The ADHD brain and learning

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ABSTRACT

The brain is the most complex organ of the human being. It is responsible for our thinking, attention, memory, and learning. A series of higher functions and neuronal circuits, allow learning to occur. A person with Attention Deficit/Hyperactivity Disorder (ADHD), has a series of problems in managing their behavior, such as difficulties in maintaining their attention, controlling, and inhibiting impulses and excessive activity, damaging their learning. In most cases, it is in the school environment that the symptoms of this disorder are most clearly observed.

A combination of educational strategies, emotional support, and adaptive interventions can be essential to optimize the learning process and promote academic and personal success.

Keywords: Neurotypical brain, Brain with adhd, Learning, School.

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INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a neuropsychiatric condition that affects people's cognitive and behavioral functioning.

In a neurotypical person, factors such as sustained attention, inhibitory control, organization and planning, and regulation of behavior tend to be more efficient than in the brain of a person with Attention-Deficit/Hyperactivity Disorder (ADHD).

Learning for a person with ADHD can present specific challenges due to altered higher functions. A combination of educational strategies, emotional support, and adaptive interventions can be essential for optimizing the learning process and promoting academic and personal success.

The present work is a research on the functioning of a neurotypical brain, that is, one that does not manifest neurological or neurodevelopmental alterations; with respect to a brain of a person with attention-developmental hyperactivity disorder (ADHD) and its relationship to learning.

The methodology applied to carry out this research was the bibliographic search in the databases of academic research, which gathered information about the proposed theme. All the material used as a reference is duly cited in the course of this work.

THE NEUROTYPICAL BRAIN AND LEARNING

The brain is the most complex organ in our body. The brain is responsible for our thinking, learning, and memory. Our brain cells are connected to other brain cells by neuronal circuits.

Learning and performing any complex task involves the coordinated operation of many different neurons in diverse regions of the brain and requires signals to proceed through large neural networks at an optimal speed.

The brain organization of mental activity, according to Luria (1981) apud Veronezi et al. (2018), consists of a complex system that recruits three main functional units: a) the unit that activates the brain in a diffuse and generalized way (brainstem and diencephalon) and in a specific and focal way (mid-basal frontal regions); b) the unit that receives, analyzes and stores stimuli, allowing us to perceive the world around us (temporo-parieto-occipital region); c) a third functional unit responsible for programming, regulating and verifying mental activity, entirely structured by language (frontal lobes). In this way, the brain is required to perform highly complex functions, and several areas work harmoniously, forming functional systems.

According to Leontiev (1978) apud Veronezi et al. (2018), the formation of these functional systems specifically in humans occurs as a result of the mastery of instruments (means) and operations, adding that such systems are nothing but external motor operations, and mental operations (e.g., logical) sedimented and consolidated in the brain

The higher nervous functions are the integrated functions unique to human beings, which

allow communication through symbols, perform mental representations, acquire, process and store knowledge, enabling variable and flexible behaviors. These functions depend essentially on the cerebral hemispheres (cortex and subcortical structures). In addition, according to Costa (2023), these are complex activities that are developed and improved by the individual's interaction with the environment and social environments (environmental and social stimuli).

According to Cosenza and Guerra (2011, p. 36), learning favors the creation of new synapses, which facilitate the flow of information within nervous circuits, increase the complexity of connections in these circuits, and promote the association of independent circuits (enabling, for example, new concepts to be learned from pre-existing knowledge).

Lopes and Maia (2000) apud Costa (2023) warn that there are moments in life that are more conducive to certain learning, such as motor and language development, however there are periods of time when an individual is more prone to the influence of an event, so that there is the possibility of the existence of several sensitive periods for the same organ or function

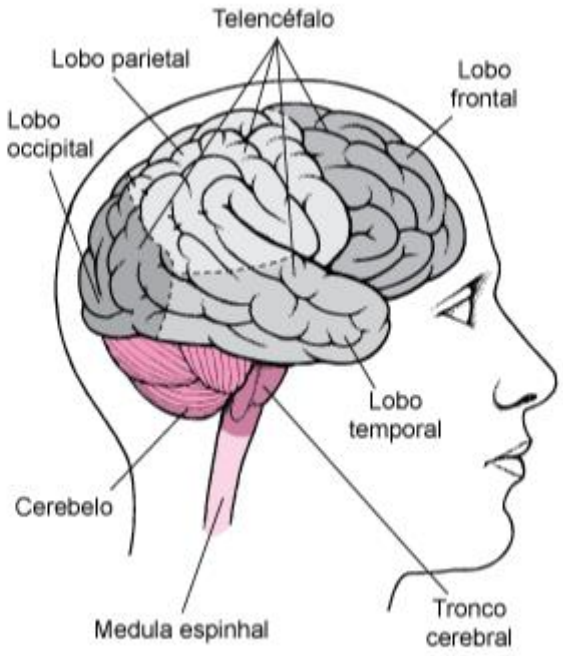
During the first years of elementary school, the child develops motor skills, visual-motor skills, reasoning, language, social comprehension, and memory.

As learning is consolidated into neural networks, concepts are combined into important units that are available for later use. The ability to generalize and abstract begins at this stage and continues into adulthood. During this time, the child learns about perspective-taking and social interaction. These abilities are closely linked to the development of the right hemisphere of the brain, as well as in the areas that are linked to emotional processing, called the limbic system (Semrud-Clikeman, 2007).

During the last years of elementary school and the beginning of high school, according to Semrud-Clikeman (2015), the child's brain activity occurs mainly in the posterior regions, where the areas of auditory, visual, and tactile functioning intersect. This intersection is called the association area of the brain, and it usually contains information that has been learned and now stored. This is information commonly measured on performance tests and verbally based skill tests.

The frontal lobes (*Image 1*) begin to mature more fully in high school. Maturation continues through high school and adulthood (Semrud-Clikeman & Ellison, 2009). The frontal lobes are a more recent evolutionary development in the brain and allow humans to evaluate and adapt their behavior based on past experience. The frontal lobes are also believed to be where social understanding and empathy reside (Damasio, 2008). Refined development of the frontal white matter tracts begins around the age of 12 and continues until the age of twenty. This region of the brain is crucial for higher cognitive functions, protected social behaviors, and the development of formal operations. As the connecting tracts in the frontal lobes become more refined, adolescents are expected to "think" about their behaviors and change them (Semrud-Clikeman, 2015)

Image 1: Source:https://www.msdmanuals.com/pt-br/casa/dist%C3%BArbios-cerebrais,-da-medula-espinal-e-dos-nervos/biologia-do-sistema-nervosa/c%C3%A9rebro – Accessed on: 28 Dec. 2023.



In a classroom, as mentioned by Amaral & Guerra (2022), the stimuli that the student receives during a class reach the brain through the sense organs and activate different sets of neurons, connected to each other, each of them involved with an important mental function for learning. Attention selects information and the brain gives meaning to it. Emotions generate the motivation necessary for executive functions to plan strategies in favor of learning. When the student elaborates, repeats, remembers, retrieves, and creates new information, he reactivates neurons and triggers neuroplasticity.

Although the brain continues to mature for most of life, the brain does not mature at the same rate in each individual, that is, according to Semrud-Clikeman (2015), just because you have a classroom full of students of the same age does not mean that they are equally prepared to learn a certain topic, concept, skill or idea. It is important for teachers and parents to understand that brain maturation influences readiness to learn. For teachers, this is especially important when designing lessons and selecting which strategies to use.

THE BRAIN OF A PERSON WITH ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD)

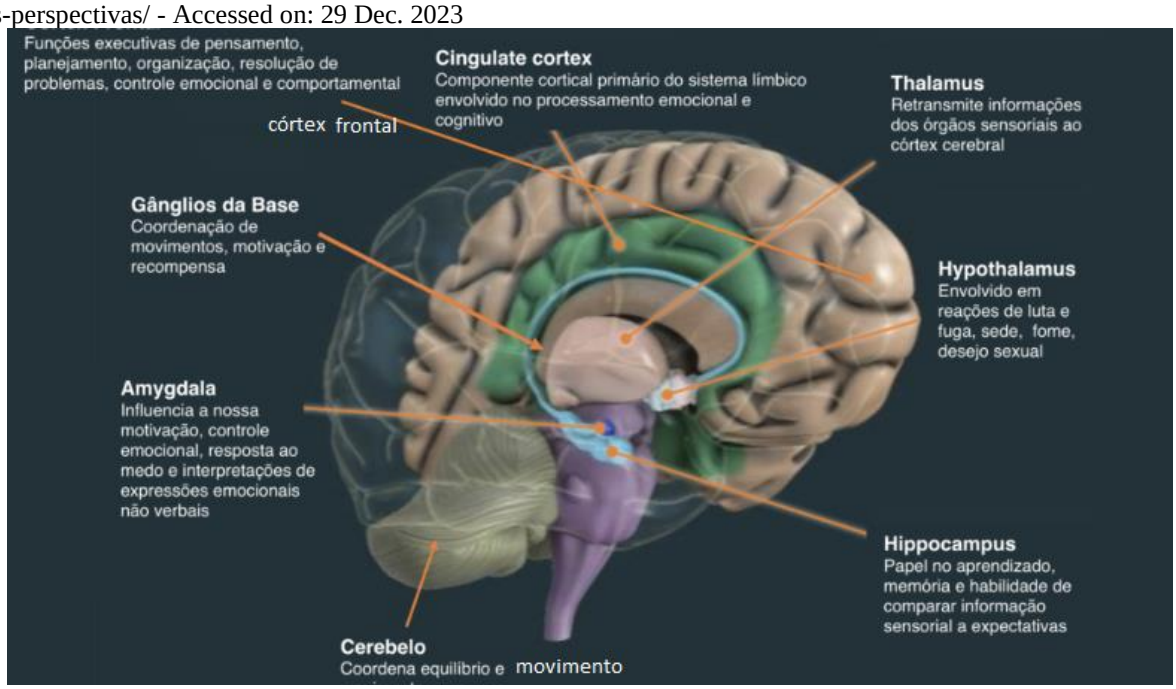
The neural network of a brain of a person with ADHD works differently. The front portion of the brain is underdeveloped in several cases of ADHD. Silver (2023), reminds us that brains with ADHD have low levels of a neurotransmitter called norepinephrine. Norepinephrine is linked arm-in-

arm to dopamine. Mason & Rosier (2023), reports that neuroimaging studies have revealed the structural differences in the ADHD brain. Several studies have pointed to a smaller prefrontal cortex and basal ganglia, and decreased volume of the posteroinferior vermis of the cerebellum – all of which play important roles in focus and attention. What this means is that ADHD is not a difference in behavioral preference. Instead, ADHD seems to be partially attributed to a difference in the way the brain is structured. What may seem like behavioral choices—laziness, sloppiness, and forgetfulness—are likely due to differences in brain structure.

In addition, research indicates that the participation of noradrenergic systems in individuals with ADHD (Han and Gu, 2006) and insufficiencies in the circuits of the prefrontal cortex and amygdala, from the neurotransmission of catecholamines, results in symptoms of forgetfulness, distractibility, impulsivity and disorganization (Armsten and Li, 2005). Studies using magnetic resonance imaging (MRI) have shown a decrease in neural activity in the frontal region, anterior cingulate cortex and basal ganglia of patients with ADHD (Bush et al., *1999 apud Couto* et al. *,2010)*

The areas of the brain that may be affected in ADHD, according to Pedroza (2023), are mainly: frontal cortex, basal ganglia, cerebellum, temporal lobe, cingulate cortex, cerebral amygdala, and thalamus (*Image 2*)

Image 2 - Source: https://caminhointegrativo.com.br/2023/10/25/transtorno-do-deficit-de-atencao-e-hiperatividade-tdah-novas-perspectivas/ - Accessed on: 29 Dec. 2023



Another avenue of investigation, according to Semrud-Clikeman (2015), is the interaction between gene and environment to help understand the etiology and course of ADHD. Nigg *et al*. (2010) reviewed the literature and detailed which psychosocial factors were important for attention

difficulties. In these families, there were genetic factors that, in turn, interact with environmental factors.

Despite many studies and multimodal approaches, according to Firouzabadi et al. (2021), the anatomical and pathophysiological bases of child and adult ADHD are not well understood. This likely reflects the nature of ADHD: the disorder is multifactorial, with heterogeneous phenotypes and genotypes, so imaging studies are not definitive unless they include large samples to stratify the disorder. In addition, the results of imaging studies are attenuated by the impact of age, gender, medications, and cognitive therapies used to reduce symptoms. The anatomical variability of the developing brain from childhood to adolescence and into adulthood may overshadow the detection of an anatomical site that may be directly implicated in ADHD. In view of this, there is a need for the neuroscientific community to invest resources, even making use of artificial intelligence, in understanding this disease that has impacts on individuals, family members, caregivers and society as a whole.

Recent studies by Lohani & Rana (2023), have focused on the development of an automatic ADHD diagnostic system using a large dataset balanced with traditional machine learning approaches to overcome the shortcomings of existing methods, since traditional methods of ADHD discovery consist of test batteries of examinations to assess neurological and mental status. This work is part of a project called "Artificial Intelligence Applications for Affordable and Accessible Health care for Differential Diagnosis of Psychiatric Disorders" of the Department of Science and Technology of the Government of India.

ADHD AND LEARNING

According to SILVA (2009), many of the characteristics of children with ADHD "rest in a state of latency" when they are enjoying only the family space or simply do not cause more serious problems. The picture usually changes as soon as the child is inserted in the school where he is asked to comply with rules and goals, follow routines, "perform tasks and is rewarded or punished according to the efficiency they are fulfilled" and at established times

For Barkley (2002), ADHD encompasses three fundamental difficulties in an individual's ability to manage their behavior: difficulties in maintaining their attention, control and inhibition of impulses, and excessive activity. It is also considered the existence of two more problems related to this disorder, such as difficulty in following rules and instructions and disagreement in responses to certain situations. Such symptoms directly interfere with the subject in his/her academic trajectory; in family, affective and social relationships; as well as impairing work performance.

Nigg (2009), states that most children with ADHD have poor academic performance; This is partly due to a lack of attention and an inability to focus on a task. However, the chances of a child

with ADHD having a formal learning disability are as high as 30%. In severely affected children, marked auditory memory and learning problems accompany the learning disability. The combination of cognitive problems can make learning and success extremely difficult for the child in an educational setting. People with ADHD may have difficulty planning the steps involved. This may be a consequence of problems in working memory capacity, in the processing of interfering information, in the integration of behavioural sequences or in the suppression of triggered responses in a context of rapid decision-making. The result is inaccurate and inefficient performance.

Executive function impairments associated with ADHD are often noticed first in school because the academic and behavioral requirements of the classroom are difficult for many children with ADHD to meet in an age-appropriate manner. Some with ADHD are able to meet these requirements quite adequately during the early years of school, but later find that their executive functions significantly interfere with the increasing demands of self-management and learning and more complex academic outcomes in the upper grades, especially during high school and college. - Secondary education. However, studies of adolescents and adults with ADHD indicate that long after the school years, many continue to have significant problems with work, social relationships, sleep, family life, household management, driving, and many other aspects of daily life (Brown, 2013; chap. 3, p. 49–55).

Sisto and Martinelli (2004) apud Scimago (2014) describe that experiencing failure to perform in academic tasks can generate feelings of insecurity and lack of confidence in children, since studies are the main activity during childhood and adolescence. As is characteristic of most children and adolescents with ADHD, having an impact on school performance is likely to have repercussions on the formation of school self-concept, which is related to the representations of one's own school achievements and the evaluations that the person makes about them. In his studies, Scimago (2014) mentioned that the observation that children with ADHD feel more guilty, show more belief in doing more wrong things and worse self-esteem. As these children have more difficulties with attention and executive functions, the worse their performance in schoolwork and daily tasks, which can impact the development of self-esteem and cause more feelings of guilt.

The lack of preparation, diagnosis, and treatment of Learning Disorders, according to Santos & Barros (2021), can awaken in falsely "included" students the development of comorbidities and antisocial behaviors, however, the possible emergence of comorbidities "unsuspectingly" is caused by low self-esteem due to school failure and social frustration, by the discrimination suffered in the school environment by both teachers and colleagues, as well as due to the practice of mockery and bullying, situations that can also come from the family itself. It is in the school space that lacks reception and correspondence with their needs that the student with the disorder can often show signs of painful and tormenting learning, circumstances that force parents to be attentive and allied to the

school in this process, especially with regard to the school reception process (GOMES, 2012). Studies indicate that students diagnosed with learning disabilities express a higher frequency of depressive symptoms and demand complaints such as sadness, loneliness, lack of motivation, pessimism, feelings of guilt, among others (RODRIGUES *et al*., 2016).

FINAL THOUGHTS

We observed through this research that although attention deficit/hyperactivity disorder has many studies, there is still a significant advance in the formation of an anatomical-pathophysiological model of the most affected brain areas, since there is a multivariability of higher functions that are impaired in the educational and social context.

In addition, we found that there are still many deficiencies in the inclusion of patients with attention-deficit/hyperactivity disorder in the family, in society and especially in the school environment, and because of an increase in associated comorbidities such as feelings of guilt and low self-esteem.

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