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CONTRIBUTIONS OF COGNITIVE NEUROSCIENCE TO TEACHING/INTERVENTION PROPOSALS IN CHILDREN WITH AUTISM SPECTRUM DISORDER BASED ON DIGITAL TECHNOLOGIES

CONTRIBUIÇÕES DA NEUROCIÊNCIA COGNITIVA PARA PROPOSTAS DE ENSINO/INTERVENÇÃO EM CRIANÇAS COM TEATRANSTORNO DO ESPECTRO AUTISTA A PARTIR DAS TECNOLOGIAS
COGNITIVA A LAS PROPUESTAS DE ENSEÑANZA/INTERVENCIÓN EN NIÑOS CON TRASTORNO DEL ESPECTRO AUTISTA A PARTIR DE TECNOLOGÍAS DIGITALES

Dagmar de Mello e Silva
PhD Associate Professor at Universidade Federal Fluminense - Faculdade de Educação/SFP, permanent professor in the Postgraduate Programs - Professional Master's Degree in Diversity and Inclusion (CMPDI), Postgraduate Doctoral Program in Sciences, Technologies and Inclusion (PGCTIn) and the Postgraduate Doctoral Program in Education. dag.mello.silva@gmail.com.
0000-0002-5863-3607

Leiliane Domingues da Silva
PhD student in Sciences, Technologies and Inclusion at the Universidade Federal Fluminense. Professor of the Postgraduate Course in Didactics and Teaching Practices at UFVJM, Tutor of the Second Degree Courses in Special Education at UFSCar and Pedagogy at UERJ/CEDERJ and the Postgraduate Course in Inclusive and Special Education at UFLA. leilanedomingues@gmail.com.
0000-0002-3764-8818

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ABSTRACT:
The present study presents empirical results that point out that digital language is a more favorable means of learning for children with Autistic Spectrum Disorder (ASD) than analogical language. Thus, the focus on Cognitive Neuroscience contributed as a source of knowledge for the deepening and elucidation of this analysis. Therefore, the fact of taking children with ASD and intervention/teaching-learning processes favorable to their global development as an object of study; it is one of the ways of re-dimensioning theoretical-methodological positions with a view to contributing to new studies for the academic area.

KEYWORDS: Neuroscience; Language; Technology; Learning; TEA.

Introduction

Sabe-se It is known that the word "autism" is related a "way to be with a oneself". This expression was mentioned for the first time by Plouller, in 1906 (*apud* Gauderer 1997), when he studied patients diagnosed with dementia. However, the word only became widespread in specialized literature in 1911, when Bleuler (1950) discussed the theme as a central symptom of schizophrenia. Since then, "autism" has received a plurality of conceptions and conceptual changes, being characterized as: "disorder", "psychopathy", "syndrome", and finally as "disorder" - initially defined as Invasive Developmental Disorder (IDD), later as Global Developmental Disorder (GAD), and more recently as Autism Spectrum Disorder (ASD).

Under this last approach, DSM-V (2014) aggregated all forms of autism manifestations - regardless of their specificities - and integrated them into a single condition, differentiated by levels of graduation (mild, moderate, and severe), classified

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by a dyad: a) communication and social interaction deficit, b) patterns of restricted and repetitive behaviors, interests, and activities. This measure aimed to facilitate the diagnosis, thus enabling the treatment and early intervention of children affected by this disorder. The change in nomenclature circumscribed autism as a neurodevelopmental disorder, highlighting "the commitment of the organizers of the manual with the authors and the theories of the so-called neurosciences" (Laia, 2012, p.12). In this sense, Klin (2006), points out that an early diagnosis (especially before the age of three) and consequent intervention gives the child an 80% chance of improvement in reducing symptoms due to the neuroplasticity of the human nervous system.

For Moojen (2004), to diagnose is not to label, because what is classified are the disorders. Therefore, it is understood that, despite the reducible and generalist nature of the diagnosis, one should avoid plastering the child with ASD within the disorder, helping him to enhance his development and reduce his limitations.

> The current development in Neuroscience is truly fascinating and generates great hope that we will soon have new treatments for a wide range of nervous system disorders that debilitate and disable millions of people every year" (Bear; Connors; Paradiso, 2017, p. 21).

According to Zorzetto (2011), it is estimated that there are 70 million people (including adults) in the world with some form of autism. Reviére (2004) points out that it is from the need to know the autistic person that the need to take a first step arises!

Preliminary considerations about the proposal of this study

For Hennemann (2013), it is through Neuroscience that one seeks to understand the individuality of each person. According to Pereira Jr. (2010), Cognitive Neuroscience has provided great contributions to the understanding of brain functioning, as it addresses the correlations between neural systems and the acquisition of learning, pointing a break with neuroanatomical and neurophysiological determinisms from active relationships between stimuli from the outside world and these functions.

> It is called neuroplasticity or brain plasticity, the ability to transform the structural organization and functioning of the nervous system when faced with different stimuli from the environment in which one lives, influencing the processes of cognition (Atlan, 1992, p. 45).

From this perspective, based on Rotta (2015), it is understood that it is possible to overcome biological and social limitations and focus on intervention as a way to enhance

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the skills and develop the potential of each subject, since the brain is plastic and capable of learning throughout the life cycle.

These considerations support the objective of this publication, which was born from studies resulting from the investigations of the Master's research conducted by one of the authors - in which it was possible to evidence, in a concrete and significant way, the acquisition of learning in children and young people with ASD through the mediation of a pedagogical game about emotions, via tablet, using touchscreen technology. The successful results of this research led us to extend our studies to the field of neuroscience, in an attempt to understand which neurophysiological processes were triggered for this learning to take place. Finally, we are supported by Mietto (2012), for whom the role of Cognitive Neuroscience is to understand how neural networks are established at the time of learning, as well as how stimuli reach the brain, how memories are consolidated, and how to access this stored information. Bear; Connors and Paradiso (2017), state that there is still little neuroscientific knowledge, but that the basis of everything is this search, this understanding, this commitment to the improvement of others.

Justification

Thirteen years ago (2010), the tablet - a portable, touch-sensitive computer - appeared on the digital market, providing a new and different way to interact with digital media. It didn't take long for this technological tool to be inserted as another instrument to contribute to psycho-pedagogical interventions. The empirical observation of the successful use of this tool with children of the Autistic Spectrum instigated the search for scientific articles that addressed issues related to this type of psycho-pedagogical intervention focused on the care of people with ASD; however, we were faced with a scarcity of scientific publications related to the topic, leaving our search restricted to a few sites that pointed very encouraging results with children with ASD through the use of this technology as a tool to enhance the cognition process.

Walter (1998), Avila (2011) and Passerino, (2011) point out that the use of alternative proposals for intervention for ASD is not something recent. However, the information found specifically about the issue of inserting the use of the tablet in people with ASD consisted only of mere news published on the Internet, since the production of knowledge in academia was still very scarce, which justified the interest in deepening the analysis observed from the perspective of learning in the Master's Thesis that inspired this study.

It is known by DSM-V (2014), that ASD is a neurodevelopmental disorder in children whose main characteristic is difficulty in communication and social interaction. According to Gadia (2015), autism is understood as a state or condition where the subject seems to

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be reclusive within himself. However, given the recent autobiographical reports of individuals with high-functioning ASD, and through the publications of Mercadante (2015), who has been propagating the studies on the "Theory of Mind" and the "Topographical Emotional Map Theory"; it is considered that the sensory issue could be a primary characteristic of ASD, an aspect that would have great influence on the symptoms already known and considered relevant to the diagnosis. From this construct emerged the interest in investigating the impact of these sensory-perceptual alterations and the consequent socio-affective, cognitive, and especially language and communication impairments that affect the lives of people with ASD.

Mercadante (2015), explains that subjects with ASD cannot naturally perceive what happens with the other; it is as if they have difficulties in "reading" the mental state of others, that is, perceiving, feeling, expressing feelings, interpreting facial expressions, gestures or behaviors, and understanding intentionality (what other people intend to do). As a result, perhaps, because children with ASD do not identify with other members of their social group, do not understand their communicative intentions, nor interact in affective exchanges; they would end up taking speech as something meaningless. This understanding is shared by Morato (1997), who states that language only works when linked to interactive processes. Moreover, Tomasello (2014), points out that the man is the fruit of the social, and it is only from the interactions and reciprocal social exchanges that knowledge, language and culture are transmitted.

It is then realized that these difficulties in the socio-affective development can lead children with ASD not to develop an intentional communication, since for Vygotsky (2007), the constitution of the subject happens through social exchanges. For Bakhtin (2014), language cannot be understood outside a concrete communication situation. Thus, depending on the degree of difficulty in this field of communication, some people with ASD would not be able to move from pre-linguistic communication to linguistic communication, affecting their overall development. Farrel (2008), estimates that between one-third and one-half of autistic children do not develop speech, and may or may not use alternative forms of communication; they are likely to make inappropriate or socially inappropriate use of gestures, eye contact, facial expressions, or body language.

The fact is, some of these children may even acquire a sophisticated language, however, agreeing with Farrel (2008), the biggest problem is not in how children with ASD understand or reproduce grammar, but in how they use language and how they adjust language to the context in which it is used, since social and emotional behaviors are also considered means of communicating intentions, desires and needs. This difficulty in social-affective engagement during interpersonal relationships manifests itself as

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impairment in symbolic and linguistic capacity. Thus, the losses in language and consequently in communication have been pointed out by Nunes and Walter (2013), as one of the biggest challenges to be faced by those who are affected by the disorder.

> How can we think of children who do not speak? That they are not "gifted" with language? Who refuse to communicate? Would that give rise to the paradoxical feeling that the encounter with such children provokes, facing the scream, the cut speech, repeated, wandering and silent? (Vasquez, 2003, p. 195).

According to Geraldi (2013), the language is fundamental to the development of each and every human being. In this sense, communication guides the interactions in life in society, since, for the "language" to achieve its goal (i.e., communicate), it is necessary that the emitted message is understood as its original sending by those who receive it and the response must correspond to the logic of this perspective. Lemos (1989) and Orlandi (2009), conclude that language serves to "communicate" and "not communicate", that is, language relations are relations of subjects and senses, and its effects are multiple and varied, because it depends on the effect of senses between speakers. Therefore, for the subjects with ASD, who relate to language in a very peculiar way, due to the issue of hypersensoriality, this becomes a big problem, since for Miilher (2006), "individual disabilities are very different" and, therefore, these differences should be understood as a spectrum, of greater or lesser degree of complexity. Thus, the way language is structured is a central aspect in autism pictures.

Watzkawick (1998), in turn, points to the existence of two forms of languages that will guide the ways in which a communication takes place: the analog form and the digital form. In this way, Watzkawick (1998, p.10) explains that analogical language is not only verbal, but also includes non-verbal elements that involve "[...] posture, gestures, facial expressions, voice inflection, rhythm and cadence of the words themselves, and any other non-verbal manifestation of which the organism is capable". Thus, as analogical language; we have images, smells, gestures, emotions, intuitions, feelings. Digital language, on the other hand, is considered logical and in the field of relations is represented by conventional digits, such as speech, writing, and the name we give to things in a given culture. It is much more precise and linear, because it creates a rational sense from the interactions between the digits, being a way to objectively translate expressions of analogical language.

Thus, in the computational perspective of the tablet, the digitization process allows processing information (even analogical ones) translating it into a language that can become more readable to people with ASD. Any message, whether in the form of formal

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words or even sounds, movement, or image, can be structured in the form of a concrete statement. Here is a crucial question for the insertion of people with ASD in the social universe: how to provide people with ASD with ways of learning so that they can move between these languages, overcoming the "disorders" that prevent them from establishing interaction relations with the world in which they are inserted and that predominate in analogical language?

Orrú (2012), points out that people with ASD are still little understood by society. In this sense, Galvão Filho (2002), points out the use of technology as a resource to destroy the barriers that hinder people with disabilities and, Seabra and Mendes (2009), reaffirm this need to provide means and create conditions for these subjects with ASD.

In this sense, despite the approach of Grandin (2000) and Gikovate (1999), on the issues of hypersensory; it is understood by the above, that in the digital environment, even when it is presented through stimuli of colors, sounds and movements, which in principle should be disturbing, due to the hypersensory of most people with ASD, this does not happen with the same intensity and impact as in the digital context; probably, because the communication in this medium takes place by digits, in an organized way, which are sustained by digital foundations, as they create common meanings from the interactions among algorithms. This proposition brings us closer to Guattari's philosophy when he tells us that:

> What of subjectivation complexes individual-group-machine-change, which we offer here, is not only the confrontation with a new matter of expression, it is the constitution to the person to diversified possibilities of recomposing an existential corporeality, of getting out of his repetitive impasses and, somehow, of resingularizing himself" (Guattari, 2012, p. 17).

It is understood then, that interactions with cyberculture can generate *autopoietic* processes (Maturana; Varela, 2001), allowing people with ASD to reconfigure themselves in the face of disturbances and noises caused by a world permeated by a language that presents itself in a distressing way for them, "recomposing an existential corporeality", as Guattari (idem) indicates. In this sense, Oliveira (1999), points out that as the nervous system is an autopoietic unit, any change in the activity of any neuron (or other component of the nervous system) has as a consequence changes in all other components and respective neuronal process exchanges. Thus, according to Flores and Winograd (1989), the creation of a new device or systematic domain can have far-reaching significance; it can create new ways of being that did not previously exist and a background for actions that previously made no sense.

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In view of this, when taking the results obtained through the participation of children and young people with ASD throughout the aforementioned Master's research (Silva, 2016), it was possible to observe an effective learning through the digital medium - since it was found that the participating group assimilated the content of facial representations of emotions proposed as learning, as well as, it was possible to observe a greater interest, autonomy and concentration in the manipulation of the tablet device, in addition to a visible decrease in anxiety and consequent reduction of stereotyped behaviors. Pereira Jr. (2010), helps to understand this phenomenon by explaining that the computational model acts on cognitive functions through dynamic, corporeal and interactive processes with the environment, focusing on the actions of cognitive systems in their respective contexts, in a process of active adaptation. For Santos (2010), these resources end up expanding the possibilities of these subjects and, for Dohme (2003), these resources enable the creation of new doors for communication.

In this logic, it was precisely by helping these subjects express themselves, "touching and being touched by the signs of the world, creating their own landscapes, thus reorganizing their patterns of understanding of the world and life" (Silva & Marton, 2012, p. 126), that the research that gave rise to this article concluded that the use of educational games permeated by digital language not only favors the insertion of people with ASD in the social universe, but also enhances teaching-learning processes. Furthermore, the research pointed to the need for a deeper look into why children and adolescents with ASD acquire more effective learning when they are in front of the digital world and what are the neurophysiological processes triggered for this learning to happen. However, due to the need for a space of study and investigation more focused on the field of neuroscience than that of education; it is that the inquiry to be developed in this present study, about the analyses and contributions of the area of Cognitive Neuroscience - which is the science that seeks to understand how brain function gives rise to mental activities, such as perception, language, learning, considering the aspects of normality and alteration -; is that this discussion unfolds.

For Nicolelis (2011), the Neuroscience of the 21st century will have to unravel the physiological commandments that govern the operation of the human brain and discover new treatments, such as brain-machine interfaces, capable of rehabilitating or even curing patients devastated by neurological diseases.

> Neuroscience applied to Education comes as one more study, not as a "cake recipe" or a "panacea" for all the ills of Education to be cured by Neuroscience (...), it is a scientific study of how the brain can learn better and store knowledge (Relvas, 2012, p. 31).

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Having said this, this dialog, more than possible, can be a way out, through Cognitive Neuroscience, to rethink teaching/learning relations for people with ASD.

Objectives of the study

As the main objective of this study, we intended to deepen, through Cognitive Neuroscience, the investigation on why the learning process in children with ASD is more effective in the digital world, also resulting in the enhancement of language and social interaction. However, we included as more specific objectives: to point out new perspectives of psycho-pedagogical interventions in the learning processes of children with ASD based on studies of Cognitive Neuroscience and to make available studies in the area of Cognitive Neuroscience, which can contribute to the work of teachers and professionals focused on the issues of teaching people with ASD.

Weak brain connections in children with ASD and the proposed intervention to strengthen these areas

Based on studies by Abrams, Phillips, and Vinemod (2013), it was found that children with ASD have altered dopamine levels that result in weak brain connections in regions that link speech to emotional rewards, causing impairment in their ability to experience speech as a pleasurable stimulus, thus impacting the development of social and language skills in this population. Therefore, we hypothesized that the use of games (as a pedagogical resource) would activate different brain areas (which make up the so-called mesolimbic pathway, one of the dopaminergic pathways of the brain) related precisely to this reward circuit, which, permeated by digital language - via tablet, ends up joining it as a facilitator in strengthening these brain circuits, motivating children with ASD to use digital language as an intercessor for social interaction, and consequent learning.

Brain circuitry - possible causes for communication difficulties in ASD

Paying attention to Nunes and Walter (2013), when he points out that the losses in language and consequently communication, have been the biggest challenges to be faced by those who are affected by the autism spectrum disorder; a study (Abrams, Phillips & Vinemod, 2013) conducted by Stanford University, took a group of children, which compared brain images of magnetic resonance imaging at rest (which allows measuring brain activity by observing changes in blood flow) while they listened to human voices. In this bias, this study ultimately deduced that children with ASD do not pay attention to voices because the voices are not rewarding or emotionally interesting, which led to the

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conclusion that children with ASD do not seem to receive the same pleasure from the human voice compared to other developing children.

According to scientists Abrams, Phillips, and Vinemod (2013), the research found that in the subjects with ASD, the right side, in the voice selective cortex (where vocal and pitch signals are detected), had a weak connection to the cerebral amygdala (a region of the brain involved in emotion, which includes the ability to perceive emotional signals from others), and the left side of the brain, showed weak connections to the nucleus accumbens and the ventral tegmental area (which are brain structures that release dopamine in response to rewards). Thus, it was observed that the more impaired the brain connections were, the more severe were the communication difficulties of these children with ASD. So, while the finding is not immediately useful in terms of diagnosis (such as using functional magnetic resonance imaging to detect connectivity problems in the brain), it does help to think about developing new treatments that can emphasize pleasurable social communication and motivate children with ASD to use language for social interaction, thus providing interventions that can strengthen these vital brain connections.

Dopamine - the molecule of motivation

Vargas (2013), explains that dopamine is a neurotransmitter, i.e., a chemical substance, which is responsible for activating the brain's reward system during any potentially pleasurable activity. Dysfunctions in dopamine levels translate into deficits in performance due to lack of motivation, i.e., engagement, as the dopaminergic circuitry is closely linked to the phenomenon called "motivation." Jensen (2011), points out that the word "motivation" comes from the Latin word *"movere",* which means to move to perform a certain action.

> Motivations or motivational states are internal impulses that lead us to perform certain bodily and behavioral adjustments [...] and the acts it provokes are called motivated behaviors. [...] Motivational states create a kind of tension (sometimes even discomfort) that raises the individual's alertness level and triggers the execution of an ordered sequence of behaviors directed toward the goal of generating pleasure or dissipating the initial tension and discomfort (Lent, 2022, p. 75).

For Cosenza and Guerra (2011), motivation seems to result from a brain activity that processes the information coming from the internal environment (forme, pain...) and the external environment (opportunities and threats), determining the behavior to be displayed. It is in this sense, that motivations lead us to repeat the actions that were able to obtain reward in the past or seek situations that have a chance of providing a desired

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satisfaction in the future, i.e., "just as without hunger we do not apprehend to eat, and without thirst we do not learn to drink water, without "motivation", we cannot learn" (Izquierdo, 2018, p. 32). It is concluded, therefore, that motivation involves learning and other cognitive processes that are in charge of organizing the actions that best ensure survival, since, most motivated, goal-directed behaviors are learned!

Digital pedagogical games as motivation in the learning of children with ASD - a teaching/intervention proposal

Based on Papert (2007), Ramos (2013) and McGonical (2012); it is understood that digital games, by being interactive and by containing promotional elements (acts of overcoming challenges or achieving a goal) and the instantaneous offer of a feedback or prize, causes the brain's pleasure circuits to be activated and releases the neurotransmitter dopamine, which in addition to increasing motivation, also has the important role of transforming all this into long-term memory, thus helping the brain to "store" information or skills more easily. Therefore, throughout the discussion herein, it is concluded that the use of educational games mediated by touch screen technology (use of the haptic system) of the tablet, and facilitated by digital language, creates brain connections in a pleasurable and voluntary way in children with ASD that ultimately results in the potentiation of language, social interaction, and the optimization of learning. Hence why learning happens and becomes more effective for children with ASD!

Deleuze (2017) says that it is necessary to leave the abstract methodology and expand the meaning of experience through other more passionate and attractive relationships. One realizes then, how pertinent it is for the area of Cognitive Neuroscience to dialogue and research on the interaction of people with ASD with the digital environment, since this intervention can provide the strengthening of these vital brain connections, precisely by emphasizing pleasurable social communication and by motivating the subjects with ASD to use language for social interaction and consequent learning. Therefore, besides creating a pleasurable relationship with learning, this may be a great ally, or even "a legitimate alternative to meet the needs involving learning" (Moraes, 2008) of children with ASD, because after all, as Herculano-Houzel (2012) said, learning has to be a desirable act, without it there is no motivation!

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Conclusion

It is a popular saying that "every child has his own time". But when should we just wait for them to develop? According to Kleina (2012), children often have limited learning capacity because they are not provided with the proper tools for their own development.

> Each person has his or her own maturation time, preferences, and ways of being. But in the case of autism, it is the connection with the world that is impaired. Waiting for this child's time is a waste of time, it is like leaving a rare bird trapped in a cage and expecting it to fly away without opening the door" (Silva, 2013, p. 25).

Therefore, through the studies of Cognitive Neuroscience, it is known that technology is the instrument that can give voice to those who cannot express themselves through analogical means. Therefore, one cannot lose sight of the real potential and limits of each child with ASD. After all, according to Silva (2016), the use of educational games permeated by the digital language of the tablet and its respective touch screen technology has been a way to help people with ASD to reduce their expressive limitations and activate new learning possibilities, because after all, symptoms exist and need to be minimized.

> For the physically handicapped, technology means an electronic notebook; for the hearing impaired, the bridge between the concrete and the abstract; for the visually impaired, the integrator of knowledge; for the autistic, the mediator of interaction with reality; and, for the intellectually impaired, an object that challenges their intellectual capacities (Valente, 1999, p. 19).

In this way, using the available resources as a bridge for communication, social improvement, and learning, is to have, without a doubt, creates a "potentializing gaze". Thus, paying attention to the fact that "one cannot teach without taking into account the functioning of the brain" (Hart, 2016, p. 15), it is necessary to "allow the brain to become, to vitalize, to produce a dialogue in praise of the new, an attempt, a longing for what teaching and learning represent" (Vasconcelos, 2012, p. 256). Thus, this study sought to present neuroscientific clarifications that can support and contribute to proposals for psycho-pedagogical intervention with the use of digital technologies that enhance the teaching/learning of people with ASD.

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RESUMO:
O presente estudo apresenta resultados empíricos que apontam que a linguagem digital, se constitui um meio mais favorável à aprendizagem de crianças com Transtorno do Espectro Autista (TEA) do que a linguagem analógica. Desse modo, o debruce na Neurociência Cognitiva contribuiu como fonte de conhecimento para o aprofundamento e elucidação desta análise. Portanto, o fato de tomar como objeto de estudo a criança com TEA e processos de intervenção/ensino-aprendizagem favoráveis ao seu desenvolvimento global; é uma das formas de redimensionar posições teórico-metodológicas com vistas a contribuir com novos estudos para a área acadêmica.

PALAVRAS-CHAVE: Neurociência; Linguagem; Tecnologia; Aprendizagem; TEA.

RESUMEN:
El presente estudio presenta resultados empíricos que apuntan que el lenguaje digital es un medio de aprendizaje más favorable para los niños con Trastorno del Espectro Autista (TEA) que el lenguaje analógico. Así, el enfoque en Neurociencia Cognitiva contribuyó como fuente de conocimiento para la profundización y elucidación de este análisis. Por tanto, el hecho de tomar como objeto de estudio a los niños con TEA ya los procesos de intervención/enseñanza-aprendizaje favorables a su desarrollo global; es una de las formas de redimensionar posiciones teórico-metodológicas con miras a contribuir con nuevos estudios para el área académica.

PALABRAS CLAVE: Neurociencia; Idioma; Tecnología; Aprendiendo; TEA.