International Journal of Early Childhood Special Education (INT-JECSE)
DOI:10.48047/intjecse/v16i4.82 ISSN: 1308-5581 Vol 16, Issue 04 2024

The importance of executive functions in the individual's daily life

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Received : 09/03/2024 ; Accepted : 22/09/2024 ; Published : 17/10/2024

Abstract:
Executive functions play an important role in the daily life of individuals, as they are the core of cognitive processes, as well as having a huge influence on different psychological, behavioral, and cognitive issues (anxiety, learning disorders…). This paper attempts to clarify the concept of executive functions, their location on the brain level, then their role and importance in the day-to-day life; as well as the different strategies that can be implemented for the bettering of these functions.
Keywords: Executive functions, response Inhibition, working memory, cognitive flexibility

1. Introduction:

Executive functions are a group of higher cognitive processes that help organize the individual's thinking process and behavior control to achieve a certain goal.
These functions include 3 major roles: **Inhibitorycontrol**or **Response Inhibition**: the ability to refrain from inappropriate reactions;**working memory**: the ability maintain and manipulate a limited amount of information for brief periods of time; **cognitive flexibility**: the ability to switch focus from one mission or concept to another.
The study of executive functions or what used to be called frontal lobe functions began in the mid-twentieth century during World War 2, through the observation of individual cases suffering brain injuries to tie the type of symptom to the location of the injury.
These observations have contributed to the progress of psychological studies, neurological and cognitive in general, and to pinpoint the disorders resulting from frontal lobe injuries, thus for treatment methods specifically.
Through the continuation of these studies, clinical notes on patients, suffering from frontal lobe injuries, have shown that they could suffer from other symptoms that affect not only the cognitive side but the emotional and behavioral ones as well and that those suffering injuries other than frontal lobe ones could also lose cognitive functions despite the lack of any abnormality while performing routine and semi-automatic functions, but they show a pronounced disruption in the case of performing new behaviors (organizing and processing new work plans). The frontal injury then does not necessarily mean the disruption of cognitive functions.

2. What are executive functions:

Lezak used the term executive functions in 1982 instead of Frontal functions, and he defined them as what successfully enable an individual to perform willing tasks derived towards goal directed behavior (Lezak, Howieson&Loring, 2004).
Seron, Van Dr Linden & Andres (1999) defined them as the number of processes that assist a person to adapt to new or complex situations, especially when semi-automatic cognitive abilities (like responses and reflexes) become insufficient.

Executive functions are then a group of cognitive processes that intertwine the individual's daily life, especially in unprecedented situations allowing them to plan an action as they are performing it, focusing and paying attention thus ceasing routine and semi-automatic responses that do not fit the current situation. So, they are higher functions that allow the organization of cognitive processes, directing behavior, and setting actions (verbal and physical) to reach a specific goal under the control of the Frontal Lobe and its different structures.

These functions appear in early childhood and continue to develop and grow for a long period reaching their peak at the age before education and during education later on.Garon Smith and Bryson (2008) pointed to the existence of two major phases for the development of executive functions: the early childhood phase being the first three years of the child's lifewhere they first appear, to later develop past the age of three, especially between the ages three to five where they are also coordinated in this phase.

3. The Neurological Base of executive functions:

Executive functions have been tied to the brain and more specifically to the frontal lobe, which is still to this day considered a base for these functions.

3.1. Brain lobes:

The human brain consists of two opposite hemispheres with two bridges made up of a substance called white matter: the corpus callosum and the trine. These bridges allow information to travel between the right and left halves of the brain and vice versa.

Each cerebral hemisphere is responsible for one side of the body and is divided into four lobes. Each lobe is named after the bone that covers it: the frontal lobe (forehead), the parietal lobe (top of the skull), the temporal lobe (from the temple to the area above the ears), and the occipital lobe (the back of the skull). Each of these lobes has different and important functions for regulating mental, motor, and sensory processes. Below is a brief overview of the brain lobes (Dardier, 2004):

The frontal lobe: is located at the front of the brain, between the central groove (Rolando's fissure), which separates it from the parietal lobe, and the lateral groove (Sylvian fissure), that separates it from the temporal lobe. This lobe covers about 33% of the total brain volume in humans, making it the largest compared to the other brain lobes.

The frontal lobe plays a key role in controlling movement (via the motor cortex) and complex thinking. It is heavily involved in planning, decision-making, problem-solving, and emotional control, and serves as a center for executive functions.

The parietal lobe: is located on the brain's outer surface, specifically in the middle region. It plays a crucial role in processing sensory information and is involved in all aspects of bodily sensation, thanks to skin receptors distributed throughout the body. These receptors are stimulated by five main factors: touch, pain, pressure, heat, and cold.

The parietal lobe contains the primary sensory area in its anterior part, just behind the central groove. This area is responsible for basic sensation. The posterior part (sensory association area) is where sensory integration occurs, linking information from different senses such as touch, smell, hearing, and sight (e.g., recognizing the position of objects in the hand and perceiving 3D shapes through touch alone). The upper part of the parietal lobe is specialized in spatial processing, including spatial orientation and positioning of the body in space. It also plays a role in locating objects to be seen (visual perception), recognizing movements, and perceiving depth.

The temporal lobe: is located on both sides of the brain, behind the ears, under the Sylvian fissure, below the frontal and parietal lobes, and in front of the occipital lobe. It is responsible for processing auditory information and is home to the primary auditory area.

This area is where auditory sensory processing occurs. The temporal lobe also contains the auditory association area, where sounds are interpreted and translated.
Since learning begins through hearing and listening, there is a third area near the primary auditory area called the language comprehension area, or "Wernicke's area", which is responsible for recognizing objects by understanding the meanings of words.
Additionally, the medial side of the temporal lobe contains the olfactory area, which receives smell inputs.
The occipital lobe: is located at the back of the brain, behind the parieto-occipital groove. It is responsible for processing visual information. In the posterior part of this lobe, the visual sensory area receives visual neural signals and is where objects are perceived.
The anterior part of the occipital lobe, known as the visual association area, is responsible for analyzing the physical characteristics of what is seen, such as its shape, color, and movement.
A fifth lobe was coinedby the famous French surgeon, Paul Broca: **The limbic lobe**: This lobe is located in the inner side of each hemisphere. It is not a true lobe, but rather a functional group of structures that control and regulate higher functions such as memory and emotion. It contains several deep nuclei within the temporal lobe. The most important of which are:
(a) Amygdala: Composed of two structures, one in each hemisphere of the brain. The amygdala is the center of emotions, particularly fear and anxiety.
(b) Hippocampus: Responsible for **episodic memory**, playing a key role in storing recent or short-term memories and later transferring them to long-term memory for consolidation. In cases of Alzheimer's disease, this area is often affected.
Although the lobes have distinct functions, they are not entirely independent. Instead, they work in an interconnected and integrated manner to perform their functions, thanks to the various connections that link them to each other and the rest of the brain and body.

3.2. Key Components of Executive Functions:

Most research that has focused on executive functions, across different ages, indicates that these functions do not develop at the same time and can be influenced by various factors. Studies show that the earliest executive functions to emerge and develop in children are: response inhibition, cognitive flexibility, and working memory, typically between the ages of 2 and 4 years old (Johansson et al., 2015).
Researchers such as Miyake, Friedman, Emerson, Witski, and Howerter (2000) agree that these three functions are fundamental for the smooth operation of other complex executive functions, such as planning, which cannot occur without the involvement of these core functions.

3.2.1. Response Inhibition:

Inhibition is one of the main components of executive functions. It is defined by Miyake & Friedman (2004) as the intentional suppression of dominant, controlling, and/or automatic responses, and the resistance to various interferences that could hinder a person's thinking or behavior while performing a task.
It refers to the ability to suppress or prevent automatic or impulsive responses that might be inappropriate or unhelpful in a given situation. It involves controlling behavior, emotions, and thinking to avoid actions or decisions that could negatively impact long-term goals or lead to adverse outcomes.
Given the complexity of this function, researchers have divided it according to the nature of the processes involved. Miyake & Friedman (2004) divided it into three types:
Resistance to interference from distractors: Filtering out irrelevant external information to the task being performed.

Resistance to proactive interference: This refers to cognitive inhibition, which is the ability to resist interference from old information stored in memory that is irrelevant to the current task, like mixing up old phone numbers with new ones.
Inhibition of dominant/automatic responses: This refers to behavioral inhibition.
Harnishfeger (1995) differentiated between **cognitive inhibition** and **behavioral inhibition.** The former is responsible for controlling mental processes, while the latter is responsible for suppressing motor responses, often referred to as motor inhibition.
The function of response inhibition is mainly linked to the activity of the prefrontal cortex, which plays a crucial role in regulating goal-directed behaviors and controlling impulses and emotions. This control relies on wide networks of interaction between other brain areas involved in processing sensory and emotional information.
Several studies, as mentioned by Lafontaine (2015), show that response inhibition appears at an early age (within the first few months after birth), but its components do not develop at the same pace or level in children. For example, infants aged 6 to 8 months can inhibit 40% of dominant simple behaviors and responses. By their first year, they can resist being visually attracted to an object inside a transparent box by going to the side opening to retrieve the object. Before this age, their natural reaction is to try to grab the object directly from inside the box without noticing the transparent barrier.
This ability develops rapidly, with children being able to suppress 78% of behaviors by 22 months and reaching 90% by 33 months. Significant and rapid development occurs between 3 and 6 years, during which children can inhibit dominant or automatic responses (behavioral or cognitive) for extended periods (Roy, 2008).
Mischel & Mischel (1983) conducted a study on response inhibition in children aged 3 to 6 years using the delay of gratification model. The child is presented with two rewards: one small and immediate, and a larger one that requires waiting. The study found that 3- and 4-year-olds tend to prefer the larger reward but cannot control their behavior and go straight for the immediate one. However, 5- and 6-year-olds can wait a little longer for the bigger reward.
A similar finding was reported by Livesey & Morgan (1991) using a Go/No Go test, where 3- and 4-year-olds failed to inhibit their responses, while 5- and 6-year-olds succeeded, demonstrating better self-control despite understanding the instructions.
The growth of response inhibition slows between 8 years old and adolescence (12-14 years), reaching full maturity around 16 years (Roy, 2008).

3.2.2. Working Memory:

Memory is a fundamental cognitive process that requires the involvement of biological and psychological systems to receive, record, retain, store, and finally retrieve and use information at the right time. Memory is classified by the retention duration:
Short-term memory: Retains information for a few seconds or minutes before either retrieving or discarding it.
Long-term memory: Stores and retrieves information and experiences from years ago.
Short-term memory plays a crucial role in various daily tasks, such as understanding speech or a text, thinking, remembering a phone number temporarily until it’s written down, counting money, and performing arithmetic tasks.
Baddeley proposed the term working memory, defining it as the ability to temporarily retain or store (for seconds or every few minutes) information needed to perform complex cognitive tasks such as learning, thinking, or language comprehension. The central executive is the core of working memory, supervising all cognitive processes like thinking and understanding, selecting

relevant information, suppressing irrelevant information, and regulating ongoing activities or automatic responses to adapt to new situations.

Baddeley (1993) emphasized the central executive's ability to hold information in long-term memory, retrieve it when needed, and use it. It can also manage dual tasks and coordinate between them. (Baddeley, Chincotta&Adlam, 2001).

The central executive also works to coordinate between two other systems known as the "slave systems" of working memory, which are:

(1) Phonological loop (verbal working memory): Retains auditory-verbal information for a short time (not exceeding 2 seconds). Repetition, or verbal rehearsal, keeps the memory active.

(2) Visuospatial sketchpad (visual working memory): Temporarily retains visual-spatial information, such as written information or spatial positioning (Mora, 2011)

In 2000, Baddeley added another component to the previously mentioned three components of working memory, called the **(3) episodic buffer or episodic memory**, which he defined as the component that allows information from different levels to remain active until a specific task is completed. This memory, like the previous ones, operates under the control of the central executive.

Working memory is associated with several brain regions, the most important of which is the prefrontal cortex. This region oversees organizing information, controlling attention, and integrating data from the brain's sensory areas. Other regions, such as the frontal and parietal lobes, also play a role in supporting working memory and guiding real-time behavior.

Working memory is one of the first functions to emerge. Studies have shown that a six-month-old infant can retain a simple image for up to four seconds. This ability gradually develops over the following months (9 and 12 months), allowing the child to retain a greater number of images with each stage of development (Lafontaine, 2015). According to Baddeley's model, working memory consists of three components that do not develop simultaneously but gradually. Before the age of four, it is difficult for a child to receive, store, and retrieve complex auditory or visuospatial information due to the incomplete development of the central executive. However, they can repeat simple sequences of numbers or words (the phonological loop). The child may also find it challenging to retrieve the spatial position of objects (visuospatial sketchpad), as this task requires the intervention of the central executive, which does not become fully functional before the age of six (Garon, Bryson, & Smith, 2008). The growth and development of working memory continue progressively until the end of adolescence, around the age of 15 (Calderon Plata, 2013).

Studies conducted on preschool-aged children have shown that it is impossible to separate behavioral inhibition (response inhibition) from working memory, particularly from the retention of information during early childhood. The coordination between these two functions does not fully develop until the age of two, when a child becomes able to retain an instruction or rule (working memory) to inhibit a dominant response (response inhibition) (Garon, Bryson, & Smith, 2008).

Nigg (2000) linked working memory with response inhibition, defining response inhibition as the process of removing irrelevant information (non-pertinent information) from working memory at three levels:

- Encoding: Inhibiting irrelevant stimuli from entering working memory by preventing their initial processing.
- Storage: Updating information by inhibiting and removing outdated or irrelevant data and replacing it with new relevant information.

- Response or Retrieval: Controlling interference by inhibiting and voluntarily deleting dominant or automatic responses.

3.2.3. Mental Flexibility:

Van der Linden &Andrès (1999) defined mental flexibility as the individual's ability to modify a certain mental plan and smoothly and quickly shift information processing to adapt to the demands of new tasks and situations. Mental flexibility, therefore, is the capacity to adapt to changes in the surrounding environment and adjust mental strategies based on new information. It enables an individual to switch from one idea to another and to adjust their thinking and behavior when encountering an obstacle or new information. For this reason, mental flexibility is considered one of the most complex executive functions, as it requires the ability to voluntarily shift attention from one task or action to another.

It can be defined as the cognitive function that allows a person to direct their attention and transition between tasks, alternating between them, through a rapid assessment of possible alternative solutions before giving a final response. While response inhibition maintains attention fixed on one task, mental flexibility involves coordinating both working memory (retaining the first piece of information or instruction in mind) and response inhibition (resisting the dominant or controlling response).

Adam et Colette (2007), citing Eslinger & Grattan (1993), mentioned that there are two types of flexibility:

(1) Spontaneous flexibility: This involves the flow of thoughts and responses needed to answer a simple question in a stable and unchanging environment that does not require adjusting or modifying the response.

(2) Reactive flexibility: This refers to the ability of an individual to shift their attention from one task to another when the environment or situation changes, allowing for an appropriate response to the new circumstances.

Mental flexibility is closely linked to the activity of the prefrontal cortex, which regulates higher executive processes such as planning, emotional control, and task-switching. It also depends on the coordination between various neural networks, including other brain regions such as the parietal cortex and the anterior cingulate cortex.

A child's ability to shift from one rule to another is connected to their capacity to reorganize these two simple rules and combine them to extract a single, more complex rule. This ability typically develops between the ages of four and five (Zelazo, Muller, Frye &Marcovitch, 2003). The success of this function is also related to the child’s ability to grasp different aspects of an object (color, size, and shape) and understand its positioning, a capacity that also emerges around the age of four (Smidts, Jacobs & Anderson, 2004). The development of mental flexibility continues through adolescence.

4. Challenges in Evaluating Executive Functions:

There are no precise diagnostic criteria for executive function disorders to date, as this type of disorder manifests in various behaviors that differ from person to person. Additionally, no specific area of the brain has been allocated for each executive function, and frontal lobe damage does not necessarily imply a disorder in executive functioning.

Moreover, it is impossible to isolate one function from another due to their interconnectedness and interdependence. For example, **response inhibition** plays a significant role in **working memory** by preventing irrelevant information from entering or removing it when updating the goals of the current or new task. Furthermore, taking a test for response inhibition or any other

executive function requires listening to the instructions, storing them in short-term memory, retrieving them at the appropriate time, and applying them. In all cases, the individual must listen, understand, store, retrieve, and select relevant information or experiences while inhibiting potential other responses. This illustrates the bidirectional relationship between response inhibition and working memory.

Since the frontal lobe, which is the center of these functions, does not fully develop until the end of adolescence, executive functions (response inhibition, working memory, and mental flexibility) gradually grow and develop from infancy through adolescence. Response inhibition shows rapid growth in early childhood, whereas working memory and mental flexibility develop at a steadier pace.

Despite researchers' efforts to simplify tests for executive function specialization, no test can exclusively assess one function. Some tests remain complex, requiring the engagement of multiple executive functions, as is the case with the “Tower of Hanoi” test.

Another challenge in evaluating executive functions is that the process of performing a task is not purely automatic and cannot be fully controlled, leading to differences in individual performance. Additionally, a controlled process can become automated, leading to variations in the same individual’s results during test/retest scenarios (Hughes & Graham, 2002).

As previously mentioned, no test exists to evaluate a specific executive function, and no executive function can be used independently without the involvement of others. Therefore, it is likely that an individual's results may differ across two tests that are presumed to measure the same executive function due to the overlap of functions and the age factor. Like other cognitive functions, executive functions develop with age, and they do not all evolve at the same rate or the same age.

5. Strategies for Managing Executive Function Disorders:

Intervention and rehabilitation for executive functions rely on continuous activation to improve, enhance, and maintain these abilities for as long as possible (in cases of developmental diseases, for example). This is achieved through cognitive activities targeting the enhancement of memory, response inhibition, and mental flexibility (Levine, B., Stuss, D. T., &Winocur, G. 2012).

Improvement depends on several factors, including the severity of the injuries or disorders, the duration of treatment, and the individual’s commitment to the programs.

Establishing agreed-upon therapeutic strategies for executive function disorders is highly challenging. Until these disorders and their causes are better understood and a treatment plan is developed, Sohlberg, Mateer, & Stuss (1993) identified three key areas for rehabilitation:

1/ Preparing the Environment and Using External Aids to Facilitate Task Completion:

As a first step in this type of intervention, a thorough functional assessment must be conducted to determine the impact of disrupted executive functions on various daily activities. This allows for selecting appropriate modifications to the environment to compensate for impaired executive functions and improve the individual's performance. For example, if the person struggles with flexibility, those around them should avoid frequent or sudden changes. It's important to consistently communicate with the person, informing them of upcoming changes before and during the transition, such as preparing for travel or changing a familiar recreational activity.

This strategy often involves the participation of an external party in addition to the use of various physical aids (such as organizing the living or working space by minimizing distractions or using visual aids to clarify task sequences). The third party plays a critical role in guiding the individual with executive function difficulties, as well as advising the family and caregivers by

providing them with necessary information about the disorder, its symptoms, and how to help and interact with the affected person.

This approach aligns with Luria's (1963) perspective, which emphasizes that the main goal of addressing executive function disorders is to compensate for the internal deficit in guiding behavior by using external aids.

2/ Training Specific Skills:

This approach focuses on gradual learning, where the individual:

(1) Learns or relearns certain action plans or routines using visual or verbal aids, with assistance provided in completing each step of the intended task. Over time, these external aids are gradually withdrawn until the person can perform the task independently.

(2) Acquires the necessary skills to use a compensatory system, such as a communication book.

(3) Improves pragmatic skills, including the ability to think before speaking (self-regulation) and social skills (e.g. conversation, waiting for their turn, and behaving appropriately in public spaces…etc).

6. The Importance of Executive Functions in an Individual's Daily Life:

Executive functions play a fundamental role in an individual's daily life, serving as the cornerstone for success in various aspects, whether academic, social, or professional.

Working Memory is essential for academic learning and performance, as it allows individuals to retain information while reading, solving problems, or processing data. For example, to solve a math problem, a student needs to understand the various given data and hold it in mind to find the solution. Working memory aids individuals in analyzing the information presented, regardless of its complexity, to make appropriate decisions. For instance, a driver needs working memory to process traffic signals, speed limits, and directions all at once, and he had to remember them.

Working memory also plays a crucial role in managing daily tasks such as preparing meals (remembering the amounts of various ingredients we are mixing together according to a recipe),attempting to keep track of our spending in a store when we are unable to use the calculator; and organizing schedules.It is vital in social interactions, enabling individuals to remember important details related to conversations (ex: being able to recall someone's name to introduce them to others after meeting them at a party) (Alloway, T., & Alloway, R. G., 2010).

Factors such as depression and anxiety can negatively affect working memory, leading to difficulties in concentration and handling pressure, which, in turn, adversely impacts an individual's mental well-being. Conversely, improving working memory through cognitive training can contribute to better mental health.

Individuals with strong working memory tend to perform better in complex tasks, while those with weak working memory may struggle with learning, remembering, and concentrating.

Regarding **Response Inhibition**, individuals who effectively control this function are often better able to adapt to stressful situations and impulses that arise from daily life pressures. This control can help prevent impulsive, negative, and unconsidered actions, such as immediate (verbal or physical) responses to provocations or resisting the urge to buy unnecessary or expensive items. It also aids in managing stress and making wiser decisions.

In academic and professional contexts, response inhibition plays a significant role in managing attention and avoiding distractions, thereby enhancing the individual's ability to comprehend information and work towards long-term goals. Students with better inhibitory control tend to perform better academically due to their ability to avoid distractions and focus on their studies (Best, Miller, &Naglieri, 2011) .

This function also greatly contributes to effective time management, whether in daily life or the workplace. It enables individuals to organize their priorities and avoid irrelevant stimuli or distractions, particularly in tasks that require sustained attention such as the urge to use a phone while driving or browsing social media during work, allowing them to focus on essential tasks to enhance productivity and achieve daily goals; Inhibiting actions that could lead to danger or accidents (Stopping yourself from crossing a road when a car suddenly comes around the corner)
On the other hand, poor control of this function can lead to impulsive behaviors, concentration difficulties, and increased exposure to stress and anxiety, as seen in individuals with Attention Deficit Hyperactivity Disorder (ADHD), for example.

Mental Flexibility plays a pivotal role in improving quality of life across various domains and is crucial for addressing daily challenges and achieving success in professional and social life.

Effective social interaction requires cognitive flexibility, which enables us to modify our behaviors and communication styles in response to various social contexts. It facilitates better conflict resolution and stronger relationships by assisting in the understanding of others' viewpoints.

Individuals need to adapt to changes in their work or personal environments. With mental flexibility, individuals can change their plans, adjust their strategies, and rethink their approaches to better cope with emergencies and manage stress and pressure. According to a study by Martin and Rubin (1995), cognitive flexibility is directly linked to adaptability in social situations and general well-being, it helps people better handle life's unpredictable challenges It plays a significant role in emotional regulation, allowing individuals to adjust their emotional responses based on the context. For example, being able to shift perspectives after a failure and view it as a learning opportunity rather than a defeat can enhance emotional resilience. Ccognitive flexibility is linked to improved emotional well-being and the ability to cope with stress (Kashdan&Rottenberg, 2010).

For instance, if an unexpected problem arises at work, mental flexibility helps individuals think of alternative solutions, adjust strategies and continue progressing rather than feeling stuck or hopeless, thereby enhancing their problem-solving abilities. If one plan fails, they can quickly adapt and seek alternative ways to achieve desired results. This aspect is crucial in professional and educational contexts, as success may require modifying strategies based on new developments or unforeseen challenges. It promotes creative problem-solving. Individuals with mental flexibility tend to be more creative in problem-solving because they can view challenges from different angles and experiment with various strategies. They also approach difficulties positively and constructively, which enhances overall mental health.

Moreover, mental flexibility can be considered an essential component of creativity and innovation, enabling individuals to think outside the box and explore new ideas and methods in fields such as art, science, or entrepreneurship, leading to innovative solutions and the development of new concepts (Diamond, 2013; Barkley, 2012; Miyake & Friedman, 2012).

7. Conclusion

Executive functions encompass a set of cognitive abilities such as working memory, response inhibition, and mental flexibility that allow individuals to solve problems and adapt to changing situations. Therefore, executive functions play a crucial role in modifying and organizing purposeful human behavior. They are vital in various aspects of life, including academic and/or professional development, managing anxiety, and social relationships. Individuals with well-developed executive functions are capable of managing their time effectively, overcoming challenges, and controlling their emotions and impulses more efficiently.

On the other hand, impairments in executive functions are often associated with developmental and mental disorders such as autism, attention deficit hyperactivity disorder (ADHD), or certain forms of neuropsychological disorders. Early intervention and cognitive training are essential in such cases, and studies have shown that targeted training, such as cognitive activities, can strengthen executive capacities even into adulthood.

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