

Review Article

Sensory integration and its importance in learning for children with autism spectrum disorder

La integración sensorial y su importancia en el aprendizaje de los niños con trastorno de espectro autista

A integração sensorial e a sua importância na aprendizagem das crianças com transtorno do espectro autista

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Abstract

Sensory integration is supported by multiple theoretical backgrounds that justify its importance in order to integrate the information coming from the different senses and to develop an adapted response to the environment. Scientific literature has also shown that there is a close relationship between sensory integration and learning. The aim of this article is to address the concept of sensory integration and its influence on learning, especially in children with Autism Spectrum Disorder (ASD). The methodology used was a narrative literature review, guided by the aim of the research. The databases consulted were: Web of Science, SCOPUS, Dialnet and RedaLyC. The main descriptors used were Sensory Integration, Learning and ASD. The results obtained support the idea that children with ASD often present difficulties in this sensory integration process, and that this is the explanatory cause of some of the learning and behavioural problems they present. It is hoped that this work will raise awareness of the need to consider this aspect during diagnosis and/or intervention in order to favour the genuine inclusion of children with ASD in society.

Keywords: Processing, Sensory; Autistic Disorder; Learning Disorders.

Resumen

La integración sensorial se apoya en múltiples antecedentes teóricos que justifican su importancia para poder integrar la información que procede de los diferentes sentidos y desarrollar una respuesta adaptada al entorno. Así también, la literatura

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científica ha demostrado que existe una estrecha relación entre la integración sensorial y el aprendizaje. El objetivo de este artículo es abordar el concepto de integración sensorial y su influencia en el aprendizaje, en especial, de los niños con Trastorno de Espectro Autista. La metodología utilizada ha sido mediante una revisión bibliográfica de tipo narrativa, orientada por el objetivo de la investigación. Las bases de datos consultadas han sido: Web of Science, SCOPUS, Dialnet y RedaLyC. Y los principales descriptores han sido Integración Sensorial, Aprendizaje y Trastorno de Espectro Autista (TEA). Los resultados obtenidos apoyan la idea de que los niños con TEA suelen presentar dificultades en este proceso de integración sensorial, siendo ésta la causa explicativa de algunos de los problemas de aprendizaje y conducta que presentan. Se espera que a partir de este trabajo se potencie una toma de conciencia de la necesidad de considerar este aspecto durante el diagnóstico y/o la intervención para así favorecer una auténtica inclusión de los niños con TEA en la sociedad.

Palabras clave: Procesamiento Sensorial, Trastorno Autístico, Dificultades del Aprendizaje.

Resumo

A integração sensorial é estudada por múltiplas abordagens teóricas que justificam a sua importância para integrar a informação proveniente dos diferentes sentidos e desenvolver uma resposta adaptada ao ambiente. Além disso, a literatura científica tem demonstrado que existe uma relação estreita entre a integração sensorial e a aprendizagem. O objetivo deste artigo é abordar o conceito de integração sensorial e a sua influência na aprendizagem, especialmente em crianças com transtorno do espectro autista. A metodologia utilizada foi uma revisão narrativa da literatura, orientada pelo objetivo da investigação. As bases de dados consultadas foram: Web of Science, SCOPUS, Dialnet, RedaLyC. Os principais descritores foram: Integração Sensorial, Aprendizagem e Transtorno do Espectro Autista (TEA). Os resultados obtidos apoiam a ideia de que as crianças com TEA frequentemente apresentam dificuldades neste processo de integração sensorial e que esta é a causa explicativa de alguns dos problemas de aprendizagem e comportamento que elas apresentam. Espera-se que este trabalho sensibilize para a necessidade de considerar este aspecto durante o diagnóstico e/ou intervenção a fim de favorecer a inclusão real das crianças com Transtorno do Espectro Autista na sociedade.

Palavras-chave: Processamento Sensorial; Autismo, Dificuldades de Aprendizagem.

Introduction

Within the explanatory theories on the neuropsychological bases of Autism Spectrum Disorders (ASD), disorders of sensory origin have been gaining momentum in recent years (Robertson & Baron-Cohen, 2017). The work initiated by Ayres in the 1970s emphasises this approach (Ayres, 1960, 1972).

This paper begins by addressing the concept of perception, understanding it as a complex mental process that the person constructs from their own experiences and

the information they receive from the outside through receptor organs arranged throughout the body (Fernández-Abascal et al., 2001).

In order to understand how the nervous system is responsible for collecting and interpreting this information, the idea of sensory integration is also introduced. A detailed explanation will be given from the moment of collection of isolated information from the senses to the moment the nervous system creates a response to adapt to the environment. For this purpose, the theory of sensory integration of Ayres (1972) will be addressed.

Subsequently, the evidence found on how people with ASD present dysfunctions in the sensory integration process is pointed out. These sensory peculiarities were included for the first time in 2013 as a diagnostic criterion in the Diagnostic and Statistical Manual of Mental Disorders, DSM-5 (American Psychiatric Association, 2013).

The article goes on to outline the sensory integration difficulties presented by people with ASD. For some authors, these difficulties are presented as dysfunctions, for others they are considered as sensory experiences, as they are not all dysfunctional, but simply different.

Therefore, the aim of this article is to address the concept of sensory integration and its influence on learning, especially in children affected by ASD.

Methodology

The methodology used for this article is based on a narrative literature search (Aguilera Eguía, 2014), guided by the objective established for this article, which is set out in the introduction. The keywords were derived from this objective: Sensory Integration, Learning and Autism Spectrum Disorder. As the selected articles were read, new keywords were added: Dysfunction and Perception. The bibliographic review was carried out in Spanish and English. The following databases were used: WOS, SCOPUS, Dialnet and RedaLyC. Subsequently, the results of each article were placed in a table according to the topic investigated.

Comments and Results

The concept of sensory integration: from sensation to perception

The human organism contacts the world around us through a complex network of receptors spread throughout the body. These receptors constantly send information to the nervous system about what is happening around and within us. Varela et al. (2014) comment that, though the five senses (sight, hearing, taste, touch and smell) are familiar to us, we also have the proprioceptive and vestibular systems.

Consequently, perception is the process by which the organism collects, interprets and understands information from the outside world through the senses (Bogdashina, 2007). Osorio (2018) defines this concept as a basic psychological process whereby a subject interprets the sensory, considering that there is a differentiation between the perception of external stimuli and their integration, to give a global sense to the experience to which we can lend meaning or symbolise.

Sherrington (1906), quoted in Swazey (1968), already made an initial classification of receptors, attributing an exteroceptive function to vision and touch, and a proprioceptive function to the vestibular system, muscle and joint receptors. Bogdashina (2007) later stated that the receptors responsible for sensing stimuli can be of two types, as presented in Table 1 below.

Table 1. Type of receivers.

Type of receivers	Function	Are divided into
Exteroceptive	They pick up stimuli from the outside.	Distance: Sight, Hearing, Smell Contact: Taste, Touch
Interoceptive	They pick up stimuli from within us. They report the position and movements of the body.	Proprioceptive System Vestibular System

Source: Own elaboration based on Bogdashina (2007).

These senses operate independently, sending information to the brain, which then processes, analyses and interprets it to provide a coherent response. This is what Varela et al. (2014) refer to as the three basic pillars of the sensory integration process: registration, interpretation and response.

Lázaro (2008) comments that each sense interacts with the rest, thus enabling a complete composition of who we are, where we are and what is around us.

In their work, Del Moral et al. (2013) state that the way in which each person processes the information received by the sensory organs depends on biological, environmental or genetic factors, and even on personal experience. This theory of sensory integration seeks an in-depth understanding of occupational behaviour and performance and, in particular, the factors that limit or interfere with this performance.

Based on neuroscience, Ayres (1972) established a theoretical framework in which she laid the neurophysiological foundations that direct, on the one hand, the sensory process and, on the other, its possible alterations. For this purpose, he established six premises in his work:

1. Based on the existence of plasticity in the central nervous system, intervention can have a direct effect on the brain;
2. There is an evolutionary sequence in the interactive sensory process;
3. The brain is organised hierarchically, although the neural systems are all integrated;
4. When an adaptive response occurs, the sensory integration function is set in motion. Sensory integration must function simultaneously with the adaptive response;
5. Children have a spontaneous tendency to develop sensory integration;
6. This is manifested in their participation in sensory–motor activities.

Ayres (2008) describes sensory integration as a puzzle that unites all the parts. She defines this concept as the neurological process that makes it possible to organise sensations from both the body and the environment, giving an adaptive response and enabling us to interact effectively with the environment around us. She considers it

the basis for further aspects of development: emotional, cognitive, communicative and motor. For this author, it is a form of organisation that entails arranging various parts to construct a whole so that something is integral when its parts work harmoniously as a unit.

In this theoretical framework, Ayres (2008) spoke of recovery of multisensory perceptions and adaptive responses generated by the nervous system that would follow the sequence shown in Figure 1.

Figure 1. Sequence of sensory integration.



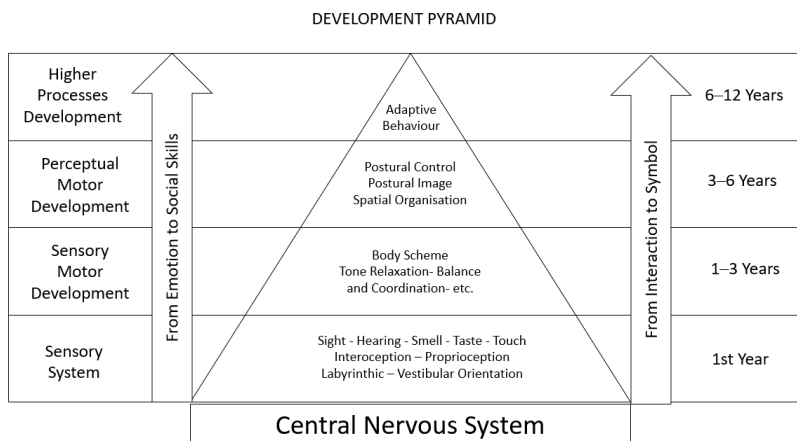
Source: Own elaboration based on Ayres (2008).

Del Moral et al. (2013) explain this sequence starting with registration, whereby external stimuli and those from the body enter through the tactile, olfactory, gustatory, visual, auditory, proprioceptive and vestibular senses. Subsequently, the nervous system regulates the intensity with which each stimulus arrives, using mechanisms of inhibition and excitation. The most important information is filtered out to avoid stimulus overload. Subsequently, in the discrimination phase, the stimuli are organised, and the different stimuli are interpreted in terms of their characteristics and level of importance. Finally, in the integration phase, the stimuli from different senses are brought together so that the brain can respond in the most adaptive way possible.

In summary, the theory of sensory integration (Ayres, 1972) was devised to describe, explain and predict the specific relationships between neurological functioning, sensorimotor behaviour and academic learning. This theory is defined as a process by which the brain receives, organises and interprets information from the senses and then responds. Miller et al. (2007) prefer to use the term sensory processing. Fröhlich (1993) contributed the concept of basal stimulation to refer to the process of perception–motoricity–perception, in which he understands perception as an active process of gathering information from the environment from which it derives meaning.

Frostig & Horne (1964) used terms such as perceptual motor or sensorimotor, giving importance to visual and auditory perception, without emphasising tactile, proprioceptive or vestibular perception. The latter are considered fundamental by Bundy et al. (2002) and reaffirmed in their latest book (Bundy & Lane, 2020). To understand the importance of these three systems, Lázaro & Berruezo (2009) propose to view human development as a pyramid with adaptive behaviour at the top and at the base, the nervous system, which would initiate its collection and processing of information through the tactile, vestibular and proprioceptive systems (see Figure 2). From these three systems, the child would reach the different evolutionary stages that would lead to the development of new concepts and skills.

Figure 2. Development pyramid.



Source: Own elaboration, based on Lázaro & Berruezo (2009).

This theory is already defended by Ayres (2008) when she argues that the sensory integration of each person is built on four steps, at the base of which are tactile, proprioceptive and vestibular sensations. Blanche (Personal Communication, Course "The Sensory Integration Perspective", Chile, May 2009) considers them fundamental. Not only are they the oldest systems and the first in the maturation process, they are the most influential in providing information about the body and influence the interpretation of information from the auditory and visual pathways. These three basic sensations integrate with others as the child progresses up the developmental ladder. Beaudry (2003) comments that individuals go through four stages (first, second, third and fourth levels). Each stage prepares for the next so that, at the end of the process, we have good sensory integration and the individual is able to respond appropriately to both social and academic demands.

Sensory integration dysfunction in children with ASD

Kanner (1943) described the fascination that certain children with autism presented in the face of sensorial stimuli such as light or reactions, including covering their ears against certain sounds and, though these manifestations were not considered necessary for a diagnosis of autism, some authors, such as Hirstein et al. (2001), already considered them expressions of associated disorders.

According to Rodríguez-Barrionuevo & Rodríguez-Vives (2002), people with ASD usually have significant difficulty in responding correctly to sensory stimuli as a consequence of a perceptual deficit, which, for Rimland (1964), was intrinsic to this disorder. However, though Gowen & Hamilton (2013) do not consider sensory impairments as central aspects of autism, they state that they are very frequently associated and have a significant effect on the quality of life of children with this condition. Indeed, for the first time the American Psychiatric Association's (2013) Manual of mental disorders DSM-5 includes this aspect in the sub-criterion hyper- or hypo-reactivity to sensory stimuli or unusual interest in sensory aspects of the environment, within the criterion of restricted and repetitive behaviour patterns, interests or activities.

Ayres (2008) argued that three main features can be observed that highlight sensory processing difficulties in children with ASD. The first is that children's brains register sensory information incorrectly. Thus, they may pay too much attention to some things and too little to others. Another key aspect is the difficulty they may have in modulating sensory information, especially at the tactile and vestibular level, which is why they may react defensively to tactile sensations and exhibit behaviours that indicate gravitational insecurity. The third and last aspect cited by this author is the difficulty at the cerebral level in wanting to do new or different things. In this vein, Frith (1989) had already argued that children with ASD, by definition, do not present difficulties in gathering information processes, which are carried out normally until this information is interpreted by the brain. This links with Peeters's (2008) postulate when he comments that most children have an innate predisposition to observe and explore the social environment. This predisposition enables the acquisition of certain developmental basics that help them to understand and relate to their environment. This ability that most children have presents difficulties in children with autism. Parents, professionals and even people with autism themselves have commented in numerous publications that sensorial difficulties are part of their way of being (Atwook, 1998).

The number of children presenting these difficulties varies according to study. Baranek et al. (1997) claim that 56% of children with ASD, aged 2–7 years, showed hypersensory responses to presented stimuli.

Atwook (1998) found that around 40% of children with ASD would have sensory processing difficulties. Tomchek & Dunn (2007) concluded in their studies that 95% of children with ASD, aged 3–6 years, had some kind of sensory processing dysfunction. Leekam et al. (2007) reported that more than 90% of children with ASD had sensory abnormalities. Costa & Lampreia (2012) found in their studies that the prevalence is significantly high at 78%. Omairi (2014) argues that between 45% and 96% of children with ASD have sensory processing difficulties.

In their study, Ausderau et al. (2014) found four sensory subtypes in children with ASD (mild, sensitive, moderate and extreme) who showed a level of stability of 91% for more than one year. They also concluded that sensory features in children with autism are frequent, but present heterogeneously.

With regard to age, Scharre & Creedon (1992) argue that many children with ASD present with sensory processing and motor control difficulties at some point in their early development. Leekam et al. (2007) suggested that these symptoms are more evident in younger children. However, Ben-Sasson et al. (2007) maintain the view that there is an increase in sensory processing difficulties in people with autism as they grow older.

On the other hand, Ausderau et al. (2014) argue that these symptoms remain stable throughout child development and are reflected in difficulties in establishing correct social relationships and cognitive development.

In relation to these research studies carried out according to the different sensory modalities, Imperatore & Reinoso (2007) found that, regarding touch, some studies have reported that the coexistence of tactile defence and stereotyped behaviours are frequently present in people with autism, an aspect we also find in Larson's (1982) work. Regarding neurophysiological studies, Barry & James (1988) concluded that children with ASD tend to present hyperresponsive responses. Samson et al. (2006) used evoked potentials and found that children with autism show lower levels of cortical activation than normotypical children in complex event-related auditory activities. Through the

use of evoked potentials, Cabrera et al. (2011) also concluded in their studies that a high number of children with ASD had alterations in the somesthetic system.

Regarding hearing, Lepistö et al. (2008) found patterns of auditory hypersensoryity in sounds involving a social component. Gomot et al. (2006) observed in their MRI studies how, in the face of new events, children with autism showed a lower level of activation in the temporoparietal and frontal areas, where changes and distribution of attention, among others, are processed.

Davis et al. (2006) found visual processing difficulties in processing face information. Snijders et al. (2013) found that the atypical steady-state gamma response to contextual modulation in subjects with ASD may capture the relationship between an imbalance in excitatory and inhibitory neural processing and atypical visual processing in ASD.

In their review study, Imperatore & Reinoso (2007) concluded that, although there is no agreement on the preferred pattern, all studies concur that children with ASD have a sensory processing difficulty, a situation recently reaffirmed by Allen & Casey (2017). Adrien et al. (1987) argue that many of these studies relate these difficulties to problems with postural control and praxis.

Types of sensory integration dysfunctions in autism

In their work, Parham & Mailloux (2001) talk about the concept of sensory integration dysfunction as a difficulty in discriminating, modulating, and coordinating and organising sensations in an adaptive way. This concept is composed of three main patterns:

1. *Dyspraxia*. There is difficulty in conceptualising, organising, planning and performing unusual sequences of motor actions, both in handling one’s own body and in handling objects. Individuals may be mistakenly considered as unwilling to work and to perform tasks with interest;
2. *Sensory discrimination disorder*. The difficulty to interpret the temporal and spatial data of sensory stimuli;
3. *Dysfunction of sensory modulation*. Sensory modulation is the ability to regulate and manage one’s response to sensory input in a gradual and adaptive manner (Mulligan, 2002). Dysfunction in sensory modulation is the difficulty to regulate the degree and intensity of response to stimuli in an adaptive manner.

Following the work of Imperatore & Reinoso (2007), Table 2 describes the different deficits in sensory modulation.

Table 2. Deficits in sensory modulation.

Hyposensoryity	There is a lack of response or insufficient response to sensory stimuli. It may affect one or more senses.
Hypersensory	There is an exaggerated response to sensory stimuli. It may affect one or more senses.
Mixed Pattern	There is a combined response.

Source: Own elaboration based on Imperatore & Reinoso (2007).

Following the work of Bogdashina (2007) and Del Moral et al. (2013), some of the basic characteristics of children with sensory modulation dysfunction for each of the senses are presented in Table 3.

Table 3. Basic characteristics of sensory modulation dysfunction for each of the senses.

Hyposensitivity	
Auditory	These children tend to make noises with their bodies or objects and shout to stimulate themselves. They slam doors open and closed. When they listen to music, they tend to do so at high volume. They tend to be very noisy when playing, and like noisy objects and noisy sequences.
Visual	They are fascinated by lights, reflections and bright colours and may even look at bright spotlights. They may run their hands around the edges of things to take in more information. They move objects or hands in front of their eyes.
Olfactory	They smell everything. They smell food before they eat. They are attracted to strong smells.
Taste	They put everything in their mouths. They eat anything. They regurgitate.
Tactile	They continually seek to touch, cuddle or caress.
Vestibular	They register vestibular stimuli poorly. They perform actions involving a lot of movement with great intensity. They turn around without getting dizzy and continually seek sensations. These children often present difficulties in postural control and in sequencing activities. They have difficulties with attention, fine motor skills and laterality, psychomotor and language delay, and academic difficulties.
Proprioceptive	Proprioceptive inputs are insufficiently registered by the brain. They often have low muscle tone and motor difficulties such as clumsiness and lack of coordination. They have poor body control and feel that their body is heavy. They constantly look for support and frequently change position.
Hypersensory	
Auditory	These children are particularly disturbed by loud sounds such as thunderstorms, rockets and noises made by people. When a sound bothers them, they tend to put their hands over their ears. They often show discomfort in crowds. They perceive frequencies that are unusual for others. They make repetitive noises to avoid hearing other sounds.
Visual	They are bothered by bright lights and tend to cover their eyes. They are frightened by flashes. They tend to look down. They have very acute vision and notice things that go unnoticed by others.
Olfactory	They can repel certain odours and avoid smells.
Taste	They may be repelled by certain tastes and may vomit easily. Problems with food. They use the tip of their tongue to taste food beforehand. They tend to eat very little.
Tactile	They experience tactile stimuli very intensely, even the most gentle. They often find contact uncomfortable. They have difficulties with hyper-reactivity in activities such as dressing, showering, eating, physical contact with people or with certain materials and textures. They react badly when they do not expect contact and try to avoid bodily contact, so they are in a permanent state of alert. They show discomfort when their head is covered, their hair is cut, their teeth are brushed, or their nails are cut.
Vestibular	They perceive the stimulus with great intensity and may present two types of reaction: gravitational insecurity and intolerance to movement. In both reactions, children react with fear, even anguish, to movement, which is why they avoid games and exercises that involve movement and balance, such as swings, slides, climbing in high places. They have poor balance.
Proprioceptive	They continually seek proprioceptive inputs in order to relax and tend to adopt strange postures. They can be confused with children who generate problems or with aggressive children, as they can present self-injurious behaviour or behaviour towards others, as they do not control their strength. They are constantly on the move and have difficulties with attention and academic performance.

Source: Own elaboration based on Bogdashina (2007) and Del Moral et al. (2013).

Sensory integration and learning

Ayres (1960) concluded in her research that the child acquires their own motor control following innate sequences influenced by information from the outside. This motor control depends on the neuromotor system and on the help of the proprioceptive and vestibular systems.

Fisher et al. (1991) understand that the process of sensory integration is supported by a theoretical construct that describes the relationship between neurobiology and the environment. Bundy et al. (2002) also argue that learning depends to a large extent on individuals' ability to receive and analyse sensations from movement and the environment, and how they are able to use this to plan and organise their own behaviour. In this sense, Imperatore (2005) comments that people who have presented hyposensoriality in the vestibular, proprioceptive and modulation systems during childhood are seekers of sensations and high-risk activities in adulthood.

Gil et al. (2008) argue that in the early childhood development stage children rely on their bodies and movement as the main vehicles that bring them into contact with the reality around them, thus enabling them to gain their first insights into the world in which they are growing and developing. Similarly, Greedfield (2007) and Rodríguez (2009), cited in Lázaro et al. (2010), argue that the brain can only know the world and its own mind through its own body.

In a review of the concept, Smith et al. (2007) argue that, through an understanding of the term sensory integration, specific strategies can be developed to intervene in sensory difficulties that are interfering with a person's functional development. Ortiz (2014) comments that the theory of sensory integration entails stimulating and improving the neurophysiology of stimulus processing, thereby enhancing the organisation of the sensation of one's own body and the surrounding environment. In the same line, Wuang et al. (2020) indicate that interventions aimed at improving bodily functions are indispensable.

Lázaro (2004) argues that proper sensory and perceptual-motor integration contributes greatly to learning, so that failures in this integration process hinder learning. León (2015) argues that children with sensory integration difficulties struggle to respond to their environments in an adaptive way and find it difficult to move to a more regulated state of alertness.

Along the same lines, Varela et al. (2014) comment that these children grapple to make sense of everything that happens around them.

Wertheimer (1912) already considered that psychological activities such as learning, memory, or thinking depend on a correct perceptual organisation of stimuli, which is supported by McCormick et al. (2016) when they argue that the atypical integration of sensory stimuli hinders academic and social learning. In this regard, Carte et al. (1984) found that 70% of students with learning and behavioural difficulties have sensory integration difficulties. Beaudry (2006) comments that many children with sensory immaturity also have difficulties with language, attention and motor control. Thus, in a longitudinal study, Parham (1998) argued how sensory integration difficulties can be used to predict academic performance. In the same vein, Bravo (2004) comments that perception is the basis of learning, since it is thanks to perception that the information that reaches us through the senses is interpreted, allowing us to create cognitive concepts.

Ayres (2008) outlined the following aspects to be considered in the relationship between sensory integration and learning:

- Sometimes learning and behavioural difficulties may be based on incorrect sensory integration. Even children with a normal IQ, or even higher, may have difficulties at school, both academically and behaviourally, regardless of the family environment in which they develop.

- Some of the common symptoms that may lead us to suspect a dysfunction in sensory integration would be:
- Hyperactivity or distractibility
- Behavioural problems
- Speech and language delays
- Problems with muscle tone and coordination
- Learning difficulties in school, such as difficulties in literacy or mathematics
- Fine and gross motor difficulties.
- These difficulties also make the pupil feel clumsier and disorientated at playtime, and they may be the victim of teasing and isolation from their classmates, generating a feeling of inadequacy that can be generalised to all classroom work.
- Sensory and motor stimulation during the early years of childhood help to create new neural connections that allow for better integration of sensory and motor processes.

Beaudry (2006) states that many of the behavioural disorders and/or motor incoordination could be based on difficulties in sensory processing, and attaches vital importance to early detection processes to prevent possible learning difficulties. Intervention could result in an improvement in a person's quality of life at a later age. Chuang et al. (2012) reinforce this concept in their studies by finding a direct relationship between difficulties in sensory processing in children with ASD and their behavioural manifestations. For Tudela & Abad (2019), the self-injurious and self-stimulatory behaviours presented by some people with ASD are mainly due to difficulties in their sensory processing. On the other hand, and along the same lines, Lee et al. (2018) confirm the value and efficacy of a sensory integration programme in reducing stereotypical behaviour and improving sensory processing. They suggest that vestibular–proprioceptive activities may be more effective in treating stereotypical behaviour compared to tactile activities.

Caicedo (2017) argues that there is a significant relationship between sensory integration and academic development. Serna et al. (2017) add that sensory integration difficulties not only affect academic but also social and emotional development. At the same time, these authors observe in their work that children who have difficulties in vestibular system development also experience difficulties in reading and writing, mathematics and sport. Erazo (2017) concludes that sensory integration continues to be an important variable in academic performance. De Abreu (2018) corroborates this by arguing that children who score low in sensory integration also score low in academic achievement. Navarrete (2018) argues that none of the classical learning theories integrate sensory strategies that help in perception management, which is key to the construction of learning. The author argues that the teaching–learning process ceases to be functional in the classroom when the teacher uses a single strategy for all students; therefore, in the opposite sense, she argues that sensory strategies are flexible and adaptable to all academic levels, and when carried out from a didactic approach, they produce an impact on student learning. However, research in this area is scarce. Cardoso & Blanco (2019) therefore encourage studies that both measure the fidelity of sensory integration and verify the applicability of sensory strategies in the activities proposed in the classroom to support school inclusion of students with ASD.

Summary and Conclusions

This review aimed to address the concept of sensory integration and its influence on learning, especially in children with ASD. Studies related to basic psychological processes indicate that human perception is a mental construct that is produced from the reception of stimuli received by the nervous system and from one's own personal experiences. When the brain receives these stimuli, it carries out a process that results in the elaboration of a response. To the extent that this response is adaptive, it is considered that there has been a correct sensory integration.

The literature supports the idea that children with ASD often present difficulties in this process of sensory integration, and that this is the explanatory cause of some of the learning and behavioural problems they present. Understanding and addressing the sensory integration processes in the people who make up this group are of paramount importance because they influence educational and social inclusion.

In our opinion, two developments in the last decade highlight the crucial role of sensory integration processes in autism. On the one hand, inclusion as a diagnostic criterion in the DSM-5 Manual (American Psychiatric Association, 2013) and, on the other, the search for interventions based on scientific evidence to improve sensory integration processes in this group. In relation to this latter aspect, it should be noted that, for the first time, in 2021, Ayres' sensory integration approach was included as a practice based on scientific evidence by an international organisation such as the National Clearinghouse for Autism Evidence and Practice (NCAEP) (Hume et al., 2021).

Our work provides a narrative synthesis of the need to address processes related to sensory integration in order to support the awareness-raising process for professionals and families who care for children with ASD, and thus favour the stimulation of these cognitive and physiological processes that are so important in the autonomous development of children with ASD in everyday activities.

The limitations of the present work include the limited focus of the study, as it has been centred on establishing the conceptual delimitation of sensory integration, the peculiarities of sensory integration processes in people with ASD and the relationships between sensory integration processes and learning. However, we consider that this is a very broad field to investigate, as more research is needed on the neurological, physiological and psychological studies that can explain the problems of sensory input, integration and output in people with ASD (Kilroy et al., 2019). These studies should be accompanied by research on assessment tools to explore the peculiarities of sensory integration difficulties in these people (Jorquera-Cabrera et al., 2017), and to find intervention techniques and procedures based on scientific evidence that enable the stimulation and development of the complex sensory integration processes that seem to be affected in people with ASD (Schaaf et al., 2018).

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