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REVIEW ARTICLE

An Overview on the Application of Neuroscience in Educational Therapy

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ABSTRACT

Educational therapy has been recognised by health and educational organisations, notably the World Health Organisation (WHO), as an effective intervention for people having learning disabilities, neurodevelopmental disorders and psychiatric disorders. This therapy addresses individual learning needs through tailored educational and therapeutic techniques, resulting in considerable improvements in academic performance and cognitive development. Educational treatment improves skills in dyslexia, dyscalculia, autism spectrum disorders (ASD), and attention deficit/hyperactive disorders (ADHD) by addressing underlying cognitive processes and neurological deficiencies. Neuroscience gives critical insights into how specific brain areas and neurotransmitters promote learning. Neuroimaging techniques highlight the relevance of the prefrontal cortex, hippocampus, and neurotransmitters such as dopamine and glutamate in therapeutic interventions, emphasising the significance of early intervention and brain plasticity.

Keywords: *educational therapy, neurodevelopmental disorders, neurotransmitters, neuroplasticity*

1. EDUCATIONAL THERAPY: RECOGNITION AND IMPORTANCE

Numerous health and education organisations, including the World Health Organisation, have recognised educational therapy as an effective intervention. Educational therapy uses individualised educational and therapeutic approaches to address the specific learning needs of people with learning difficulties, neurodevelopmental disorders, and psychological illnesses.

Educational therapy is critical for treating various forms of learning challenges, including dyslexia, dyscalculia, and dysgraphia. These problems can severely undermine a child's academic progress and cognitive development. Educational therapists use a variety of intervention strategies to improve reading, writing, and math skills, each tailored to the individual's unique challenges and strengths by concentrating on basic cognitive processes such as phonological processing and working memory, aids in the development of foundational abilities required for academic success (Fletcher, 2018).

Educational therapy is essential in the treatment of neurodevelopmental disorders such as ADHD and ASD. Repetitive behaviors, social skills and communication are common challenges faced by children with ASD, which can inhibit their academic progress. To establish a nurturing learning environment that meets the requirements of the child, educational therapists employ structured teaching methods, social skills training, and sensory integration approaches (Chia, 2010). The educational therapy goal for children with ADHD is to enhance executive functioning abilities including self-control, time management, and organisation, all of which are essential for everyday functioning and academic success (Collado-Valero, 2021).

A child's capacity to learn can also be impaired by psychological conditions such as anxiety and depression. In order to address these problems, educational therapy incorporates mindfulness exercises and cognitive-behavioral strategies to lower anxiety and enhance emotional control. Students can realise their full academic potential thanks to this holistic strategy, which also helps to establish a positive and supportive learning environment (James et al., 2020).

The importance of educational therapy extends beyond academic achievement. It cultivates resilience, self-esteem, and a positive outlook on learning. Educational therapy helps students overcome their obstacles and cultivate a lifelong love of studying by addressing both the emotional and cognitive aspects of learning. This holistic approach is essential for children with learning and developmental disabilities who need specific help to succeed in educational settings.

2. THE ROLE OF NEUROSCIENCE IN EDUCATIONAL THERAPY

Neuroscience is important in educational therapy because it provide insights on how the brain learns and processes information. Understanding the neurological basis of learning and cognitive development enables educational therapists to create more effective, evidence-based intervention that are targeted to the specific requirements of students with learning and developmental issues.

Functional neuroimaging techniques, such as fMRI and PET scans, have helped us understand the exact brain regions involved in various cognitive functions (Wijbenga et al., 2024). Educational therapists can help students enhance their overall cognitive functions by addressing these areas with particular therapeutic exercises. For example, dyslexic students show aberrant activity patterns in brain regions related with phonological processing and reading. This research is used by educational therapists to create phonics-based programs that target these brain impairments, boosting reading skills (Kuhl, 2020). Similarly, knowing the neurological underpinnings behind ADHD, such as dopamine modulation and prefrontal cortex activity, enables therapists to employ treatments that improve attention and executive functioning (Wolraich, 2019).

Incorporating neuroscientific principles into educational treatment improves intervention effectiveness while also aiding in progress and outcome monitoring. Using psychoeducational, neuropsychological evaluations and neuroimaging data, therapists can objectively quantify changes in brain functions and structure, offering useful feedback on the effectiveness of their therapy approaches (Yen et al., 2023).

3. NEUROPLASTICITY AND EARLY INTERVENTION

Neuroplasticity, or the brain's ability to reorganise itself by creating new neural connections throughout life, is a critical notion for understanding the efficacy of educational treatment and early intervention. The brain's plasticity is especially evident during early childhood, a period of rapid neuronal development and significant synaptic plasticity. Early educational interventions that take advantage of this window of opportunity can have a major impact on a child's cognitive and academic development (Chen et al., 2024).

Early intervention is essential for children with learning disabilities like dyslexia, dyscalculia, and specific language impairments. These therapies are intended to address the underlying neurological abnormalities associated with these illnesses. For example, phonics-based reading programs for dyslexia have been shown to increase the activation of brain areas involved in phonological processing, such as the left temporoparietal cortex, hence increasing reading skills (Economou et al., 2024).

Similarly, early intervention for neurodevelopmental disorders like ASD and ADHD uses neuroplasticity to encourage more adaptable brain connections. Executive function training can cause anatomical and functional changes in brain areas responsible for social behavior, attention, and executive functioning (Rapport et al., 2020). These therapies work best when performed throughout early childhood, when the brain is most susceptible to environmental stimuli and therapeutic inputs.

Neuroplasticity further highlights the need of early intervention in reducing the consequences of adversity in childhood (ACEs) and mental health conditions. Early intervention with social-emotional learning (SEL) and mindfulness techniques can assist to reorganise brain circuits involved in stress regulation, emotional control, and resilience. Mindfulness-based therapies, for example, have been demonstrated to increase prefrontal cortex thickness and improve connection between the prefrontal cortex and the amygdala, both of which are important in executive control and emotional regulation (Holz et al., 2020).

Furthermore, early intervention frequently incorporates multisensory and movement-based exercises that stimulate many brain regions at once. These activities not only improve cognitive and physical skills, but they additionally foster the integration of sensory stimuli, which is critical for children with sensory processing disorders. Sensory integration treatment employs neuroplasticity to strengthen the brain's ability to interpret and respond to sensory input, thereby improving overall learning and daily functioning (Randell et al., 2022).

Research has repeatedly shown that the earlier an intervention develops, the greater the impact on the child's brain development and learning results. Early intervention can have long-term benefits that include improved academic achievement, social skills, and emotional well-being. By addressing cognitive, emotional, and behavioral issues early on, these interventions can change the developmental trajectory of children with learning and developmental disorders, allowing them to reach their full potential.

4. THE IMPORTANCE OF NEUROTRANSMITTERS IN OUR BRAIN

Neurotransmitters (see Table 1) are chemical messengers which promote communication between neurons in the brain. They serve an important part in signal transmission across synapses They are the connectors between neurons that allow the brain to function properly and efficiently. Neurotransmitters play a crucial part in many aspects of mental and physical health, including mood, cognition, behavior, and overall bodily functions (Teleanu et al., 2022). The exact number of identified neurotransmitters is difficult to pinpoint due to ongoing discoveries, but over 100 neurotransmitters have been identified to date, categorised into several major groups (Su et al., 2020).

Neurotransmitters are primarily responsible for regulating mood and emotional reactions. Serotonin, also known as the "feel-good" neurotransmitter, is essential for mood regulation and preventing mood disorders. Low serotonin levels have been associated with depression, anxiety, and other mood disorders (Ketchesin et al., 2020). Dopamine, another important neurotransmitter, regulates reward, motivation, and pleasure. It plays an important function in rewarding behaviours and is associated with addiction and other psychiatric problems (Volkow et al., 2019).

Neurotransmitters also play an important role in cognitive functions like learning, memory, and attention. Acetylcholine is essential for memory development and learning. It is especially active in the hippocampus, a sub-cortical region area responsible for these activities. Acetylcholine deficiencies are associated with cognitive decline and disorders such as Alzheimer's (Winek et al., 2021). Glutamate, the brain's primary excitatory neurotransmitter, is required for synaptic plasticity, which underpins learning and memory (Stacho and Manahan-Vaughan, 2022). GABA (gamma-aminobutyric acid), the major inhibitory neurotransmitter, regulates neuronal excitability and maintains a balance between excitement and inhibition in the brain (Nimgampalle et al., 2023).

The delicate balance and interaction of neurotransmitters are required for optimal brain function. Disruptions in this balance can result in a variety of neurological and mental diseases. For example, an imbalance of excitatory and inhibitory neurotransmitters can cause seizures, whereas abnormalities in dopamine pathways have been linked to schizophrenia and bipolar disease (Howes & Shatalina, 2022). Understanding the relevance of neurotransmitters and their activities in the brain has substantial implications for the development of therapies for various illnesses (Edinoff et al., 2021).

Enhancing neurotransmitter production can have a major impact on cognitive performance, mood, and overall mental wellness. Several measures can be used to increase neurotransmitter production and efficiency, including as regular exercise, a healthy diet, appropriate sleep, sunlight exposure, mindfulness and meditation, and herbal supplements (Sejbuk et al., 2022).

Regular physical exercise activity is one of the most effective methods for increasing neurotransmitter production. Exercise stimulates the release of endorphins, dopamine, serotonin, acetylcholine, and norepinephrine, which can boost mood, reduce anxiety, improve concentration, self-control, and cognitive function. Aerobic workouts like running, swimming, and cycling are very effective at increasing these neurotransmitters (Pahlavani, 2023). Furthermore, exercise raises levels of brain-derived neurotrophic factor (BDNF), a protein that helps neurons survive, develop, and function, as well as acetylcholine activity by promoting the growth and differentiation of new cholinergic neurons and synapses (Ruiz-Gonzalez et al., 2021).

Nutrition is essential for the creation of neurotransmitters. A balanced diet rich in amino acids, vitamins, and minerals promotes the development of important neurotransmitters. For example, foods high in tryptophan (e.g., turkey, eggs, nuts) can increase serotonin levels, whereas tyrosine-rich foods (e.g., cheese, meat, soy products) promote dopamine production. Fish, flaxseeds, and walnuts provide omega-3 fatty acids, which are required for proper brain function and neurotransmitter balance (Mishra et al., 2021).

Quality sleep is essential for neurotransmitter modulation. Sleep deprivation can have a substantial impact on the levels of serotonin, dopamine, and other neurotransmitters, causing mood swings and cognitive impairment. Ensuring enough and consistent sleep promotes neurotransmitter balance and overall brain function (Sejbuk et al., 2022).

Mindfulness meditation can boost the production of neurotransmitters such as serotonin and GABA, lowering stress and improving mood. Regular meditation has been demonstrated to improve emotional regulation, reduce anxiety, and increase general well-being (Dudi, 2024).

Exposure to natural sunlight can increase serotonin levels and improve happiness. Sunlight exposure also modulates melatonin production, a neurotransmitter involved in sleep regulation, which promotes healthy sleep patterns (Taniguchi et al., 2022).

Table 1: Association of Neurotransmitters and its Production Methods with Different Cortical Regions and Functions

Neurotransmitter	Production Methods	Cortical Regions	Functions
Dopamine	Exercise, proper diet (tyrosine-rich foods), medications	Prefrontal Cortex, Hippocampus, Amygdala	Reward, motivation, attention, learning
Serotonin	Exercise, sunlight exposure, proper diet (tryptophan-rich foods), SSRIs, herbal supplements (St. John's Wort)	Prefrontal Cortex, Hippocampus, Amygdala	Mood regulation, sleep, appetite, cognition
Norepinephrine	Exercise, proper diet (tyrosine-rich foods), medications	Prefrontal Cortex, Amygdala, Thalamus	Attention, arousal, stress response
Acetylcholine	Exercise, proper diet (choline-rich foods), acetylcholinesterase inhibitors	Prefrontal Cortex, Hippocampus, Occipital Lobe, Temporal Lobe	Muscle activation, memory, learning
Glutamate	Proper diet (glutamine-rich foods), tDCS	Hippocampus, Amygdala, Cortex	Excitatory signalling, synaptic plasticity
GABA	Proper diet (glutamine-rich foods), tDCS, meditation	Hippocampus, Amygdala, Cortex	Inhibitory signalling, reducing neuronal excitability
Endorphins	Exercise, meditation	Various brain regions	Pain relief, mood enhancement
BDNF (Brain-Derived Neurotrophic Factor)	Exercise, proper diet (omega-3 fatty acids)	Hippocampus, Cortex	Supports neuron survival, growth, and differentiation

5. BRAIN REGIONAL FUNCTIONS AND NEUROTRANSMITTERS SUPPORTING LEARNING

The human brain is a complex organ with many different regions that specialise in distinct functions. These regions work together to assist learning. Understanding these brain regions and their functions critically helps educational therapists to establishing effective educational therapies and interventions.

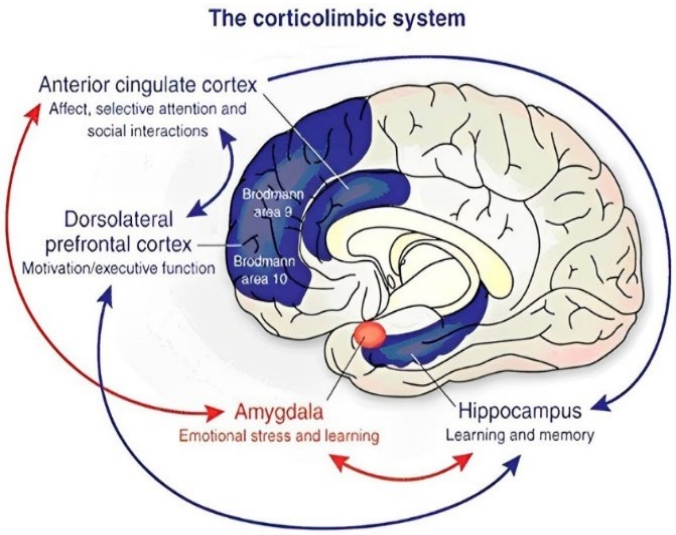

Figure 1. The Corticolimbic System Model. The corticolimbic system consists of several brain regions that include the rostral anterior cingulate cortex, hippocampal formation, and basolateral amygdala (Benes, 2010).

5.1 Prefrontal Cortex

Located at the frontal lobe of the brain, the prefrontal cortex (PFC) (*see* Figure 2) is responsible for *executive functions*, a set of cognitive processes that are essential for goal-directed behavior, problem-solving, and adaptive functioning. These processes include working memory, cognitive flexibility, inhibitory control, planning and organisation, which are crucial for academic success as they enable students to manage their thoughts, actions, and emotions effectively, facilitating learning and the execution of complex tasks (Widge et al., 2019). The PFC primarily utilizes dopamine and glutamate. Dopamine is crucial for modulating reward, motivation, and cognitive functions, while glutamate is involved in synaptic plasticity, essential for learning and memory. Additionally, serotonin plays a role in mood regulation and social behavior in this region (Zahra et al., 2022).

Developing strong executive functions is critical for academic success and lifelong learning. By understanding the role of executive functions in education therapy and implementing intervention strategies to enhance these skills, educators can provide students with the tools they need to succeed academically and beyond.

ADHD is the most prominent neurodevelopmental disorder associated with executive function deficits, particularly in inhibitory control and working memory (Crisci et al., 2021). Children with ASD often exhibit impairments in cognitive flexibility and planning (Nicita et al., 2023), while intellectual disabilities can result in broader executive function deficits affecting multiple cognitive domains. Executive function deficits are also commonly seen in students with mood disorders, including depression and anxiety. They struggle with emotion regulation and decision-making (Wijbenga et al., 2024). Additionally, individuals with schizophrenia and bipolar disorder also experience significant executive function impairments. The impairment in executive functions disrupt their ability to plan and organize tasks effectively (Cotrena et al., 2020).

Dyslexia and dyscalculia, specific learning disorders involving reading and mathematical difficulties, can also involve executive function deficits. Dyslexia is frequently associated with impairments in working memory and processing speed (Kızılaslan, A., & Tunagür, 2021). In children with learning disabilities, executive function deficits often manifest in difficulties with organisation, planning, and attention regulation, complicating the learning process (Theodoratou et al., 2023).

5.2 Hippocampus

The hippocampus (see Figure 1), which is located in the medial temporal lobe, is essential for memory creation, organisation, and retrieval. Declarative memory, which deals with the recollection of information and events, is especially dependent on it. Additionally, the hippocampus facilitates spatial memory, which helps people move around their surroundings. Anterograde amnesia, a disorder where new memories are difficult to create, can be caused by damage to this area (Urgolites, 2022). The main neurotransmitter implicated in these processes is acetylcholine, which promotes long-term potentiation (LTP), a crucial synaptic plasticity mechanism. Additionally, glutamate is important for excitatory signalling and hippocampal plasticity, which support memory and learning.

5.3 Amygdala

The amygdala (see Figure 1), located next to the hippocampus, processes emotions, primarily fear and pleasure. It has a substantial impact on emotional learning and memory by changing how events are encoded and retrieved according on their emotional relevance. The amygdala's relationship with the prefrontal cortex and hippocampus is critical for integrating emotional and cognitive learning (Bradley & Sambuco, 2022). The amygdala regulates emotional and stress responses via the neurotransmitter’s norepinephrine and serotonin. Alongside each other glutamate aids in excitatory transmission and

emotional responses as Gamma-aminobutyric acid (GABA) serves as the primary inhibitory neurotransmitter in amygdala and helps to regulate excitatory signals and prevent overstimulation.

5.4 Temporal Lobe

The processing of language and auditory information depends on the temporal lobes (*see* Figure 2), which are found on the sides of the brain. While the right temporal lobe is important in identifying and deciphering nonverbal cues and facial expressions, the left temporal lobe, specifically, Wernicke's area, is engaged in language comprehension. Additionally, memories are formed and retrieved via the temporal lobes (Wijbenga et al., 2024). The main neurotransmitters in this area are glutamate and GABA, which promote excitatory and inhibitory signalling, respectively. Acetylcholine also affects how the temporal lobe processes auditory information and makes memories.

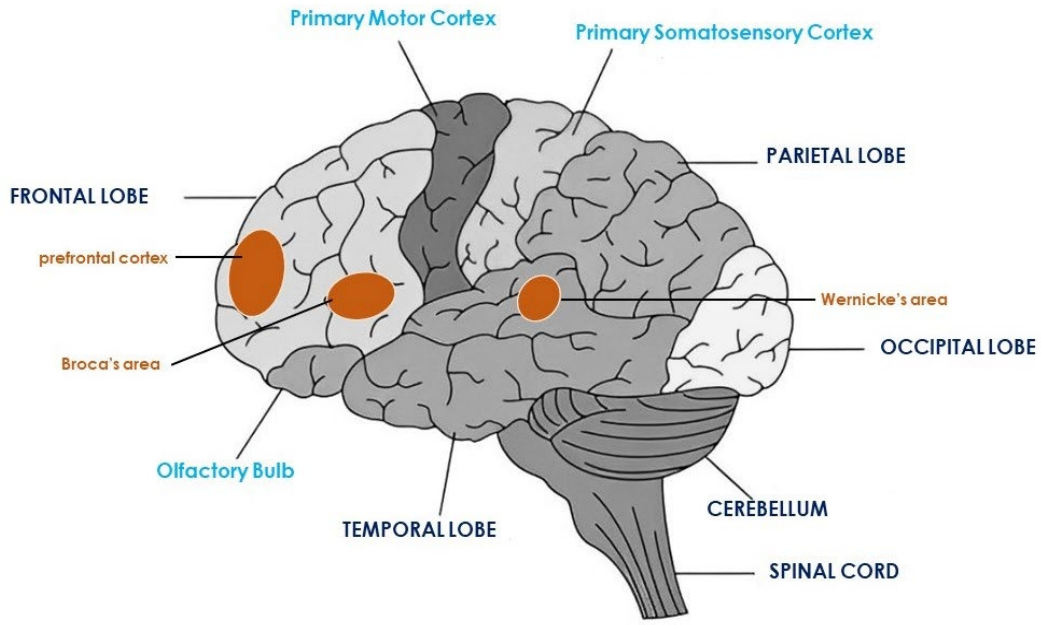

Figure 2: The Cortical Lobes of the Brain. Each lobe does not work in isolation. On the contrary, the neural network is interwovenly connected yet highly plastic, allowing it to adapt to changing environmental circumstances.

5.5 Occipital Lobe

The occipital lobe is located in the back of the brain and is primarily responsible for visual processing. It processes information from the eyes, allowing the sense of forms, colors, and movements. Visual information processed in the occipital lobe is subsequently combined with sensory inputs from other brain regions to build a cohesive image of the environment, which is required for tasks like reading and visual-spatial thinking (Luo, 2020). It primarily uses glutamate and GABA. Glutamate transmits excitatory impulses that are essential for visual perception and processing, whereas GABA offers inhibitory regulation to guarantee appropriate visual signal modulation and avoid excessive excitement. In addition, acetylcholine modulates visual attention and improves visual information processing in the occipital lobe.

5.6 Parietal Lobe

The parietal lobe, located between the frontal and occipital lobes, integrates sensory input from multiple modalities, including touch, proprioception, and spatial awareness. The parietal lobe is important for

visuospatial processing, attention, and motor coordination. It enables people to perceive spatial relationships and navigate their surroundings, which is essential for activities like sketching, sports, and mathematics problem solving (Bazaz et al., 2024). Glutamate is the predominant excitatory neurotransmitter in this area, responsible for synaptic plasticity and sensory integration. GABA, the primary inhibitory neurotransmitter, aids in the regulation of neuronal excitability and the maintenance of an excitation-inhibition balance in sensory processing (Metkus et al., 2024). Acetylcholine also influences attentional mechanisms and sensory perception in the parietal lobe (Ruiz et al., 2021).

The neurotransmitter systems in various brain areas work together to support their respective roles. For example, dopamine dysregulation in the prefrontal cortex is linked to attention-deficit/hyperactivity disorder (ADHD) and schizophrenia (Nourredine et al., 2021), but serotonin abnormalities can cause mood disorders like depression and anxiety (Pourhamzeh et al., 2022). Understanding the many types of neurotransmitters employed in different brain regions sheds light on the intricate interaction of neuronal circuits that underpin behavior, cognition, and emotion. This information is critical for designing targeted medication to address specific neurotransmitter abnormalities associated with a different disorder.

6. EXECUTIVE FUNCTIONS OF OUR BRAIN

As mentioned earlier, located at the PFC, executive functions are higher level cognitive processes that are essential for flexible and adaptive thinking, emotional control, and efficient problem-solving. They are also essential for self-management and resource management in order to accomplish a goal. While academic achievement is frequently given priority in the educational setting, encouraging the development of the executive functions can provide students the skills they need to succeed in the long run both inside and outside of the classroom.

According to Tobia (2015), in the story of Phineas Gage, a railroad construction foreman in the 19th-century, despite surviving a severe and damaged brain's frontal lode after an iron rod that accidentally shot through his skull, he lived for another 12 years. However, his family and peers realised drastic changes in his personality, temperament and decision-making abilities post-accident. His case not only provided early evidence of the importance of the frontal lobes in executive functions and emotional regulation, it also suggested the brain's neuroplasticity attributes when he managed to gain some functions and adjust to this new situation. This underscores the profound connection between brain structures and executive functions processes, demonstrating how physical changes in the brain can alter fundamental aspects of human identity.

6.1 Inhibition Control

Inhibition control is the ability to suppress irrelevant or distracting impulses and responses, allowing for better focus and self-regulation (Spaniol and Danielsson, 2022). This skill is essential for students in maintaining attention in class, resisting temptations, and adhering to social norms. As inhibition control develops, students become better at managing their behavior, leading to a more conducive learning environment. By emphasising the development of inhibition control over academic results, schools can help students build the self-discipline needed for both academic and personal success. This foundational skill enables children to focus on tasks, follow instructions, and engage in goal-directed activities, ultimately enhancing their overall learning experience.

6.2 Working Memory

Hocking et al. (2020) in their studies mentioned that working memory is the ability to store and manipulate information for brief periods of time. Such ability is essential for the students to accomplish a variety of cognitive and academic tasks, such as reading comprehension, arithmetic problem solving,

and following multi-step directions. Good working memory enables students to retain and process information, resulting in improved knowledge and performance. Developing working memory skills in school can increase students' capacity to handle complex cognitive activities considerably. Prioritising this ability over rote learning over test scores can help the students develop a deeper understanding and more meaningful connection with educational material, preparing them for future academic and life problems.

6.3 Cognitive Flexibility

According to Tong et al. (2023), cognitive flexibility is the ability to think about multiple ideas at the same time. It is also the mental ability to switch between thinking about two different concepts. It is also a skill that allow the students to view issues from different perspective, allow the students to adjust to new information and changing situations in their mind, boosting their creativity, innovation and problem-solving skills. By developing this skill, the students can be better prepared to handle the constantly changing modern world. It's essential for adapting to new challenges and seizing opportunities, making it a crucial part of a comprehensive education.

6.4 Planning and Organisation

The capacity to establish objectives, create plans, and efficiently handle duties are all part of planning and organisation skills. According to Kofler et al. (2024). These abilities are essential for academic achievement because they enable students to prioritize work, fulfil deadlines, and divide assignments into digestible chunks. Better academic results and a decrease in the stress and distress that come with disorganisation can result from students learning planning and organisation skills in school. Students can develop habits that will help them in their academic careers and throughout adulthood by prioritising these skills over standardised test scores. A healthy and productive life and the accomplishment of long-term objectives depend on efficient planning and organisation.

6.5 Emotional Regulation

In the studies conducted by Groves et al. (2022), the capacity to control and react to emotional situations in a positive and healthy way is known as emotional regulation. It is essential for preserving concentration, developing resiliency, and encouraging constructive social connections. Strong emotional regulation abilities help children manage stress, overcome obstacles, and work cooperatively with their colleagues in the classroom. Teachers can foster a friendly environment that supports mental health and well-being by placing a strong emphasis on emotional control in the classroom. Students who concentrate on this area can gain the emotional intelligence necessary to succeed academically and personally by navigating challenging social situations.

6.6 Task Initiation

Task initiation is having the capacity to start things quickly, effectively, and without excessive procrastination. Such an ability is essential for academic success since it guarantees results in timely completion. According to Wijbenga et al (2024), students' productivity and time management can be enhanced in the classroom by cultivating such an ability. Students can acquire a proactive attitude toward their work and the confidence to take on new tasks by placing a higher priority on task initiation than just academic results. This change may result in more motivated and involved students who are ready to take on greater responsibility in the future.

6.7 Goal-directed persistence

Goal-directed persistence is the ability to persevere and focus on long-term goals in the face of challenges and problems. Perseverance and persistence are essential for overcoming challenges in both academic and personal settings. By cultivating this executive function, students develop a strong work ethic and a growth mindset, helping the to see task to completion, and equipping them for lifelong learning and success (Freed, 2022).

6.8 Problem-solving

Problem-solving is the ability to identify, evaluate, and develop solutions to complex situations. The capacity enables students to overcome problems and use their knowledge in real-world settings. As stated by Schäfer et al. (2024), solving problems are also important in developing students' critical thinking and creativity, which leads to higher academic accomplishment and more imaginative solutions. Students are encouraged to think independently and build the abilities necessary to tackle real-world problems during problem solving.

6.9 Metacognition

Metacognition refers to the awareness and comprehension of one's own mental processes. It refers to the ability to think and reflect about one's own thinking and cognitive activities. it allows students to reflect on their learning practices and make changes to improve (Wu and Was, 2023). Developing metacognitive skills in school can lead to more effective learning and problem-solving as students gain a better grasp of their learning style. Schools that emphasise metacognition can help students build self-regulated learning habits that will serve them well throughout their academic careers and beyond. This transformation has the potential to promote a culture of continual development and lifelong learning.

7. STATISTICAL EVIDENCE AND LONG-TERM OUTCOMES

Numerous studies have demonstrated the long-term benefits of well-developed executive functions. According to the longitudinal studies conducted by Moffitt et al. (2011), they discovered that children with good inhibitory control had better health, income, and criminal outcomes three decades later than those with worse inhibitory control. Motiff et al (2011) followed 1,000 people from birth to age 32, demonstrating the importance of executive skills in influencing life outcomes. Similarly, Diamond and Lee (2011) found that early interventions and educational therapy aiming at enhancing executive functions in the early years of school children can result in significant gains in academic achievement, social skills, and emotional control. According to Diamond and Lee (2011), the early interventions and educational therapy that could enhance the executive functioning skills of children include mindfulness training, physical exercise and cognitive training. Children who participated in these early intervention programs showed improved academic performance, better social interactions, and enhanced emotional regulation.

8. CONSEQUENCES OF EXECUTIVE FUNCTION DEFICITS IN CHILDREN WITH ASD AND ADHD

Deficits in executive processes can have serious consequences for academic performance, typically resulting in learning disabilities or difficulties. Multi-step activities that require planning, organising, and execution might be difficult for children with executive function impairments (Schäfer et al., 2024). This can emerge as difficulties finishing homework, organising their thoughts for writing assignments, or recalling and applying previously learned knowledge. These problems can lead to lower academic accomplishment and a negative self-image of their learning ability. As a result, these youngsters may be misdiagnosed with specific learning problems, when in reality, their difficulties come from underlying executive function abnormalities.

Executive function deficiencies are more noticeable in children with neurodevelopmental disorders such as ASD and ADHD (Kofler et al., 2024). These deficiencies can cause considerable difficulties in daily living and academic success.

According to Kofler et al. (2024), children with ASD frequently suffer with cognitive flexibility, making it difficult for them to adapt to changes in routine or approach problems from new angles. This rigidity may limit their capacity to participate in classroom activities that involve creative thinking or switching between tasks. They also find it challenging to read social cues and adjust their behaviors to interact socially with others accordingly. As such, children with ASD may ended up being isolated or in conflict with their peers.

Similarly, children with ADHD generally have problems in inhibitory control and working memory, which can make it difficult to retain concentration, follow multi-step instructions, and manage urges. These issues might cause frequent interruptions in the classroom, incomplete tasks, and an overall sense of discontent. Peers of children with poor inhibitory control may find the latter's behaviour as intrusive or inappropriate (Groves et al., 2022). As such, children with ADHD may it challenging to form and maintain friendship, adding further emotional distress especially children with poor emotional regulation skills may see an increase in having depression and anxiety disorders. They may also find it challenging to sustain attention during lessons and reinforcing a vicious cycle of poor academic performance and diminished motivation.

Recognising and addressing the significance of executive function impairments allows educators and parents to develop interventions that support these children's learning requirements, thereby reducing the impact on their academic performance.

9. RELATIONSHIP BETWEEN EMOTIONAL DISORDERS AND EXECUTIVE FUNCTION DEFICITS

Emotional disorders are a broad category of mental health disorders that primarily influence mood, emotions and behavior. These emotional disorders which include anxiety disorders and depression can significantly affect executive functions, which are responsible for directing thoughts, actions, and emotions in goal-directed behavior. Fernandes et al. (2023) in their studies found that emotional disorders significantly impair working memory performance, which disrupt the ability to hold and manipulate information. They stated that anxiety impairs inhibitory control, as anxious children are more likely to react impulsively to avoid perceived threats, leading to difficulties in classroom settings and social interactions.

Anxiety and depression also closely associated with the impairment of cognitive flexibility. The rigidity in thinking can make it difficult for children to adapt to new or changing situations, and a reduced ability to shift from negative thoughts or beliefs contributing to feelings of hopelessness and decreased problem-solving abilities. Children with depression might find it hard to control their focus and avoid getting stuck in negative thought patterns, which can exacerbate their depressive symptoms and impact their ability to engage in daily activities (Pourjaberi et al., 2023).

Individuals with emotional disorders often find it hard to set goals, develop strategies and manage time effectively. The constant worry and fear associated with individual having anxiety while reduced motivation in depressive individual can interfere with the ability to plan and organize tasks (Liu et al., 2024). The lack of motivation can result in procrastination and difficulty completing tasks, further impacting academic and social functioning. The cognitive load of managing anxiety leaves fewer cognitive resources available for planning and executing tasks effectively.

10. CONCLUSION

Neuroscience knowledge is extremely beneficial in educational therapy because it provides a scientific framework for understanding and treating learning, neurodevelopmental, and psychological issues. This understanding improves intervention effectiveness by revealing brain systems that underpin cognitive and behavioral functioning. Knowledge of neuroplasticity guides the timing and type of interventions, increasing cognitive and behavioral gains during periods of high synaptic plasticity (Wilkinson et al., 2019). Evidence-based strategies, such as early intervention, educational therapy, cognitive training and mindfulness, have been verified by neuroimaging research, increasing the legitimacy and effectiveness of educational therapy (Ng et al., 2021). Furthermore, knowing the neurological foundation of emotional and psychological illnesses helps to create holistic treatment strategies that meet both cognitive and emotional requirements. Overall, neuroscience provides educational therapists and interventionists with vital insights, allowing them to create targeted, effective, and evidence-based therapies, ultimately leading to better outcomes for individuals with learning and developmental challenges.

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12. COMPETING INTERESTS

Author has declared that no competing interests exist.

13. FINANCIAL DISCLOSURE

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14. ARTIFICIAL INTELLIGENCE DISCLOSURE

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15. DATA AVAILABILITY STATEMENT

Not applicable. No primary data were generated in this study.

16. ETHICS APPROVAL

Not applicable. This study did not require ethics approval.

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