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# Findings on sensory deficits in autism: implications for understanding the disorder

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## Abstract

Among the many lines of research related to autism, investigations of sensory dysfunction have recently gained attention. The objective of this article is to briefly review the main findings of sensory deficits in autism, raise possibilities of early identification research in the area, and discuss the significance of these sensory problems for the understanding of autism. A review of the scientific literature with regard to sensory problems in autism was performed. A review of autobiographical reports of high-functioning autistic individuals was also performed. This review showed that sensory problems have always been mentioned in the autism literature, but their relevance has been underestimated. Scientific research and autobiographical reports suggest a high prevalence of sensory problems in autism. Although not yet considered in the official diagnosis of autism, sensory problems appear to not only exert a considerable impact on the configuration of the disorder but also directly influence autistic persons in their daily lives. Such impairments may begin to be thought of as fundamental in autism. However, these characteristics deserve to be further investigated by researchers who are dedicated to the study of autism.

**Keywords:** autism; sensory problems; triad of impairment; early identification; autobiographical reports.

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## Introduction

Autism, also known as autism spectrum disorder or infantile autism, is a neurodevelopmental disorder with an innate biological basis and unknown etiology. No known specific biological marker for autism exists. Autism is believed to be caused by multiple factors including a genetic component.

The current diagnostic criteria for autism do not refer to any sensory deficits, but this does not suggest that such deficits do not play a key role in the disorder. The pioneering work on autism included descriptions of uncommon responses to sensorial stimuli (Kanner, 1943; Asperger, 1944, cited by Frith, 1991). The current literature suggests that the prevalence of sensory problems, although not universal or specific to autism, is relatively high. An average of 69–80% of autistic individuals present with these symptoms.

Diagnosis of autism is based on the criteria of the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition, text revision (DSM-IV-TR, 2002) and *International Classification of Diseases*, 10th revision

(ICD-10; World Health Organization, 1992). The specific criteria used by these two diagnostic manuals refer to a triad of impairment: (i) communication, (ii) social behavior, and (iii) restricted and repetitive patterns of behavior, interest, and activities that manifest before the age of 3 years.

The upcoming revision of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) to be released in 2013 proposes some modifications in the current diagnostic criteria, among which are (a) the new category name Autism Spectrum Disorder, (b) the reduction of the triad of impairment to two main areas (social communication and interaction; restricted, repetitive patterns of behavior, interests, or activities), (c) the addition of three severity classification levels (requiring very substantial support, requiring substantial support and requiring support), as well as (d) the inclusion of sensory criteria (hyper- or hyporeactivity to sensory input or unusual interest in sensory aspects of environment) under the “restricted, repetitive patterns of behavior, interests, or activities” domain (APA, 2011). This last item enhances the relevance of sensory aspects to autism as discussed in this paper. Various theoretical approaches have been proposed to explain autism, with cognitive and developmental approaches predominating. From a cognitive perspective (e.g., Theory of Mind), social behavior in autism is affected by impairment in innate cognitive mechanisms that allow humans to imagine and decipher the intentions, wishes, and mental states of

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others (i.e., to develop a theory of the mind; Lampreia, 2004). From a developmental perspective, autism is conceived as a deviation from normal development with a biological basis that compromises affection and the general capacity for social relationships. According to the latter approach and its main proponent (Hobson, 2004), innate impairment in emotional/affective/social sensitivity, responsiveness, and expressivity in the autistic baby causes the child to display deficits in the basic abilities of communication essential for the early process of emotional socialization characteristic of the mother/baby dyad. As a consequence, the autistic baby displays difficulties developing a mother/baby/object triad, leading to impairments in the development of joint attention and symbolization. In other words, a biological “failure” impedes the ability of the baby to normally relate socially and affectively beginning at a very young age, thus causing a deficit in the development of language and consequently cognition. Stern (1992) emphasizes the innate sensory abilities of the baby as the base for interpersonal relationships, so it is reasonable to think of autism from a sensory perspective.

The aim of this paper is to briefly review the main findings of sensory deficits in autism, raise possibilities of early identification research in the area, and discuss the significance of these sensory problems for the understanding of autism. It is proposed that from a developmental perspective, sensory problems may be fundamental in autism, contributing to the main deficits associated with the disorder (the triad of impairment) and, therefore, should be considered in early identification studies.

### **Hypotheses of sensory problems in autism**

In recent decades, different theories have been proposed that consider sensory abnormalities as the basis of the main symptoms of autism. Some authors refer to autism as a disorder of the senses in which every sense operates in isolation from the other senses, and the brain is not able to organize these stimuli in a meaningful manner (Hatch-Rasmussen, 1995). Other authors suggest that the behavioral problems associated with autism are a consequence of brain lesions that make them perceive the world’s stimuli differently (Delacato, 1974; Doman, 1986).

Some authors such as Hutt, Hutt, Lee, & Ounsted (1964) consider that some behavioral patterns in autism such as repetitive activities may be attributable to a deficit in the arousal-modulating system. The goal of these behaviors would be to reduce attention and unexpected and potentially uncomfortable stimuli. Ornitz and Ritvo (1968, as cited by Dawson & Lewy, 1989) further elaborated this hypothesis by suggesting that autism is characterized by fluctuations between overarousal and underarousal, resulting in a failure to modulate sensory inputs and an unstable perceptual experience. Dawson & Lewy (1989) suggested a complementary theory in an attempt to explain the relationship between the level

of arousal in an autistic child, attention deficits, and impairments in social–emotional development. The authors introduced the concept of an optimum level of stimulation. Studies indicated that when this level is exceeded in autistic children, they react in various ways including avoidance of visual contact, social distancing, ritualistic behavior, and motor stereotypes. Moreover, according to these authors, the difficulties of an autistic child establishing affective contact with another individual are at least partially attributable to a lower threshold of social stimulation, thus making it aversive. When this threshold is exceeded, the child becomes inattentive and may express negative affection. Additionally, this low threshold of social stimulation may also affect the social–emotional development of the autistic child while it impedes the early formation of attachment to others, expression of emotions, and interpersonal coordination of affection. The tendency of an autistic child to experience aversion and negative affection during social stimulation by the child’s caretaker interferes directly with the process of attachment. The interpersonal coordination of affection depends on the innate or early developed capacity of the baby to sustain attention to social stimuli and respond with affection, interest, and pleasure similar to those of the caretaker. The inability to emotionally engage with a peer impedes the autistic child to display affect attunement. A major part of the early process of emotional socialization occurs in the context of mutual satisfaction in face-to-face interactions between the baby and the caretaker, but the autistic child loses the opportunity to learn about emotions. Thus, the child does not benefit from social interaction, including the ability to articulate, modulate, and represent emotions.

Another sensorial hypothesis of autism concerns attention. Many autistic individuals exhibit superselective attention, focusing on a single element of complex stimuli (Lovaas & Newsom, 1976). The theory of superselectivity suggests that its mechanism is at least partially responsible for the difficulties behaving socially, learning to speak, and participating in traditional models of education. Auditory superselectivity appears to explain, for example, the language impairments in autism.

Attempts to explain autism from a sensory perspective have been numerous. Although no hypothesis can fully explain the disorder in sensory terms, a consensus appears to have been reached that these impairments contribute to the symptomatology of autism.

### **Scientific research**

Although sensory problems have never been directly included in the diagnostic criteria of autism (Gikovate, 1999), studies in this field have been performed more frequently since autistic individuals began to self-describe the importance of sensory problems in their lives. However, the most studies investigating sensory problems in autism were based only on questionnaires from parents and caretakers and did not directly evaluate autistic individuals. Several instruments have

been used to identify, through questionnaires, sensory problems, with the goal of creating a sensory profile for each individual. For example, the Sensory Profile (Dunn & Westman, 1995), Short Sensory Profile (Dunn, 1999), Sensory Profile Checklist-Revised (Bogdashina, 2003), Sensory Sensitivity Questionnaire-Revised (Talay-Ongan & Wood, 2000), Sensory Experiences Questionnaire (Baranek, David, Poe, Stone, & Watson, 2005), and Evaluation of Sensory Processing (Johnson-Ecker & Parham, 2000) have been used, with the first two being the most frequently utilized.

A review of the literature revealed that 70–80% of autistic children exhibit sensory abnormalities (Harrison & Hare, 2004). In a review of the literature based on clinical reports, Dawson & Waitling (2000) found that the prevalence of sensory problems in autism ranged from 30% to 100%. Baranek, David, Poe, Stone, & Watson (2005) reported similar results with a prevalence of sensory symptoms in autistic children of 69%. Miller (2007) reported a 78% prevalence of these symptoms in high-functioning autistic individuals.

Recent studies, in addition to reporting the existence of sensory problems in autism, have contributed important findings. Autistic individuals tended to present sensory deficits in more than one sensory modality (Leekam, Nieto, Libby, Wing, & Gould, 2007; Baker, Lane, Angley, & Young, 2008). Uncommon sensory responses also appear to be present in autistic children beginning at an early age. In a case study, Osterling, Meltzoff, and Kuhl (2000) reported that sensory problems such as hypersensitivity to touch could be seen in the first year of life in an autistic child. These observations are consistent with another study by Baranek (1999) that involved retrospective analysis of family videos. Sensory–motor measures, in addition to social deficits, were found to be potential indices of autism in the first year of life and thus should be considered in studies of the early identification of the disorder. In the study by Baranek (1999), autistic babies showed lower orientation toward visual stimuli, put objects in their mouth at a higher frequency, showed aversion to social touch, and needed a greater number of hints to orient them when their name was called.

Furthermore, evidence suggests that sensory problems in autism are more common during childhood than during adulthood (Baranek, Foster, & Berkson, 1997). Kern et al. (2006) reported that sensory problems in autism tend to be ameliorated with age. According to the authors, this is in accordance with reports from parents and caretakers who frequently describe a greater number of signs of sensory problems in their child during childhood. In another study, the same authors found a correlation between sensory problems in autism and the severity of the disorder in children but not adolescents or adults with autism (Kern et al., 2007).

### Autobiographical reports

One of the main sources of evidence with regard to sensory problems in autism comes from high-

functioning autistic individuals who self-report how they perceive sensory stimuli. Autistic individuals who wrote autobiographies consider the disorder a condition that is directly related to sensory processing and suggest that the cause of social and communication problems has a sensory–perception basis (Grandin, 1996; O’Neill, 1999; Williams, 1992).

More than 50 autobiographies have been published (Rose, 2008), in addition to unpublished reports that are posted on websites and blogs. A qualitative analysis of reports of uncommon sensory–perceptive experiences by high-functioning autistic individuals that are available on websites revealed that sensory–perceptive abnormalities are commonly described as the principal characteristics of their lives (Jones, Quigney, & Huws, 2003).

According to a survey of autobiographical reports, sensory alterations found in autism are not limited to hyper- or hyposensitivity (O’Neill & Jones, 1997). They also include fluctuations between these states, sensory distortions and shutdowns (e.g., vision or hearing stop working for a short while and return), sensory overload, difficulties processing information from more than one sensory channel at the same time, and difficulties identifying from which sensory channel the information has been perceived. Bogdashina (2003), another author dedicated to this subject, compiled information from the autobiographic reports of high-functioning autistic individuals and clinical observations of 20 sensory patterns in autism. Notable among these patterns were gestalt perception, fragmented perception, perception delays, hypo/hypersensitivity, and synesthesia.

With regard to gestalt perception, Grandin (2000) self-described great difficulty talking on the phone in a noisy environment and reported that if she tries to ignore the background noise, then the voice on the phone also disappears because all of the sound stimuli are perceived simultaneously as a single and inseparable entity. A very common situation for autistic individuals is when, for example, a minor detail of the environment is changed, such as when an object changes places. In this case, the scene perceived by autistic individuals becomes different and unfamiliar (i.e., it is a new gestalt that needs to be processed), which may cause stress.

According to Bogdashina (2003), fragmented perception is characterized by the inability of some autistic individuals to give contextual meaning to the smallest perceived detail. In this case, for example, a crowd is not perceived by an autistic individual as a gathering of people but rather as a collection of arms, legs, hair, mouths, and so on. Similarly, an autistic individual may recognize a person from stored sensory fragments instead of as a whole. The person is then recognized by the color of their clothes, their smell, or even their movements. Williams (1992), a high-functioning autistic individual, reported that her mother was a smell, her father was a color, and her brother was something that moved.

Delayed perception is characterized by delayed responses to stimuli. Williams (Bogdashina, 2003)

reported that, as a child, people thought she felt no pain or discomfort and that she did not want help or that she did not hear or see. This is because when some of these sensations were decoded to generate personal meaning in order for an appropriate response to be made, she was already 15 minutes, 1 day, or weeks or more removed from the context in which the experience occurred.

Autistic individuals commonly show hypo- or hypersensitivity that can be experienced in all sensory modalities. A high sensory threshold is characteristic of hyposensitivity, whereas a low sensory threshold is characteristic of hypersensitivity. Autistic individuals who exhibit tactile hyposensitivity, for example, may not feel a burn. Conversely, auditory hypersensitivity causes autistic individuals to feel uncomfortable with sounds that are normally tolerable or even imperceptible to non-autistic individuals, such as the sound of air conditioning. The same autistic individual may also very commonly present fluctuations between states of hypo- and hypersensitivity. For example, a child who appears to be deaf in certain situations may react strongly, as if in extreme pain, to auditory stimuli that are common in day-to-day life. Similarly, a favorite food may not be tolerated at certain moments.

Another phenomenon that appears in the self-reporting of some autistic individuals is synesthesia. Synesthesia occurs when stimulation of a sensory modality causes simultaneous perception in another, like an intersection between sensory modalities. All combinations of modalities may occur, and the senses of sight, hearing, and touch are the most frequently involved. Tammet (2007) reported that his synesthesia is unusual and complex in which he sees numbers as shapes, colors, textures, and movements. The number 5, for example, is experienced as a storm, whereas the number 1 is seen as a bright white light, such as the light from a flashlight. Numbers serve as his first language, even helping him to understand the emotions of others to the extent that each emotion refers to a predetermined number with consistent characteristics.

One of the major issues concerning autism is the fact that autistic individuals present a wide range of symptoms. Some speak, others do not speak, some present mental retardation, some do not present mental retardation, some have high skills, and others do not have these skills. Similarly, finding two autistic individuals with exactly the same sensory experiences is virtually impossible. Therefore, despite attempts to classify these experiences, one cannot overlook the particularities of each individual. It is possible that many other sensory experiences have not yet been self-described by autistic individuals or considered in the literature.

Both scientific research and autobiographical reports in this area have limitations and weaknesses (Iarocci & McDonald, 2006). Most scientific research uses questionnaires for parents and caretakers, which depend on the accuracy of memories. Another problem concerns the variability of the clinical profiles of autism spectrum disorder, which hinders the creation of homogeneous

research groups. The same difficulty is encountered when attempting to create control groups. Furthermore, the number of subjects used in research is usually very low. Importantly, autobiographical reports mostly originate from high-functioning autistic individuals with sufficient communication skills to describe their sensory experiences, and do not necessarily correspond to those of other autistic individuals.

## Research perspective

The importance of the early identification of infants at risk for developing autism has been increasingly emphasized, even though according to the ICD-10 and DSM-IV-TR, diagnosis of autism can only be officially made at 3 years of age. This is because early detection allows for early intervention that can also yield improvements in the clinical condition of the autistic individual. According to Lampreia (2008), the evaluation criteria in both the ICD-10 and DSM-IV-TR are very generic and do not allow early identification, which has led researchers to develop instruments that enable such identification. The main instruments for early identification are the Checklist for Autism in Toddlers (Baron-Cohen, Allen, & Gillberg, 1992) and Autism Diagnostic Interview-Revised (Lord, Rutter, & Le Couteur, 1994). However, these instruments only evaluate the risk of autism after 18 months. Nonetheless, the reports of parents of autistic individuals, analyses of family videos, and research on behaviors of joint attention (i.e., preverbal communication in typical development) point to even more precocious signs of autism.

According to Lampreia (2009), since 2005, prospective longitudinal studies have sought to identify signs of autism as early as 6 months of age. These studies have involved infants at high risk for autism (i.e., infants with autistic siblings because they have a higher risk of developing the disorder than the general population; Sumi, Taniai, Miyachi, & Tanemura, 2006). Longitudinal studies are based mainly on mother/baby/object triad interactions, taking into account quantitative discrete categories of joint attention (e.g., looking at the experimenter, alternating gaze, pointing, and following pointing) that develop between 9 and 15 months of age. These categories are considered precursors of language and markers of autism. Lampreia (2009) mentioned the importance of considering the precursors of these precursors of language that are found in mother/baby dyad interactions between birth and 9 months of age (i.e., dyadic basic communication skills such as contingency, reciprocity, anticipation, and turn-taking, that permit dialogue). However, according to this author, such dialogue is possible only if the baby is able to engage in affection (i.e., the baby is, according to Hobson [2004], sensitive and responsive to the emotional expressions of others), which does not seem to occur in infants at risk for autism.

The inclusion of categories that assess sensory problems in studies of the early identification of autism

could shed new light on both autism as a whole and its nature. According to the developmental approach, social relationships and consequently the entire development of the autistic child are prejudiced because of a failure in the ability to affectively engage as a baby. Perhaps thinking of a sensory nature of this failure is reasonable (i.e., affective engagement is possible only with a preserved sensory apparatus).

According to Stern (1992), the first experiences of a baby are sensory in nature, and it is through these innate sensory abilities, such as the preference for human voices over nonhuman sounds, that the baby begins to give the world meaning. A baby without these skills has limited opportunities to learn about the world (Brazelton & Cramer, 1990). A healthy sensory apparatus allows the baby to relate and interact socially from birth. According to DeGangi & Greenspan (1989), the ability to tolerate sensory stimulation occurs primarily in mother/baby interactions, and sensory tolerance is closely related to the regulation of arousal and development of early interaction skills. Babies who are unable to process sensory experiences appropriately are also unable to use them for learning. These babies often have maladaptive responses when forming emotional relationships throughout their development. A baby who is hypersensitive to touch, sound, and movement, for example, may resist physical contact when held, avoid eye contact, and not participate in face-to-face interactions.

Considering the importance of the sensory apparatus in the development of the baby and evidence of sensory deficits in autism even from the first year of life, as described above, recognizing sensory-perceptual problems in babies who exhibit signs of risk for developing the disorder is essential. Further reducing the age of diagnosis or risk identification of autism is important, especially because cumulative evidence suggests that early interventions can improve the clinical condition of autistic individuals (Baron-Cohen, Allen & Gillberg, 1992). For this reason, researchers must consider sensory problems in studies of early identification.

Sensory categories alone will probably not be able to detect possible risk factors for autism in the first year of life but may provide more useful information when combined with other categories in studies of early identification. An answered question about the inclusion of these categories in such studies concerns the limitations of the current instruments of sensory assessment. Only one known instrument of direct sensory evaluation exists, but it is still not widely used in research. The Test of Sensory Functions in Infants (DeGangi & Greenspan, 1989) may contribute to studies of early identification because it was specifically designed to determine whether—and the extent to which—a baby between 4 and 18 months of age presents sensory processing deficits.

Finally, prospective longitudinal studies with infant siblings of autistic individuals that include sensory categories may also be important for investigating

the involvement of these sensory deficits in the symptomatology of the disorder. The correlation between sensory dysfunction and different clinical manifestations of the disorder may help to identify subtypes of autism within the broad spectrum that encompasses varying degrees of severity (Lampreia, 2009).

## Conclusion and discussion

Although not yet included in the diagnostic criteria for autism, sensory problems have long been reported in the literature. Autobiographical reports from high-functioning autistic individuals have begun to be considered in studies of autism, and one can get a better idea of the importance of these problems in the daily lives of autistic individuals and how these deficits influence the configuration of the disorder.

Considering what has been presented in the present review, sensory problems may contribute to the main deficits associated with autism from a developmental perspective, which would lead to the triad of impairment. A reasonable assertion is that the sensory apparatus allows the baby to be sensitive and responsive to the emotions of others, emotionally engage, and interact with the surrounding world. If autistic children experience the world differently beginning at an early age because of a defective sensory apparatus, then to what extent do their experiences provide what is needed to establish interpersonal relationships and integrate themselves into social life?

Sensory problems may foster a new understanding of the triad of deficits in autism. In the area of social interaction, during early development, sensory problems may hinder the ability of babies with autism to participate in primary social interactions. In the area of communication, these deficits in relating socially and emotionally reflect deficits in language development (i.e., communication skills). Restricted, repetitive patterns of behaviors, interest, and activities may also be better understood based on sensory deficits. These patterns appear to reflect attempts to manage and control an environment perceived as chaotic by autistic individuals, and the ability to manage and control such environments worsens because of a lack of appropriate social and communication skills. Investigating the bases of this triad would be interesting as well as viewing these as a group of compensatory reactions caused by fundamental deficits of a sensory nature.

Some issues related to this topic still remain unresolved and require further investigation. If an imperfect sensory apparatus lies at the heart of some of the clinical characteristics of autism, preventing the baby's socioaffective development and consequently permitting the emergence of the symptoms of the disorder, then will all babies who have general sensory abnormalities be diagnosed with autism? The answer is likely "no." It is important to clarify that autism continues to be considered the result of a combination of unknown factors, but the possibility indeed exists that

these problems are among the principal fundamental deficits associated with this disorder and may be used as early indicators of autism.

Do all autistic individuals exhibit sensory problems? To date, although much evidence points to a significant number of autistic individuals with such problems, the evidence is inconclusive, which may be attributable to the limitations of scientific research and autobiographical reports mentioned above.

Given the evidence presented herein, sensory problems undoubtedly deserve greater attention on the part of professionals involved in the study, diagnosis, and treatment of autism. Sensory deficits should begin to be considered a fundamental part of the autism spectrum disorder. If sensory problems are later determined to not be among the main factors associated with autism, then they are sufficiently important to at least characterize a subgroup within the spectrum of the disorder. More research is needed with regard to the prevalence of these sensory problems in autism, their specificity, their manifestation in the disorder, and the relationship between sensory problems and the triad of deficits. The most significant finding to date may be that sensory problems occupy a space in the framework of autism. Acceptance of the sensory criteria in the next Diagnostic and Statistical Manual of Mental Disorders (DSM-5) would represent formal acknowledgment of the role of sensory issues in the Autism Spectrum Disorder.

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