy, including the broad range of symptom severity and manifestation, lack of cohesive outcome measures, and family-related factors that make treatment responses variable.[13]

The relationship between sensory processing and problem behavior, adaptive behavior, cognitive functioning, emotional intelligence, executive function, and sensory processing relates to social sufficiency, high-risk sexual behaviors, spirituality, and empathy. Sensory diet programs, through virtual and in-person occupational therapy, enhance sensory processing patterns, social competence, and work functioning in children with Autism Spectrum Disorders, fostering desirable social behaviors to reduce high-risk sexual behaviors in social settings. Despite the increasing interest in sensory processing sensitivity in communities and media, research in this area is limited, and information on sensory processing sensitivity remains scarce.[11,13]

RESULTS

Sensory processing differences are widespread among individuals with ASD, with studies suggesting that 80-90% of individuals with ASD face sensory processing challenges.[4] These sensory processing differences can significantly affect daily functioning, behavior, and participation in various contexts.

- Sensory Modulation: Sensory modulation involves regulating responses to sensory input, which varies widely among individuals with ASD. Sensory modulation challenges can be categorized into:
- Sensory Over-Responsively: Individuals may exhibit heightened responses, avoidance behaviors, and even fight-or-flight reactions. Environmental factors are often restricted to avoid triggers, which can limit participation in daily activities.
- Sensory Under-Responsively: Reduced awareness or delayed re-

sponses to sensory input may lead to safety concerns and engagement challenges. This type of modulation often involves seeking environmental stimulation to remain engaged.

• Sensory Seeking/Craving: This category includes behaviors marked by a high pursuit of sensory experiences. Individuals may frequently seek movement, tactile experiences, auditory stimuli, or visual fascination to satisfy sensory needs

• Sensory Discrimination: Sensory discrimination involves interpreting sensory details to differentiate between sensations, which can be a challenge in ASD. Key areas affected include:

• Tactile Discrimination: Individuals may struggle with identifying objects by touch, recognizing textures, applying appropriate pressure, or distinguishing temperatures and pain.

• Vestibular Discrimination: Difficulties in perceiving movement, position in space, and balance affect an individual's motor planning and feelings of security.

• Proprioceptive Processing: Challenges with body awareness, force regulation, and stability can impact movement control, postural alignment, and overall physical coordination.[7]

Sensory-Based Motor Disorders

Motor skills are often affected by sensory processing differences, leading to specific categories of sensory-based motor disorders:

• Postural Disorders: These issues impact core stability, muscle tone, balance, and endurance, affecting how individuals maintain alignment and respond to physical demands.

• Dyspraxia: Difficulties with motor planning, task sequencing, bilateral coordination, and visual-motor integration hinder the execution of new tasks and affect independence.[7,14]

Assessment Tools for Sensory Processing

Standardized Assessments

Standardized tools are critical for assessing sensory processing differences in a structured and measurable way:

• Sensory Integration and Praxis Tests (SIPT): A detailed evaluation tool providing age-specific norms and insights for treatment planning through multiple subtests.[15]

• Sensory Processing Measure (SPM): This tool includes home and school forms, allowing comparisons across environments to gauge social participation and sensory processing challenges).

• Sensory Profile-2: A comprehensive questionnaire available in caregiver, self-report, and teacher forms, analyzing environmental influences and sensory processing patterns.[16]

Clinical Observations

Clinical observations provide insight into how sensory processing affects behavior and functional abilities in natural settings:

• Postural Control: Observing both static and dynamic postures, antigravity movements, and environmental adaptability helps identify specific challenges in stability.

• Movement Patterns: Examining movement quality, preferred strategies, and avoidance behaviors highlights compensatory mechanisms that individuals may use.

• Sensory Responses: Noting initial reactions, habituation, recovery, and attention effects gives a rounded picture of sensory processing, emphasizing behavioral responses to sensory input.

Sensory Integration Interventions

Ayres Sensory Integration® (ASI)

ASI is a well-recognized approach emphasizing sensory experiences that provide a '*just-right challenge*' to foster adaptive responses.

• **Core Principles:**

o Just-Right Challenge: Activities are designed to match the individual's skill level, promoting engagement and success.

o Active Participation: Child-directed activities foster intrinsic motivation and meaningful engagement.

o Environmental Setup: Carefully selected equipment and organized spaces create safe, multisensory opportunities.

• **Implementation Strategies:**

o Vestibular Processing: Interventions use controlled movement activities such as linear or rotary movement to enhance postural control.

o Proprioceptive Input: Engaging in resistance exercises, joint compressions, and heavy work supports body awareness and motor planning.

o Tactile Processing: Discriminative touch exercises, texture exploration, and therapeutic touch build sensory awareness and support adaptive responses (6).[17]

Environmental Modifications

Modifying the environment can reduce sensory stress and promote engagement:

• Physical Environment: Adjustments to lighting, sound, and space organization reduce sensory overload and create more accessible environments.

• Sensory Tools: Using items like fidgets, weighted materials, texture options, and visual or auditory supports enables self-regulation and enhances focus.

Sensory Diet Programming

A sensory diet includes carefully structured sensory activities throughout the day to support self-regulation:

• Program Components:

o Schedule Development: Setting consistent timings, intensity, and duration for sensory activities.

o Activity Selection: Choosing activities that incorporate proprioceptive, vestibular, tactile, visual, and auditory inputs.

o Implementation Support: Training families, consulting with schools, modifying activities, and monitoring progress to ensure successful integration.[18]

Evidence-Based Outcomes

Research supports sensory integration interventions for improving

functional outcomes in individuals with ASD:

- Participation Improvements: Sensory processing interventions enhance academic engagement, social interaction, self-care independence, play skills, and family participation.
- Behavioral Impact: Improved regulation, attention, activity tolerance, transition success, and emotional stability.
- Skill Development: Gains in motor planning, coordination, balance, body awareness, and task completion.[19,20]

CONCLUSION

Sensory processing is an important stage in performance during which the organization and interpretation of received messages is done, and finally the final decision is made. Development in an efficient sensory-perceptual-motor processing system plays an essential role in the successful execution of a task and learning, and a defect in skills may be related to one of the sensory systems and lead to functional problems .many articles focusing on Sensory Processing Disorder in Autism Spectrum Disorders, attention deficit hyperactivity disorder, Developmental Coordination Disorder and learning disorder were examined. This disorder is caused by damage to areas of the brain, including the white matter, and Sensory Modulation Disorder (SMD (is the most common type. In these people, usually, skills deficits make it difficult for the child to play the role, and the most common interventions among them are based on sensory integration. Conclusion: Among the four groups, Sensory Processing Disorder is very common and can be the cause of many problems in their perceptual, motor, behavioral and academic skills.[21]

This research highlights the importance of understanding sensory processing in early development, Contributing valuable insights to pediatric rehabilitation and early childhood development. By emphasizing the need for awareness and support, the study aims to foster healthy sensory experiences.

Understanding unique problem behaviors and the significant role of SPD and parenting stress in problem behaviors could help occupational therapy clinicians plan interventions accordingly.

Also Communication skills, self-restraint, perceived parenting style, and sensory processing are predictors of school engagement in students. Among these variables, communication skills have the highest effect.[8]

Studies have addressed these risk factors to a considerable extent, less attention has been given to sensory processing, impulsivity, and substance abuse, which are significant factors in self-harm and suicide, as well as their predictive value for suicide. Further studies in this area are recommended.[12]

The relationship between emotional intelligence, executive functioning, and sensory processing has been independently studied. Children with lower emotional intelligence showed differences in sensory processing. The current research provides initial evidence of relations between emotional intelligence, stress management and sensory processing in children.[22]

Understanding unique problem behaviors and the significant role of SPD and parenting stress in problem behaviors could help occupational therapy clinicians plan interventions accordingly.[23] The current research provides initial evidence of relations between emotional intelligence, stress management and sensory processing in children.

Clinicians should be aware of differences in sensory experiences between adults on the spectrum and non-autistic adults and differences between men and women during assessment and subsequent counselling.[24]

Studies have addressed these risk factors to a considerable extent, less attention has been given to sensory processing, impulsivity, and substance abuse, which are significant factors in self-harm and suicide, as well as their predictive value for suicide. Further studies in this area are recommended.

It was concluded that as the levels of attachment styles, emotional reactions, negative behaviors, and avoidance of attachment increase in children with a history of prematurity, their behavioral problems increase as well. Conversely, increased positive adaptive development is associated with decreased behavioral problems. With increased interest in sensory processing sensitivity within communities, media, and healthcare systems, I concluded to author a relevant chapter derived from years (25 years) of studies and research as part of your esteemed book. I hope it paves the way for a new perspective and more principled treatment for occupational therapy clients.

CONFLICTS OF INTEREST

None.

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