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Language acquisition in Autism Spectrum Disorder: Strategies for early diagnosis and intervention – A review of literature

Aquisição da linguagem no Transtorno do Espectro Autista: Estratégias para diagnóstico e intervenção precoce – Uma revisão de literatura

Adquisición del lenguaje en el trastorno del espectro autista: Estrategias para el diagnóstico e intervención temprana – Una revisión de la literatura

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Abstract
Autism Spectrum Disorder (ASD) is characterized as a neurodevelopmental disorder, with deficits in communication and social interaction with a defined diagnostic criteria. Although the main diagnosis is made by the pediatric neurologist and/or the psychiatrist, the clinician ability to refer children with a suspected condition, based on language differences to their neurotypical peers, is crucial for shortening the diagnosis time. Because it is a neurodevelopmental condition, the earlier the interventions, the better the responses and prognosis in development. In this literature review, we aim at an updated discussion about the role of ASD on the child brain, the language development differences in neurotypical and ASD children, the emerging early diagnosis technologies, and the early intervention therapies available for verbal and non-verbal ASD children's, as well as adults, with a final focus on music therapy.
Keywords: Autism spectrum disorder; Language development; Child Language; Music therapy; Psychotherapy; Early intervention; Early diagnosis.

Resumo

O Transtorno do Espectro Autista (TEA) é caracterizado como um transtorno do neurodesenvolvimento, com déficits de comunicação e interação social com critérios diagnósticos definidos. Embora o diagnóstico principal seja feito pelo neurologista pediátrico e/ou pelo psiquiatra, a capacidade do médico de encaminhar crianças com uma condição suspeita, com base nas diferenças de linguagem para seus pares neurotípicos, é crucial para encurtar o tempo de diagnóstico. Por se tratar de uma condição do neurodesenvolvimento, quanto mais precoces as intervenções, melhores serão as respostas e o prognóstico no desenvolvimento. Nesta revisão de literatura, tem como objetivo a discussão atualizada sobre o papel do TEA no cérebro infantil, as diferenças no desenvolvimento da linguagem em crianças neurotípicas e com TEA, as tecnologias emergentes de diagnóstico precoce e as terapias de intervenção precoce disponíveis para problemas verbais e não-verbais. Crianças com TEA, bem como adultos, com foco final em musicoterapia.

Palavras-chave: Transtorno do espectro autista; Desenvolvimento da linguagem; Linguagem infantil; Terapia musical; Psicoterapia; Intervenção precoce; Diagnóstico precoce.

Resumen

El Trastorno del Espectro Autista (TEA) se caracteriza por ser un trastorno del neurodesarrollo, con déficits en la comunicación y la interacción social con unos criterios diagnósticos definidos. Aunque el diagnóstico principal lo realiza el neurólogo pediátrico y/o el psiquiatra, la capacidad del médico para derivar a los niños con una afección sospechada, basándose en las diferencias de lenguaje, a sus pares neurotípicos, es crucial para acortar el tiempo de diagnóstico. Por ser una condición del neurodesarrollo, cuanto más tempranas sean las intervenciones, mejores serán las respuestas y el pronóstico en el desarrollo. En esta revisión de la literatura, enfatizamos la discusión sobre el papel del TEA en el cerebro infantil, las diferencias en el desarrollo del lenguaje en niños neurotípicos y con TEA, las tecnologías emergentes de diagnóstico temprano y las terapias de intervención temprana disponibles para niños verbales y no verbales. TEA tanto para niños como para adultos, con un enfoque final en la musicoterapia.

Palabras clave: Trastorno del espectro autista; Desarrollo del lenguaje; Lenguaje Infantil; Terapia musical; Psicoterapia; Intervención rápida; Diagnostico temprano.

1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder in which fundamental processes of socialization, communication and learning are disrupted. ASD covers a range of different clinical manifestations and levels of severity. It is estimated that around 1 in every 100 children has an autism spectrum disorder worldwide, according to the WHO (Zeidan et al., 2022). The prevalence rate may vary according to the diagnostic criteria and the availability of health services. It is diagnosed four times more frequently in males than in females (Zeidan et al., 2022). The exact cause of autism is still unknown. It is known that there are genetic influences, such as the presence of parents with ASD and the analysis of concordance in identical twins, in addition to environmental factors. Furthermore, the suspicion generally arises early in childhood, mostly in the first years of life, with an essentially clinical diagnosis (Orefice, 2020).

Usually, the first symptoms are manifested in the first year of life, but in most cases, ASD symptoms are only consistently identified between 12 and 24 months of age. In general, more serious cases are discovered earlier, which helps in the development of the individual as alternatives and therapeutic methods are sought more quickly, thus reducing damage. Unfortunately, the diagnosis of ASD is mostly late. Therefore, it is important to recognize early signs that may indicate changes in the child's development (Moriuchi et al., 2017).

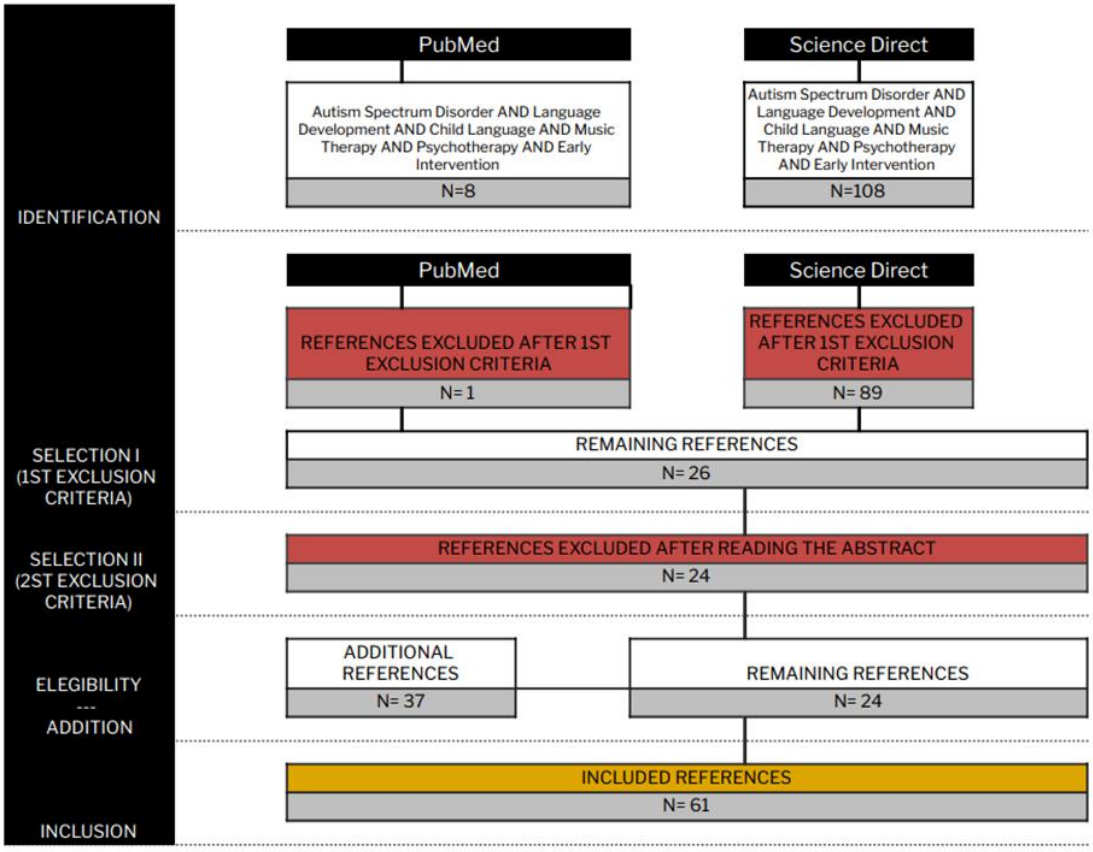
Early intervention is essential in the presence of multidisciplinary follow-up by the family doctor, pediatrician, neurologist, psychologist, psychopedagogue, speech therapist, physical educator and occupational therapist. Therefore, therapeutic individualization is extremely important, with the possibility of using ABA therapy, speech therapy, occupational therapy with an emphasis on sensory integration, physical education and music therapy (Green et al., 2020).

2. Methodology

A narrative literature review was conducted in the Medline Databases, from 2010 to 2022, on language acquisition in autism spectrum disorder. In PubMed, eight (8) articles were found by the Mesh descriptor Autism Spectrum Disorder AND

Language Development AND Child Language AND Music Therapy AND Psychotherapy AND Early Intervention, and 108 were found on the ScienceDirect database, of which 19 were selected, after the first set of criteria — exclusion of titles not addressing to the topic "language acquisition and/or autism disorder and/or early interventions", articles not included in the search period 2010-2022, as well as non-English articles. The second set of criteria — exclusion of the abstracts not addressed to ''language acquisition and/or autism disorder and/or early interventions'', was applied, by which 92 articles were excluded. Moreover, although not the focus of the population study, some articles (52) were also included when addressing language acquisition. Other articles that did not contemplate these conditions were excluded. To ensure content saturation, the authors checked the included research references and related reviews on topics to identify missing publications. Furthermore, 116 articles from PubMed and ScienceDirect were manually screened and added according to their relevance in the qualitative evidence synthesis. Of the total, 24 original articles remained (Table 1).

Table 1 -



Articles addressing to Autism Spectrum Disorder, Language Development, Child Language, Music Therapy, Psychotherapy and Early Intervention. Source: Authors.

Table 2.

Study (autor/ ano)	Title	Objectives	Significant findings
Karin Mössler, 2019	The Therapeutic Relationship as Predictor of Change in Music Therapy with Young Children with Autism Spectrum Disorder	This study examined whether the therapeutic relationship in music therapy with children with Autism Spectrum Disorder predicts generalized changes in social skills.	Music therapeutic is an important predictor of the development of social skills, as well as communication and language specifically.
Hayoung A Lim, 2010	Effect of "developmental speech and language training through music" on speech production in children with autism spectrum disorders	The study compared the effect of music training, speech training and no-training on the verbal production of children with Autism Spectrum Disorders (ASD).	Results showed that participants in both music and speech training significantly increased their pre to posttest verbal production.
Istvan Molnar-Szakacs, 2006	Music and mirror neurons: from motion to 'e'motion	The study proposes that some aspects of musical experience may be mediated by the human mirror neuron system.	The ability to integrate and represent cross-modal information, the mirror neuron system may provide a domain-general neural mechanism for processing combinatorial rules common to language, action and music, which in turn can communicate meaning and human affect.
G A Thompson, 2014	Family-centred music therapy to promote social engagement in young children with severe autism spectrum disorder: a randomized controlled study	This study investigated the impacts of FCMT on social engagement abilities.	FCMT improves social interactions in the home and community and the parent-child relationship, but not language skills or general social responsiveness.
Shulamit Epstein, 2020	Music Therapists' Perceptions of the Therapeutic Potentials Using Music When Working With Verbal Children on the Autism Spectrum: A Qualitative Analysis	This qualitative study aimed to explore music therapists' descriptions of the use of music and its therapeutic potential in their work with children on the autism spectrum who have verbal skills.	Musical interactions help to create a shared experience between the child and therapist that are perceived to help the child's different forms of regulation, continuity, and vitality within the play.
Hayoung A Lim, 2011	The effects of music therapy incorporated with applied behavior analysis verbal behavior approach for children with autism spectrum disorders	This study explored how the perception of musical patterns incorporated in ABA VB operants impacted the production of speech in children with ASD.	Music can be incorporated into the ABA VB training method, and musical stimuli can be used as successfully as ABA VB speech training to enhance the functional verbal production in children with ASD.
Tatiana Dănciulescu, 2023	Piano with a twist: A pilot study exploring the preliminary effects of a piano therapy program for children with autism spectrum disorder	The current pilot study aims to present a new music-based intervention – the Piano Therapy program – and to explore its effects on social communication, motricity, self-care, and adaptive behavior skills in children with ASD.	These preliminary results have clinical implications for practitioners and bring new evidence about the beneficial effects of a piano-based intervention in individuals with ASD.

Thomas Rabeyron, 2020	A randomized controlled trial of 25 sessions comparing music therapy and music listening for children with autism spectrum disorder	This study examines if MT is more effective than simply listening to music for children with ASD.	The findings suggests that music therapy is more efficient than music listening for children with ASD.
Supritha Aithal, 2020	Resilience enhancement in parents of children with an autism spectrum disorder through dance movement psychotherapy	In this study, the lived experiences of parents of children with ASD who participated in six DMP sessions were analysed from a hermeneutic phenomenology perspective.I	The qualitative findings of this study contribute to the existing body of information by offering a theoretical framework that explains the benefits of DMP for nurturing resilience in parents of children with ASD.
Jung Eun Park, 2021	Effectiveness of creative arts-based parent training for parents with children with Autism Spectrum Disorder	The mixed-method study evaluated the effectiveness of the 6-week long Creative Arts-based Parent Training program for parents with children with Autism Spectrum Disorder (ASD).	The program showed the promise of group-based supplementary parent training in parent-mediated, creative arts–based intervention as an early intervention treatment for children with ASD.
Faith Thayer, 2021	An evaluation of a developmental individual differences relationship-based (DIR®)- creative arts therapies program for children with autism	The study evaluated whether a DIR-based CAT program met its stated goals to stimulate individualized social-emotional growth for children with ASD.	The study found moderate evidence supporting the proposition that children who participated in a DIR®-based creative arts therapy program experienced increased and improved social/emotional skills.
Tamar Dvir, 2020.	The body communicates: Movement synchrony during music therapy with children diagnosed with ASD	This study examines the synchrony of body rhythms between children with ASD and their music therapists.	The results revealed higher levels of synchrony between the therapists and children when the latter were using repetitive rhythmicity that occurred 2 or more times per second.
Olivia Brancatisano, 2020	Why is music therapeutic for neurological disorders? The Therapeutic Music Capacities Model	This review illustrates how seven capacities of music make it a highly effective tool for neurorehabilitation in the context of four disorders: dementia, PD, stroke and ASD.	The TMCM provides a novel framework for conceptualising the essence of music's therapeutic value for neurological disorders, and has applications for all disadvantaged communities.
Roland M. Dardennes, 2011	Treating the cause of illness rather than the symptoms: Parental causal beliefs and treatment choices in autism spectrum disorder	To explore the relationship between causal beliefs on autism (CBA) and treatment choices.	Causal beliefs are associated with treatment choices
Alaine E. Reschke-Hernández, 2011	History of Music Therapy Treatment Interventions for Children with Autism	History of music therapy research and treatment of children with autism.	Provide an understanding of the evolution of music therapy for children with autism
Celine Schweizer MA, 2014	Art therapy with children with Autism Spectrum Disorders: A review of clinical case descriptions on 'what works'	Our study explored academic and practice-based sources with the aim to identify core elements of art therapy for normal/high intelligent target group children up to 18 years.	Art therapy might be able to have a positive contribution to both problem areas of ASD children

Summary of the main studies used for the results in this review, and their main objectives and findings

Source: Authors.

3. Results and Discussion

3.1 ASD on the brain

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder that affects the development of social communication with restricted and repetitive behavior patterns. The impairment of autistic individuals can vary widely, and it is common that there are structural and functional differences in the brain of the person with ASD compared to that of neurotypical individuals, including: abnormal cortical surface growth and volume increase between 12 and 24 months of age (Zeidan et al., 2022), increased connectivity between the anterior insula and sensorimotor areas and the amygdala, increasing sensitivity to aversive sounds and tactile information. Interestingly, it was recently discovered that increased sensitivity to peripheral stimuli was correlated to gene mutations at the peripheral sensory neurons, adding the notion that higher sensitivity to touch in ASD occurs not only as a mutation in the neurons at the brain (top to bottom) but also as in peripheral neurons (bottom to top) (Orefice, 2020). These differences may help explain the social, communication and sensory processing difficulties that many autistic individuals face, helping to develop new therapeutic approaches.

Neural connectivity refers to the way different parts of the brain communicate, and is affected by dysregulation of synaptic activity. In this context, ASD has been conceptualized as a disturbance in long-distance cortical and subcortical connectivity, through malformed circuits that lead to impairment in successful sensory integration. Functional magnetic resonance imaging studies show alterations between connectivity in the networks responsible for processing socioemotional information, which involves facial recognition and by a lower activation of the fusiform cortex which may explain their difficulties in understanding, recognizing and responding to emotions and social cues. Interestingly, toddlers who later develop ASD have typical interests in faces and eyes (Moriuchi et al., 2017) at six (6) months of age. Knowing that sensory inputs are the basis for the development of higher order social and cognitive skills (bottom-to-top), this inability to synthesize multiple sensory inputs alters the ability to form metaphors and complex cognitive representations, necessary to effectively abstract, understand language and respond to social cues (Green et al., 2020). Furthermore, magnetoencephalography (MEG) studies demonstrated complex connectivity patterns in the somatosensory cortex, reducing the sensorial feedback (top-down) and increasing the feedforward (bottom-up) (Hari & Forss, 1999). Thus, synaptic dysfunction is one of the main mechanisms underlying ASD, affecting the function of neuronal connections and the brain's ability to process information properly, which can cause a disturbance of behavior and cognition. According to Bristy (2022) (Taniya et al., 2022), autistic individuals have mutations in genes that regulate the formation and function of synapses, as well as alterations in synaptic proteins (the Neuroligins and neurexins (Südhof, 2008)), causing a reduction in the number of connections between neurons and their ability to transmit information properly. The study of the molecular bases of these dysfunctions, through the analysis of molecular biomarkers, highlights that the dysfunction of synaptic signaling pathways is presented in several pathways such as fodatidilnositol-3-kinase, the nerve growth factor pathway, dopamine, and glutamate, highlighting the role of abnormal regulation of its receptor and the alteration of the excitation-inhibition balance (Spooren et al., 2012).

Importantly, molecular and functional changes are not uniform in all autistic individuals (different phenotypes); moreover, epigenetic regulation is an important mechanism underlying synaptic dysfunctions. Thus, different molecular profiles may be associated with the different autistic individuals (Spooren et al., 2012). These molecular alterations lead to functional modifications, affecting the connectivity between different brain regions and impairing the integration and coordination of neuronal activity, as well as reducing synaptic plasticity, which causes a difficulty in adapting to diverse experiences and environmental changes (Taniya et al., 2022).

3.2 Language development in children with Autism Spectrum Disorder

Delayed language acquisition is a common characteristic of children with ASD (Hartley, 2019), as they typically start to speak at 38 months on average, while typically developing (TD) children usually have their first words by 12 months. Qualitatively, ASD children have a much smaller vocabulary than their TS peers and may produce 'echolalic' sentences.

Comprehension of language is also impaired, as they understand fewer words than their peers and have a more impaired receptive than expressive language. Interestingly, almost all ASD children have an impaired understanding of pragmatics (how language is socially used), a trait generally linked with Theory of mind and deficits in executive functioning (Akbar et al., 2013). Also, they tend to make more morphological errors and generate less syntactically complex and spontaneous language than they matched in the control group (Hartley, 2019).

First, it should be borne in mind that the development of language in children with ASD depends on intellectual and social development and may be from verbal or non-verbal communication. It is also worth remembering that child language develops through four basic conditions. The first, being the presence of interest, associated with the desire to play, because the author describes that emotionally disorganized children have greater difficulties in learning speech; the second says that it is necessary to have at least one sensory motor system without alteration, whether audiovisual or visuomanual; third, it would be necessary for the child to be in an environment where language is inserted in the routine and fourth, it would be a way of teaching the language with grammatical mechanisms that would help the child to discover how words are organized and the meanings attributed to them (*Silva, Romero, 2020*).

3.3 The importance of Early diagnosis

As recommended by the American Academy of Pediatrics (Hyman et al., 2020), universal screening in the second year of life for ASD is highly recommended due to the significant improvement of the outcome for neurodevelopment. However, the emergence of symptoms to a clinically identifiable pattern tends to occur only in the second year of life (Klin et al., 2020). As early intervention normally requires the diagnosis of ASD, the chances for better outcomes depending on early stimulation and treatment are threatened by the constraints of clinical diagnosis, with the median age being 4½ years in the US.

In the first two years of human development, there is a continuous increase in brain transformation. The size doubled in the first year, increasing another 35% by year three. The synaptic density (experience-dependent brain specialization marker) quadruples in the first year, reaching 200-300% greater than an adult by the end of the third year (Shultz et al., 2018). Of note, longitudinal gene expression associated with synaptogenesis over the first two years of life is characterized by maximal values across the 6-to-12-month window, then drastically decreases after 15 months, a long time before ASD symptoms emerge, and the condition can be reliably diagnosed (Shultz et al., 2018).

The classic notion of critical periods (CP) defends a window in which a sensory system is open to structure the inputs from the environment by experience-induced plasticity in early life. The opening of these CPs is defined by the maturation of the circuits (when they are ready to receive sensory inputs) and the environmental inputs themselves. The onset, duration, and closure of these windows depend on the biological and environmental manipulations (sensory stimulation, synapse pruning, environment enrichment, molecular brakes), indicating the importance of early stimulation for sensorial development in toddlers (Werker & Hensch, 2014). The advantage periods of plasticity is that it allows the developing brain to dynamically adapt in response to important environmental cues. There is increasing evidence that positive environmental factors, such as warm and highly responsive caregiving, support healthy brain development. Unfortunately, it also makes developing neural circuitry more vulnerable to adversity pre- and post-natal. Moreover, the effect of adverse events, including inflammation and chronic environmental stress, is most disruptive to neurocircuitry when neural structures and neural networks are actively developing (DeMaster et al., 2019).

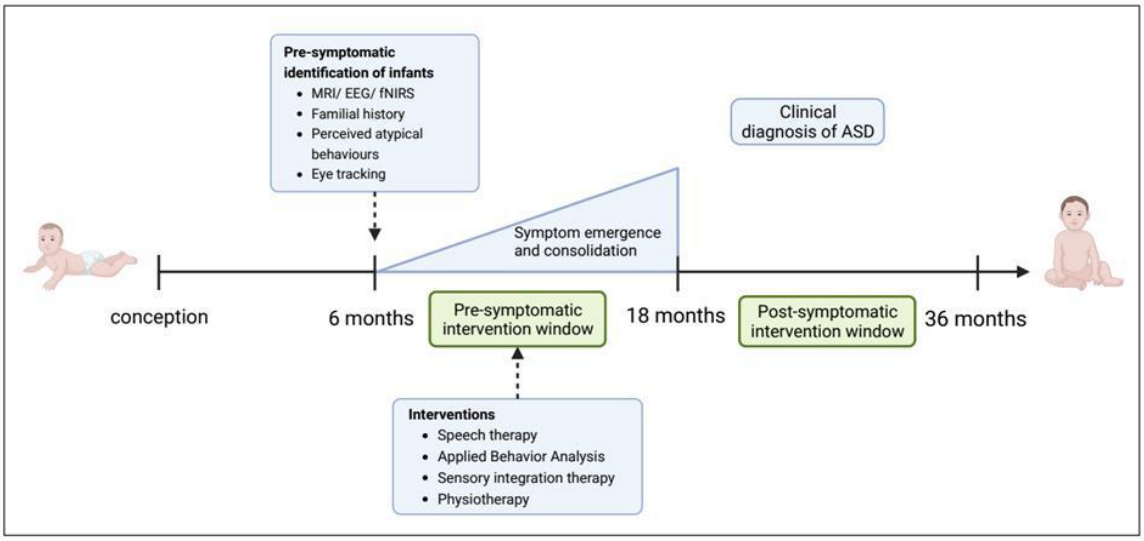
Of note, language acquisition has multiple critical and sensitive periods, being influenced even by prenatal listening experience, as it has shown the presence of anatomical organizations of speech processing as early as 29 gestation weeks. Neonates had shown a preference for listening to languages that are from the same rhythmical class as those heard in utero (Werker & Hensch, 2014). Also, there are some windows that close early (acquisition of syntax), and others remain across a lifetime (as vocabulary acquisition). In this context, it is crucial for toddlers who present neurodevelopmental impairments in language acquisition to be early diagnosed and stimulated, decreasing further impacts on language development.

Interestingly, thinking on the later clinical diagnosis of ASD and delayed therapy interventions, recent studies are pointing to pre-symptomatic interventions between 6 and 18 months old, based on the identification of a high likelihood of developing ASD by brain biomarkers (MRI or EEG), genetics (older sibling with ASD), atypical behaviors and eye tracking. These interventions consist of five developmental principles such as redundancy, reorganization, niche construction, and timing, and aim to mitigate the subsequent cascading events that will lead to the impaired outcomes associated with ASD, leading to benefits, such as increased social awareness, responsivity, and decreased maladaptive behavior. Therefore, when/if the diagnosis occurs by the later clinical manifestations, the intervention would have already started (Grzadzinski et al., 2021).

Aiming at early diagnosis, new technologies and clinical tests emerged. Eye-tracking, for example, was able to identify an increasing decline in eye fixation, beginning at two (2) months of age and being a strong predictor of ASD and social disabilities at ages 24 and 36 months (Jones & Klin, 2013). Eye fixation, present from the first days of life, is under strong genetic influence and is altered in toddlers with ASD. In this way, infant and toddlers create their own words, individual niches that constrain the environmental realm, and intensify their interactions with this preferred aspect of the world (Klin et al., 2020). As demonstrated, children's social gaze aversion is learned because of insensitivity to the adaptive value of eye gaze, a skill present in newborns (Moriuchi et al., 2017). However, genetic influence is limited by the predisposition to engage, or not, with the social world. As proved by Klin & Jones (Jones & Klin, 2013; Klin, 2022), when watching videos, children with ASD missed opportunities for social learning at a rate of hundreds of times in only 6 minutes. As a result, there is no reason to wait for clear symptoms to start early interventions aimed at normalizing communication and social engagement, as they hold the promise of attenuating symptoms (Grzadzinski et al., 2021).

In this context, the interventions should focus on altering the environment in which the infant interacts by altering social and communication supports by the caregiver (Wetherby et al., 2014), represented in Figure 1, that should be trained on interventions focused on promoting shared attention, reciprocal communication, and social-emotional reciprocity (Schreibman et al., 2015).

Figure 1 - Proposed timeline for ideal early diagnosis and interventions. Adapted from Grzadzinski[32], using Bio Render.



Source: Authors.

3.4 Early interventions and therapies

Children with autism/autism spectrum disorder present communication alterations that can occur at different language levels, with varying degrees in relation to difficulties and abilities. Among these alterations, the most important and almost always present aspect in children with autism is the difficulty in the functional use of language, that is, in social communication. This is because, in order to communicate effectively, children need to make use of receptive language, that is, understanding what people say, and expressive language, which involves expressing themselves through words and gestures, using skills of these languages in socially appropriate ways. In this way, the child presents intelligible speeches from the phonetic-phonological point of view, that is, correct speech, but that present losses to the adequacy to the social context, thus, the use of language is made without communication purposes, revealing losses in the practical aspect of language.

Since the work done by Kanner in 1943 - initiating the study of what would come to be understood as Autism Spectrum Disorder (ASD) - much has been debated about this multifaceted disorder (Masi et al., 2017). Diagnosis, behavioral characterization, recognition of heterogeneities and so many other aspects of ASD, through then, began to be factually observed and properly studied and catalogued. Therefore, therapeutic approaches aimed at ASD have been molded to new scientific discoveries in order to give a better and more efficient follow-up to these patients who are so affected by this disorder.

The way in which these individuals are affected is very relative to the presentation of the disorder of each one of them, however, in a non-specific way, it usually has diverse dysfunctions associated with social communication and restrictive and repetitive behaviors (*SADOCK, 2017*). In addition, this is a disorder that is often observed early - usually during the second year of life (12-24 months of life) (*SUSAN E. SWEDO., 2014*), so these characteristics are usually observable in consultations during the individual's early childhood - despite the wide spectrum of presentation of the disorder.

Due to the fact that the early stages of childhood are the period of most expressive brain plasticity, it is the best period to therapeutically approach the individual with ASD (*POLANCZYK, 2012*). In general, the therapeutic approaches associated with ASD will have a very similar goal. Basically, their goals will be to stimulate social and communicative development, improve learning and problem-solving skills, decrease behaviors that interfere with learning and access to opportunities for everyday experiences, and finally, support families in dealing with ASD.

All these established targets seek to stimulate, in the person with ASD, their independence in the various areas of their life and their full capacity for social interaction. Thus, it is necessary to point out which therapeutic approaches have currently been most effective from a scientific point of view.

The first therapeutic approach associated with ASD mentioned here and certainly the one that has shown the most effectiveness in qualitative and quantitative data is *Applied Behavior Analysis* (ABA) (*MORIYAMA, T. S., 2018*). Such an approach needs to be done, ideally, until the age of 5, because ABA has conceptual programs that compose it, such as *Early Intensive Behavioral Intervention* (EIBI), which advocates this age group due to the aspect of neurological development mentioned above (Sharma et al., 2018). ABA is primarily defined as the process of systematically applying interventions based on the principles of Learning Theory in order to improve relevant social behaviors to significant degrees. Furthermore, it is also understood as demonstrating that interventions employed from this perspective are responsible for slowing down ASD presentations in the long term (Hyman et al., 2020).

Broadly speaking, ABA aims to increase and maintain desirable adaptive behaviors, reduce the interference of maladaptive behaviors - by decreasing the conditions under which they occur - teach new social skills, and standardize acceptable behaviors associated with new environments and situations (Myers & Johnson, 2007). Such aspects will be observed and their progress will be measured by the main sites of intrinsic interactive need (home, school and community circles).

Early intervention with ABA is usually carried out in several weekly sessions (preferably five times a week, for two hours a day) in the patient's home or in other less structured and more common environments of the individual's routine. For each patient, a plan is drawn up that focuses on the areas that need to be stimulated in that specific case. For each case, the therapist must define, through the individual's history and direct observation, which reinforcements should be used, such reinforcements being fully associated with the possibility of acquiring certain desirable behaviors (*MORIYAMA, T. S., 2018*). In addition, such desirable behaviors - composed of actions and skills - are understood in ABA as fully influenced by the environment (physically and socially). Thus, these behaviors can be acquired as they are positively reinforced with considerable emphasis. Similarly, dysfunctional behaviors can be extinguished by the absence of positive reinforcement.

Among the extensive list of areas that can be addressed through these reinforcements are social skills, imitation, expressive language, self-care, motor skills, among others. In addition, evaluations of the progress of the individual with ASD will be carried out periodically and the planning of the ABA intervention will be redone to seek the acquisition of more complex skills (*MORIYAMA, T. S., 2018*). This graduation of complexities is advocated by *Early Intensive Behavioral Intervention*, one of the applicable programs within ABA, as mentioned.

Finally, it is ideal in the implementation of ABA that the whole family is intensively involved in the implementation of this approach. Such involvement is associated with both the creation of the notion of a safe and pleasant environment in which ABA can be applied and the implementation of skills practices even in the absence of the therapist. However, for this, it is necessary that there is also a training of the family so that they can participate in the implementation of ABA (*MORIYAMA, T. S., 2018*).

Another therapeutic approach widely used today is Occupational Therapy (OT)(Como et al., 2020). Current OT models aim to improve functional activity from a perspective of participation and gradual performance. In addition, there is also, in the current approach, the consideration of the family role as an important contributing factor to the therapeutic approach integrated into daily life (Novak & Honan, 2019). This approach is made by an occupational therapist and uses the observation of the routine activities of the individual with ASD in order to set goals aimed at improving the activities he needs to do, the activities he wants to do and the activities that others expect him to do. Thus, in general, the main focus of OT is to verify the deficient biological or psychosocial skills in the routine of the individual with ASD (sensory, motor, cognitive,

social, communicative, among others). Such skills can be observed at school, at home, in community circles or any socialization environment where possibly deficient skills have to be put into practice. Once these skills have been identified, a specific strategic plan of adaptive, dynamic and interactive activities associated with the deficient aspects will be drawn up. Such an approach will need to take into account all the individuality of the patient, and it is therefore necessary to punctuate their strengths and main challenges.

Although the last two approaches are the most widely used, many other therapeutic approaches can be recommended for individuals with ASD, such as *Naturalistic Developmental Behavioral Interventions* (NDBIs) that use ABA techniques together with theories from Developmental Psychology. In this approach, the focus will be on achieving multiple skills in a holistic way and no longer targeting isolated skills (*Horst, J., & von Koss Torkildsen, J., 2019*). Still within Developmental Psychology, we can mention approaches such as the *Denver Model,* for example, which is mainly based on remedying the main deficits in imitation, sharing emotions and social perception. This is possible thanks to play, interpersonal relationships and activities to stimulate communication skills - which are directly associated with these deficits (Myers & Johnson, 2007).

In addition to these developmental approaches, speech therapy has also been a very common approach when it comes to the communicative and linguistic integration of the individual with ASD. An important approach used in this context to stimulate the development of the communication skills of the individual with ASD is the *Picture Exchange Communication System* (PECS). In this approach, ABA concepts and pragmatic development principles are used together so that the individual with ASD can be stimulated to understand basic communication concepts. The application of PECS takes place through the provision of figures, symbols, and written words to the individual with ASD in order to stimulate him to communicate by these elements without necessarily needing to communicate verbally (Myers & Johnson, 2007). Such therapy is of fundamental importance, because, as seen in the topic ‘‘ASD on the brain’’, one of the ASD impairments is the difficulty of assimilating multiple sensory afferences, compromising their ability to abstract.

Finally, the therapeutic approaches applicable to ASD are diverse and each of them will aim to act in the various contexts of motor, communicative and social deficits. Thus, it will be up to the team of professionals to evaluate, recommend and offer the best approach for each individual with ASD within their individual and social particularities.

3.4.1 Older non-verbal individuals with ASD (Adults)

The understanding of ASD has been widely debated and several advances have been evidenced throughout this understanding, however, ASD in adulthood, remains as a little elucidated understanding. Factors such as family, work, prolonged and constant social interaction have not yet been proven to be factors that change prognosis (Howlin, 2021).
Despite this fact, it is now understood that a proportion of children who have experienced language dysfunction throughout childhood or in some part of childhood, during adolescence and adulthood can develop functional speech (Cabral & Marin, 2017). In addition, adaptive functioning and independence skills, both often acquired in adult life experiences, are already understood as part of this language development, although it is not yet known whether as a consequence or as a cause of this process (Gillespie-Lynch et al., 2012). Reaching these conclusions has certainly been a crucial part of the process of building knowledge related to adults with ASD, however, there is still a lot of lack of theoretical basis about the interventions associated with this group, especially when compared to the knowledge that has been built so much, related to children with ASD (*National Institute for Health and Care Excellence (NICE) - 2012*).

In this context, a 2014 analysis found that only 13 of 1,217 studies reviewed had adequate methodological rigor, and most focused on the aforementioned *Applied Behavior Analysis* (ABA) intervention or social cognition training (Bishop-Fitzpatrick et al., 2013). The lack of progress in adult intervention research is confirmed in a recent review that identified that

only 52 articles (less than 1% of the more than 23,000 studies reviewed on ASD) focus on support systems, services, or intervention programs for autistic adults (Shattuck et al., 2020).

Among the few interventions that are known to be put into practice, the most currently used as an intervention to improve not only communication skills but also sociability skills is the so-called PEERS (*Program for the Education and Enrichment of Relational Skills*)(Howlin, 2021). This intervention program is known worldwide for providing evidence-based social skills treatment for preschoolers, adolescents and young adults with ASD and other disorders (*LAUGESON, Elizabeth A.; FRANKEL, Fred. 2011*). It is a 14-week program composed of several skills, or challenges, in which each skill is complemented by homework assignments, reviews and fun socialization activities that help the adult with ASD in the various areas in which they may have deficits (social, linguistic, behavioral, among others). Companions, whether family or friends, can also participate in the sessions by being taught to participate, helping to expand the skills acquired, providing feedback through training during weekly socialization tasks. Therefore, the focus is not solely linguistic, but this is a skill that can be very well developed within the PEERS intervention (Laugeson et al., 2015).

3.4.2 Interventions for Nonverbal or minimally verbal children

Most children learn to communicate with spoken language - short, simple sentences by age 2 and more complex sentences by age 5 - yet approximately 25-30% of children with ASD remain minimally verbal, even after interventional practices. Such failure to develop spoken language after the age of 5 increases the likelihood of a poor long-term prognosis for the social and adaptive functioning of the individual with ASD (Kasari et al., 2014).

In view of the severity of this reality and the impact it can have on the social and cognitive capacity of the individual with ASD, certain interventional approaches aimed at improving communicative capacity can be adopted. However, it is important to emphasize that the focus of these approaches will be the functionality of communication, that is, the approaches will not necessarily aim at spontaneous initiations of communicative processes by the person with ASD, but will simply focus on developing the ability to request something or to correspond to some communicative process initiated by another person and directed to the person with ASD (Tager-Flusberg & Kasari, 2013).

For this group of individuals with ASD, there is considerable emphasis on the use of so-called *augmentative and alternative communication* (AAC) approaches. In the context of AAC, the main approach currently used with this specific group of individuals with ASD is the *Picture Exchange Communication System* (PECS). This approach is defined as a systematic communicative act between the individual with speech difficulties and an adult through picture exchanges. The practice of PECS consists of six phases, which are: 1) making requests by exchanging pictures for the desired items; 2) going to the communication board, picking up a picture, going to an adult and handing it over; 3) discriminating between the pictures; 4) requesting items using several words in simple sentences, fixed on the communication board; 5) answering the question: "What do you want?"; 6) making spontaneous comments (Mizael & Aiello, 2013).

These steps will be repeated in order to generate satisfactory responses to improve the child's communicative ability. Among these responses, it is expected to teach, for example, the essentials, such as the ability to request water and food and even the ability to be able to practice personal hygiene, perceiving, understanding and using all the items necessary for this. Another alternative approach to language stimulation in these individuals involves the use of *speech-generating device* (SGD). In general, this approach is understood as the use of a device that generates specific speech that the child can repeat and assimilate in order to use it in their routine language. In addition, the device to be used may be specifically used for this purpose or may be a *tablet* or even a cell phone, given that there are already applications for this purpose (Kasari et al., 2014).

3.5 Musicotherapy

Music therapy is a research-based practice that uses music to actively support people to improve their health, functioning and well-being. Music is used as a means to achieve personalized goals within a therapeutic relationship, promoting experiences centered on the interests and expressions of the client (Dvir et al., 2020). In ASD children, the individuals with more probability to benefit from it are those with low levels of cognition (IQ < 70), non-verbal individuals, and children younger than five (5) years (Bieleninik et al., 2017), reassuring the notion of music as a more fundamental way of communication than verbal language. Also, beyond improvements in communicative abilities, music therapy was shown to improve parent-child relationships (Thompson et al., 2014).

As discussed, it was demonstrated that the brain in ASD children has hypoconnectivity in sensorimotor networks, typically facing adversities in social communication and sensory processing, often experiencing challenges in integrating multisensory information (Kwakye et al., 2011). These networks can be modulated during musical activities (the so-called music-induced neuroplasticity) by a bottom-up sensorimotor integration through sound and auditory-motor entrainment of neural networks through synchronization, leading to modulation of atypical sensory processing, which, in turn, may improve social communication (Sharda et al., 2018). However, the heterogeneity of ASD also reflects its response to therapies, as recently shown in the Improvisational Music Therapy's Effectiveness for Children with Autism (TIME-A) study, which was a multicenter and pragmatic randomized clinical trial that compared music therapy added to enhanced standard care. This trial, having a high-level heterogeneous population of ASD patients, did not demonstrate a significant difference in symptom severity based on the ADOS social affect domain over five (5) months (Bieleninik et al., 2017), indicating the importance of investigating heterogeneity (Sharda et al., 2019). Interestingly, music therapy has been used in other realms of neurology to increase connectivity in brain networks in preterm children (Haslbeck, 2020) and patients who had a stroke (A. Sihvonen & Särkämö, 2021).

Research has shown that music therapy facilitates motivation, improves communication and social interaction skills, and supports the development and sustainment of attention in children with autism (Dvir et al., 2020). In addition, robust systematic reviews highlight the effectiveness of music therapy in enhancing various aspects of development, such as social interaction, verbal and non-verbal communication skills, socio-emotional reciprocity, social adaptation as well as promoting joy and the quality of parent-child relationships. Improvisation-based music therapy methods provide a space where the client and therapist create music spontaneously through singing, playing and movement. This approach harnesses the potential for social engagement and emotional expression that occur through improvisational music making (Dvir et al., 2020).

In this way, music is an excellent language therapy in autism spectrum disorder (ASD) in view of the limited capacity for social engagement, which is a central feature and often evident early in the child's development. Although these skills are difficult to train, there is some evidence that active engagement in music making offers unique opportunities for social interaction among participants (Lim, 2010), as music therapy is an important tool in the development of social skills as well as communication and language skills and is considered a promising early intervention for young children with ASD and their families. Although there are a limited number of studies, these indicate that music therapy is especially satisfactory in developing social interaction and communication skills in children with ASD (Rickson et al., 2016).

As evidence of this, the results of a study that compared the effect of music training, speech training and no training on the verbal production of children with ASD showed that participants of music and speech training significantly increased their verbal production pre- and post-test (Mössler et al., 2019). Another study (Thompson et al., 2014) showed that the tuned application of music in music therapy facilitates the creation of meaningful interactions on a non-verbal level and strengthens the communicative skills of the child with ASD, as music creates connections, coherences and context.

Music has a recognized impact on emotional regulation and mood, both in people with ASD and with other impairments in language acquisition. Passive listening and especially active engagement in music activates areas related to cognition, sensory-motricity and perception-action, increasing synchrony between these cortical areas and promoting greater sensory integration (Sharma et al., 2018). Due to this, music therapy helps children with autism to improve social skills, communication, behavior and socioemotional reciprocity, promoting social adaptation and quality family relationships, as it is able to alter brain structure and connectivity, promoting multisensory integration from the beginning of development. In addition, individuals with ASD demonstrate preserved or enhanced musical skills throughout life, allowing interpretation and emotional response to music, even when speech is limited (Sharma et al., 2018).

3.5.1 Neurorehabilitation in ASD

It is known that the effectiveness of this method depends on two factors, among them, we have the therapeutic context and the neuronal mechanisms that will be accessed during therapy. The context is classified between individual or group therapy (Brancatisano et al., 2020), and may be in a passive format, in which only the act of listening occurs or active, in which the patient will be encouraged to dance, sing, clap, express themselves in the way they feel most comfortable from listening. With regard to the neurological process (A. J. Sihvonen et al., 2022), the benefits can range from behavioral, psychosocial, and an improvement in stress, anxiety and depression levels is also noted. In this context, it was seen that music therapy acts by activating the mirror-neuron system (Altenmüller & Schlaug, 2015), a group of neurons, located in the lower part of the frontal lobe and parietal lobe, specialized in behavioral actions and involved in the process of imitating actions performed by other individuals (Hamilton, 2013; Rizzolatti & Craighero, 2004), through the activation of somatosensory areas and the premotor cortex (Hamilton, 2013). It is believed that this system, in children with ASD, is commonly defective, being known as "Broken Mirror Theory", which is a theory in which it is believed that there is a "break" in this system, this being the main cause of little or lack of imitation in autism, which together with other factors, cause the difficulty of social interaction.

There is evidence that music can act on seven different components related to neurorehabilitation, namely, social, personal, emotional, physical, persuasive, encouraging synchronized body movements of speech and involving the patient, being able to bring behavioral, neurological and psychological benefits to the patient (Brancatisano et al., 2020). Regarding autism (Birnbaum, 2014), the child has a preference for improvised music, which is able to express and involve them in a unique way, being able to achieve the seven components mentioned. This knowledge was presented in the book "Creative Music Therapy" by Nordoff and Robbins (1977), and is currently used as a fundamental basis for music therapy.

Rhythmic auditory input is a rationale for improving sensorimotor functioning in children with autism as it provides a predictable structure that helps stabilize variability in movement patterns and promote the development of internal models for motor planning. Because of this, a music therapy environment can facilitate the development of a cognitive process of movement simulation by stimulating the use of a synchronized movement rhythmicity in a didactic interaction (Dvir et al., 2020). Thus, we conclude that the brain areas involved in language processing, little activated by speech in ASD, are significantly activated by music, increasing the evidence on the concomitant use of this therapy, in the therapeutic process of the child with ASD.

However, there is a clear need for more high-quality research, including experimental studies, to provide a solid basis for music therapy practice in this context. It is important to emphasize that the implementation of experimental research may face challenges due to the diversity of both the population with ASD and the music therapy approaches used (Rickson et al., 2016).

4. Conclusion

This study concluded the importance of an early diagnosis associated with therapeutic interventions for individuals with ASD. This is necessary because neurological language development begins in the first years of life, which would ensure a more efficient window of opportunity for intervention. ABA, Occupational Therapy and Developmental Psychology, with their diverse approaches; as well as Music Therapy, are effective therapeutic interventions in language development in autistic individuals. The focus of these therapies is to support the family, help the child to improve their quality of life and develop independence. However, more studies are needed to evaluate their specificity and time-dependent efficacy.

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