Early Childhood Education Researches
ISSN: 2980-2393

Makale gönderim tarihi: 25.10.2025 **Makale kabul tarihi:** 24.12.2025

A Neuroscience Perspective: The Pivotal Role of Environment and Teacher in Early Childhood Education

Dicle Akay[1]

ÖZ

Bu çalışma, erken çocukluk dönemini nöroplastisite ve sinaptik gelişim açısından kritik bir "fırsat penceresi" olarak ele almaktadır. Temel amacı, karmaşık nörobilimsel verileri eğitimciler için somut ve uygulanabilir bir müdahale çerçevesine dönüştürmektir. Nörobilim ve eğitim bilimleri arasındaki etkileşim, bu dönemdeki yüksek beyin plastisitesinin zengin deneyimlerle şekillendiğini doğrulamaktadır.

Araştırma, oyun temelli ve duyusal açıdan zengin uyaranların sinaptogeneziyi (yeni sinaps oluşumu) doğrudan desteklediğini, buna karşın çevresel yoksunluğun sinaptik budanma sürecini olumsuz etkilediğini vurgular. Bu bağlamda öğretmenler, güvenli öğrenme ortamları ve çoklu duyusal aktiviteler kurgulayarak çocukların bilişsel ve sosyo-duygusal kapasitelerini optimize etmede anahtar rol oynarlar.

Sonuç olarak bu derleme; sınıf tasarımı, müfredat geliştirme ve eğitim politikaları için stratejik öneriler sunmaktadır. Erken beyin gelişimini desteklemek adına, bireyi çevresiyle bir bütün olarak gören ekolojik bir yaklaşımın benimsenmesi gerektiğini savunmaktadır.

Anahtar Kelimeler:
Beyin, Beyin Gelişimi, Kritik Dönem, Erken Çocukluk Dönemi

ABSTRACT

This study considers the early childhood period as a critical 'window of opportunity' in terms of neuroplasticity and synaptic development. Its primary aim is to translate complex neuroscientific data into a concrete and actionable intervention framework for educators. The interaction between neuroscience and educational sciences confirms that the high brain plasticity during this period is shaped by rich experiences.

Research emphasizes that play-based and sensory-rich stimuli directly support synaptogenesis (the formation of new synapses), whereas environmental deprivation negatively affects the synaptic pruning process. In this context, teachers play a key role in optimizing children's cognitive and socio-emotional capacities by designing safe learning environments and multi-sensory activities.

Consequently, this review offers strategic recommendations for classroom design, curriculum development, and educational policies. It advocates for the adoption of an ecological approach that views the individual as an integral part of their environment to support early brain development.

Keywords:
Brain, Brain Development, Critical Period, Early Childhood Period

Introduction

The human brain, recognized as the most complex organ, has been a central subject of study for centuries. Gaining a deep understanding of its developmental trajectory, especially during the formative early childhood years, is paramount for maximizing cognitive, emotional, and social outcomes. This interest is not new; researchers as far back as the 1780s, including Charles Bonnet and Johann Spurzheim, proposed that brain structure could be modified

[1] Assist. Prof. Dr, Bahcesehir University, The Faculty of Educational Sciences, Preschool Education, dicleakay91@gmail.com, Orcid ID: 0000-0003-3513-7886
Akay, D. (2025). A neuroscience perspective: The pivotal role of environment and teacher in early childhood education, *Early Childhood Education Researches 3*(2), 15-34.

through education and exercise (Costandi, 2019). Modern neuroscience affirms this, emphasizing that early brain maturation is not merely a genetic script but is heavily sculpted by continuous environmental interactions (Ahmad et al., 2012). Experiences during this period activate neuroplasticity mechanisms, strengthening the brain's synaptic connections, and supporting learning processes.

Early childhood is deemed a critical developmental period due to the brain's rapid growth and heightened environmental sensitivity. Synaptic connections—the core communication pathways between neurons—form the functional basis of the brain. Research demonstrates that the richness of the early environment directly reinforces these connections. For instance, early exposure to language and artistic activities like music can boost cognitive flexibility by increasing synaptic density. Conversely, an environment that is apathetic or restrictive causes these crucial connections to weaken, potentially limiting a child's long-term learning capacity (Huttenlocher, 2002; Kuhl, 2010).

Environmental influence extends beyond mere cognitive stimulation; social interactions and emotional security are equally determinant. Children with secure attachments exhibit lower stress levels, making them more receptive to learning (Gunnar & Quavedo, 2007; Sroufe, 2005). Conversely, chronic or extreme stress elevates the hormone cortisol, which is known to negatively impair synaptic connections (Lupien et al., 2009). Thus, a healthy brain requires a safe, loving, and exploration-rich setting.

Research Aim and Scope

Despite the overwhelming theoretical evidence supporting the impact of brain-based strategies, a significant gap persists in the widespread implementation of these methods within early childhood education settings. This study aims to address this disconnect by investigating the mechanisms through which the brain is shaped during this critical early phase.

The primary objective of this research is to evaluate the influence of specific environmental stimuli, diverse experiences, and teacher strategies on early childhood brain development. The subsequent sections will first establish the fundamental concepts of neuroplasticity and synaptic connectivity, then link these mechanisms to core early childhood experiences and finally propose evidence-based strategies that educators can employ to enrich the classroom environment.

Neuroplasticity and Synaptic Connections

The concept of neuroplasticity—the brain's capacity to adapt and reorganize itself—is a modern cornerstone of neuroscience, yet its origins trace back to earlier observations. Pioneering work by the Italian anatomist Michele Vincenzo Malacarne provided early structural evidence, as he observed variations in the cerebellum that suggested an inherent link between physiological structure and psychological dimensions (Zanatta et al., 2018). Although he did not yet name the concept, his findings hinted at the profound influence of experiential factors and challenged the notion that the brain structure was immutable.

The idea was formally introduced in the late 19th century by William James as neuroplasticity, and later championed by Santiago Ramón y Cajal, who advanced the understanding to the cellular level. Ramón y Cajal demonstrated that the changes allowing the brain to reorganize occur specifically at the synapses—the connection points between nerve cells (Cherici, 2006). This established the synapse as the functional locus of brain flexibility. While earlier scientists incorrectly believed neural growth ceased after key developmental milestones, mid-20th-century research decisively confirmed that synaptic connections remain modifiable across the lifespan (Bruel-Jungerman et. al., 2006; Heynen et. al., 1996). This shift in perspective confirmed the brain's ability to continue learning and adapting even after the primary developmental windows closed.

Modern science has provided compelling evidence of this flexibility, proving that it extends beyond mere learning to profound reorganization following injury or sensory loss. Studies on individuals who are blind, for instance, demonstrate the brain's remarkable capacity to adapt, showing that their visual cortex can be co-opted to process auditory or tactile information based on experiential factors (Murphy et al., 2016). This modern perspective solidifies the understanding that synapses represent the essential infrastructure for information processing and storage (Ferrucci et al., 2023), and that neuroplasticity is the operational backbone of brain function across the lifespan, from development to damage repair (Pratico et al., 2024; Stiles & Jernigan, 2010).

The period of early childhood remains a critical window for cognitive development, characterized by fundamental synaptic dynamics. This period involves a rapid increase in new synapses (synaptogenesis), followed by a necessary process of synaptic pruning that selectively eliminates weaker connections (Zhang et al., 2022). This refinement is crucial for establishing the efficient neural architecture required for complex cognitive tasks and emotional regulation. The formation of this neural foundation is complex, involving genetic factors (Xia et al., 2017), neurogenesis, and the active regulation of synaptic stability and pruning glial cells like astrocytes and microglia (Costandi, 2019). Ultimately, the proper management of these synaptic dynamics, including mechanisms like Long-Term Potentiation (LTP) and Long-Term Depression (LTD), is vital for maintaining cognitive health, learning, and memory throughout an individual's life (Zhou et al., 2011).

Learning, Memory, and the Synaptic Plasticity

The relationship between learning, memory, and synaptic plasticity is a crucial area of inquiry within neuroscience. The process of strengthening synaptic connections through Hebbian plasticity—often encapsulated in the phrase "cells that fire together, wire together"—is fundamental to how experiences shape neuronal networks. Hebbian theory suggests that simultaneous activation of pre- and post-synaptic neurons strengthens the connection, thereby facilitating associative memory, such as linking an earthquake to the smell of lemons when both experiences occur concurrently (Lazari et al., 2022; Johansen et al., 2014). This concept underscores the importance of environmental interactions in driving neuroplasticity, particularly during formative early years when the brain exhibits heightened plasticity (Fernandes & Carvalho, 2016)

In the context of educational interventions, understanding how associative learning and synaptic strengthening can be optimized is crucial. For instance, research shows that long-term potentiation (LTP) serves as a cellular basis for memory, and it can be influenced by various factors including neurotransmitter systems like norepinephrine, which enhance synaptic plasticity during emotionally charged experiences (Tully & Bolshakov, 2010). Neuroimaging studies have further illustrated that LTP-induced neural network reorganization is evident in learning contexts, emphasizing that structural changes in the brain are a direct response to learning environments (Canals et al., 2009). Furthermore, incorporating principles of Hebbian plasticity into learning strategies could leverage the natural mechanisms by which the brain optimizes synaptic connections and enhances memory retention (Fernandes & Carvalho, 2016; Goldman et al., 1990).

Moreover, the efficacy of learning interventions could be improved by considering the role of homeostatic mechanisms in synaptic plasticity. These mechanisms help regulate neuronal activity and prevent instability within networks, which is critical for maintaining a balanced learning environment conducive to memory formation (Pozo & Goda, 2010). The interplay between Hebbian and homeostatic plasticity is particularly significant, as they jointly modulate the development of neuronal assemblies that are essential for effective memory recall (Humble et al., 2019). This duality in synaptic regulation provides a better understanding of how training and educational methodologies can be designed to not just present information but also to actively shape the underlying neuronal mechanisms.

In summary, by integrating insights from synaptic plasticity mechanisms, educators and neuroscientists can collaborate to create learning environments that not only facilitate immediate learning but also foster ongoing cognitive development through sustained synaptic enhancements.

Effects of Experience on Neuroplasticity and Synaptic Connectivity

It is widely accepted that the development of sensory systems is fundamentally experience-dependent (Costandi, 2019). This principle means that neural connections are strengthened or weakened based on interactions with the environment. A classic example is the visual cortex, which requires visual stimuli during a critical period—a specific developmental window—to form properly. Studies involving children with congenital cataracts show that delaying treatment often leads to irreversible visual deficits, underscoring the brain's heightened sensitivity to environmental input early in life.

However, the notion that neuroplasticity halts completely after a certain age is inaccurate. While the formation of new synapses is most vigorous in early childhood, contemporary neuroscience confirms that the modification of synaptic connections persists throughout life, particularly in response to focused learning and rehabilitation. Although the human brain is nearly complete in size by age 10, the maturation and refinement of neural circuits continue, especially within the association of cortices responsible for complex cognitive functions. Processes like synaptic pruning (up to age 30) and myelination (up to the mid-20s) increase cognitive efficiency by refining the neural circuits required for executive functions (Luna et al., 2004; Miller et al., 2012).

The timing of the prefrontal cortex (PFC) development—responsible for high-level executive functions—is subject to debate. While some research suggests its development may conclude around age 16 (Costandi, 2019), other studies track changes well into adulthood. For instance, the density of gray matter in the frontal cortex decreases between adolescence and adulthood (Sowell et al., 1998), while white matter density often stabilizes around age 30 before gradually declining (Teffer & Semendeferi, 2012). These findings indicate that cognitive control and executive functions continue to refine into early adulthood.

Crucially, the brain's ability to form and strengthen new synapses is undoubtedly more pronounced before age seven. The period around age five is considered a peak for brain development, making the 0–6 age range maximally susceptible to learning. Unfortunately, this extreme vulnerability means that exposure to negative factors like poverty or abuse during this time is linked to structural differences in brain regions like the hippocampus, amygdala, and PFC, leading to impairments in attention, memory, and emotion regulation (Costandi, 2019).

Extreme cases of deprivation illustrate the dire need for a stimulating environment during early years (Swaab, 2018). Children who suffer severe neglect often exhibit smaller brain size and limited cognitive, language, and motor skills (Perry & Szalavitz, 2017). Conversely, environmental enrichment yields powerful, enduring benefits. Canadian psychologist Donald Hebb observed that laboratory rats raised in enriched environments showed superior problem-solving skills compared to those in standard conditions (Bondi et al., 2014). This established the foundational understanding that a stimulating environment enhances cognitive abilities, a concept supported by research showing that environmental enrichment produces measurable benefits in learning across various species (Branchi, 2023).

Furthermore, the impact of experience is seen in the physical structure of the adult brain. For example, studies experienced London taxi drivers reveal that they possess increased gray matter volume in the hippocampus compared to non-drivers. This demonstrates that intensive learning and sustained practice can induce structural changes, much like physical exercise affects muscles (Cano-de-la-Cuerda, 2021; Krageloh-Mann et al., 2017). This process is perfectly summarized by Hebb's foundational rule: "Neurons that fire together wire together" (Bondi et al., 2014).

The strengthening of synaptic connections—the basis of learning and memory—occurs when neurons fire simultaneously and repeatedly (Costandi, 2019). The frequency of experience is as important as the richness of the environment itself (Save the Children, 2018). Repetitive, meaningful interactions reinforce neural pathways, making learning faster and more permanent (Shonkoff & Philips, 2000).

The process of memory consolidation is closely tied to the hippocampus, where a network of neurons fires together during memory formation. Recalling a memory reactivates this same neural network (pattern completion), explaining why a partial cue (like a familiar smell) can trigger a vivid recollection (McClelland et al., 1995).

Given that brain development is most rapid in the first three years of life and the central nervous system is highly sensitive to stimuli before age six (Bonnier, 2007; Kearns, 2017), early childhood is correctly identified as a critical period or "window of opportunity" (Jensen, 2001). As Moheb Costandi summarizes, *"The flexible changes that our experiences and behaviors create in the brain can in turn affect our future behaviors and experiences"* (Costandi, 2019, p. 142). This emphasizes that the environment must be socially and emotionally supportive to maximize positive developmental outcomes (Rowley & Williams, 2015).

The Critical Impact of Environment on Early Brain Development

Building on the concept of neuroplasticity—the brain's ability to change and reorganize itself—it becomes evident that external factors play a crucial role in shaping neural architecture. Lenroot et al. (2007) also report that brain structure is influenced by both genetic and environmental factors, with certain brain regions exhibiting considerable heritability while others demonstrate plasticity shaped by environmental conditions. Moreover, the role of brain-derived neurotrophic factor (BDNF), crucial for neuronal plasticity, is influenced by these environmental conditions. Fluctuations in BDNF expression act in response to environmental challenges and highlight its role in neuronal adaptation, shaped by both genetic risk factors and environmental stresses (Ċastrén & Rantamäki, 2010). This underscores that brain development is fundamentally influenced by the interplay of genetic frameworks and external experiences that interact with these biological predispositions.

Environmental influence is particularly pronounced during early childhood, when experience dynamically interacts with an individual's genetic makeup. Boyce et al. (2020) state that gene-environment interactions emphasize the biological embedding of experiences, whereby early environmental exposures can alter biological responses and thus shape subsequent development. This concept finds support in research by Claessens et al. (2010) that notes the enduring impact of early adverse experiences on stress responsiveness and overall health in later life.

Our choices and exposures—including parents, schooling, peer groups, and life experiences—continuously modify and mature in our preferred ways of thinking and behaving. Crucially, environmental stimuli such as play, movement, and authentic real-life experiences exert a powerful impact on the formation and strengthening of neural connections. These stimuli are foundational for supporting the development of all major domains, including sensory, motor, cognitive, emotional, and social capacities. Research has consistently shown that enriched environments lead to increased cognitive flexibility and adaptability, which are essential attributes for lifelong learning (Greenough et al., 1987). This confirms that despite the dominant influence of genetics, personal growth and learning are fundamentally driven by environmental factors (Hermann, 2017), underscoring the vital role of education.

Overcoming the Impact of Adversity

Given the immense power of education to build capacity and competence, targeted attention must be directed toward children growing up in inadequate or disadvantaged settings**.** Today, many children still suffer the consequences of social inequalities stemming from differing socioeconomic conditions. They may be exposed to violence or abuse, lack access to appropriate educational curricula, or even be denied the fundamental right to education (Landsdown, 2005). Furthermore, widespread adversities such as child labor, migration, or family instability affect countless young lives (UNESCO, 2007).

These adverse experiences are often linked to chronic stress, which can negatively alter brain structures like the hippocampus, thereby impairing memory and emotional regulation (Semrud-Clikeman & Ellison, 2009; White & Pulla, 2012). These negative environmental conditions necessitate specific interventions designed to foster their capabilities and increase their resilience (White & Pulla, 2012). Sensory, motor, and cognitive stimulation, along with responsive caregiving, are essential for optimizing and regulating the neural connections required for normal brain function (Novkovic et al., 2015). Therefore, neuroscience research actively seeks to identify the most favorable environmental conditions that can counteract negative experiences and support brain plasticity (Stack, 2013).

For example, powerful evidence supporting the long-term benefits of early psychosocial stimulation comes from a well-documented longitudinal study conducted in Kingston, Jamaica**.** Researchers examined the effects of a nutritional supplement program with or without a psychosocial stimulation component on toddlers (9–24 months) (Grantham-McGregor et al., 1991). The experimental group received a four-week psychosocial program aimed at training mothers to stimulate their child's development through play and enhance mother-child interaction (Grantham-McGregor et al., 1997).

The follow-up results demonstrated profound and lasting effects:

- At ages 7–8, the intervention group displayed higher perceptual-motor skills (Grantham-McGregor et al., 1997).

- By ages 11–12, they achieved superior scores on intelligence and cognitive tests (Walker et al., 2000).
- At ages 17–18, they maintained higher performance across intelligence, verbal analogies, and reading measures (Walker et al., 2005).
- Most compellingly, by age 22, the stimulated children showed significantly lower rates of violent behavior (physical fights or weapon use), achieved higher educational attainment (maths, school scores), and exhibited fewer symptoms of depression and social inhibition compared to the control group (Walker et al., 2011).

In conclusion, these findings clearly illustrate that environmental conditions, particularly those rich in sensory and social experiences like play, movement, and responsive interaction, are essential prerequisites for healthy brain development in early childhood.

The Necessity of Early Intervention in terms of Economy and Development

The period of early childhood is recognized as the most effective time to minimize or prevent the negative effects of adverse environmental conditions, largely because this stage is considered a critical period for brain development (Fox et al., 2010). During these years, preschool children demonstrate an ability to learn more easily and quickly than their school-age counterparts (Fox et al., 2010; Rowley & Williams, 2015).

Because the quality of education received in this period profoundly influences an individual's future educational success, there is a strong argument that educational resources should be disproportionately allocated to the early childhood sector (Farmer-Dougan & Alferink, 2013). Considering the eventual contributions and savings provided by effective early education, investing in these years is regarded as both highly effective and economically appropriate (Stack, 2013).

The investments in early childhood period are also compatible with Heckman’s Model. The empirical studies associated with Heckman's model, particularly in the realm of economic analysis and labor economics, reveals significant insights into the essential role of human capital formation and how various influences, both genetic and environmental, affect economic outcomes. A primary focus of Heckman's contributions pertains to the importance of skill formation at various life stages, emphasizing the cumulative nature of learning processes. His model integrates complex interactions between human capital, educational attainment, and labor market outcomes (Ginther, 2010). The research findings align with Heckman’s assertion that early investments in skill formation are particularly beneficial, creating a foundation for lifelong learning and adaptability (Pfeiffer & Reuß, 2008).

Bartling et al. (2011) illustrates how health disparities among children can hinder their human capital development, thereby affecting long-term economic productivity. Heckman’s framework suggests that addressing health and educational inequalities is essential for maximizing human capital formation and optimizing economic growth (Ginther, 2010).

In conclusion, the insights from Heckman’s model and accompanying empirical studies illustrate that human capital is not merely a function of innate abilities but is significantly shaped by environmental factors, educational policies, and health systems. Strengthening human capital through informed policy decisions is critical for fostering economic development and enhancing overall societal well-being.

The Pivotal Role of Teachers Optimizing Early Childhood Brain Development

The long-term findings underline the importance of creating an environment that supports brain development in early childhood, emphasizing the need for tailored interventions and activities that can have lasting impacts. The activities to be implemented in early childhood education to develop children's capacities and competences should generally support brain development. Brain development is a complex and dynamic process that requires stimulation through appropriate activities tailored to children's needs. But first of all, these activities should be appropriate for children's developmental levels. At this point, the greatest responsibility falls on the teacher (Enz & Stamn, 2013). Teachers act as facilitators of learning, ensuring that activities align with developmental milestones. Because teachers are the most important people who will contribute to children's learning by using these strategies and they are responsible for planning appropriate experiences to support children's learning and development (Enz & Stamn, 2013; National Association for the Education of Young Children [NAEYC], 2009). Teachers need to recognize that children have different learning styles, work on the best learning methods for children and identify them with students and make educational materials easily accessible to children (Steif & Alishah, 2020). Differentiated instruction plays a key role in ensuring that all children can benefit from learning experiences.

According to NAEYC (2009), a good teacher is a teacher who fulfilling his/her responsibilities in many areas such as organizing the classroom, planning the curriculum, using various teaching strategies, assessing children, interacting with children, and working with children's families. Effective early childhood educators take a holistic approach, integrating multiple strategies to meet the diverse needs of young learners. On the other hand, the basic principles required by NAEYC for the realization of practices appropriate for children's development are given below:

- All areas of development and learning (physical, social, emotional, and cognitive) are important, and all areas of development are interrelated. The development and learning of children in one area of development is affected by the development and learning in other areas.
- Development and learning are influenced by the dynamic and continuous interaction of biological maturation and the environment.
- Early experiences have a great impact on children's development and learning, both cumulative and delayed, and the most appropriate period for children's development and learning to occur is early childhood.
- Children develop best when they have the necessary opportunities for positive relationships with caring adults and peers and when they have secure and lasting relationships.
- While development and learning take place in multiple social and cultural environments, they are also affected by these environments.
- Children are always mentally active in understanding the world around them. While they understand the world, they learn in various ways. Therefore, teaching strategies and interactions should be utilized to support learning.
- Play is an important tool for developing self-regulation and promoting language, cognitive and social competence.
- Development and learning are enhanced when children's existing skills are raised to a higher level and when they are provided with opportunities to practice newly acquired skills.

The brain is always open to new information. Therefore, environments that support children's brain development should be provided to ensure the production of appropriate chemicals necessary for effective learning (Sprenger, 1999). Neuroplasticity, or the brain's ability to reorganize itself, is at its peak during early childhood, making stimulating environments crucial. These environments should support children to play and move according to their age group.

The most important learning tool for preschool children is play. Play is necessary for the healthy development of the child. Research shows that 75% of brain development takes place after birth and that play contributes to the development of children by stimulating the brain in the regulation of connections between nerve cells (Anderson-McNamee, 2010). This finding aligns with neuroscience research demonstrating that sensorimotor experiences enhance synaptic growth. Therefore, for the environment to stimulate children's brain development, it is necessary to create playgrounds where children can interact (Kaplan-Sanoff, 2002).

The positive effects of play on children are small muscle skills when holding scissors and pencils, large motor skills when jumping and running, learning the roles of family members in marital games, language skills by modelling other children and adults, thinking skills, problem solving skills through games and puzzles (Anderson-McNamee, 2010), social skills such as understanding and obeying rules, their creativity while developing their imagination, negotiation skills and their capacity to care for others (Landsdown, 2005).

Each of these skills contributes to multiple brain areas, reinforcing the holistic nature of learning through play. As can be seen, play has aspects that develop every area of the brain. While skills related to the fourth dominant area such as role playing and imagination are developed, they can also develop skills related to the third dominant area such as caring for others. Brain imaging studies confirm that different play activities activate distinct neural pathways, enhancing overall brain function. In free play time, children engage in a variety of physical activities other than typical physical activities. In free play, in addition to large muscle skills, activities such as role playing, moving, and building objects, and pretending are also performed (Farmer-Dougan & Alferink, 2013). Unstructured play has been linked to better executive function and problem-solving abilities in young children.

Burdette and Whitaker (2005) state that cognitive development is supported more with free play compared to physical activities. This is because during free play time, children's attention, social skills, and cognitive development are both realized. The cognitive domain is related to how children discover what is happening around them, how they solve problems, how they remember and retrieve information, and how they use their imagination. Therefore, cognitive development refers to children's development in thinking, questioning, and understanding. Positive early experiences that support the development of these skills are very important in the acquisition of lifelong skills such as curiosity and sustainability (Early Childhood Intervention/Texas Department of Assistive and Rehabilitative Services, 2013).

Another important learning tool for preschool children is movement. Movement-based learning theories suggest that physical activity enhances cognitive function by increasing blood flow and neurotransmitter activity. Also, cerebellum provides movement, balance, and coordination. It is known that the cerebellum is more functional in young children than other parts of the brain (Gerdes, Durden, & Poppe, 2013). This is because sensory and motor areas are the first parts of the brain to develop (National Centre for Education in Maternal and Child Health, 2007). This aligns with findings that motor development precedes cognitive and linguistic development in early childhood. While active participation of the body is the best scenario, forcing children to sit quietly in the classroom is the worst scenario for the brain. Because there is a very close relationship between the brain and the body (Al Ghraibeh

& Al-Zahrani, 2013). Motor skills are the most important thing for any brain function such as memory, emotions, learning and language. If we can understand motor skills well, we can understand thoughts better (Caulfik, 2004). According to a study conducted between sensory-motor integration and brain dominance of 12–17-year-old children, learning and thinking preferences for each dominant area were found to be related to sensory-motor integration (Al Ghraibeh & Al-Zahrani, 2013). A child's perception of his/her competence in tasks that require motor skills affects his/her persistence for that task. Therefore, perceptions about competence and the difficulty of the task also affect a preschool child's participation in games involving physical tasks (Boss, 2014). Fox, Levitt, and Nelson (2010) support motor skills in early childhood period and De Michael (2016) states that sensory activities should be offered to children. From this point of view, it can be concluded that the stimuli and experiences in the environment presented to preschool children should encourage their movements and trigger them sensually. Therefore, activities should be movement-based and stimulate the relevant brain regions to support children's senses.

Most learning and development take place when new experiences build on children's prior knowledge and what they can do, and when causality is established between new skills, abilities, or knowledge to be gained for these learning experiences (Enz & Stamn, 2013). Constructivist learning theory emphasizes the role of prior knowledge in shaping new learning experiences. However, it is also necessary to provide children with experiences that support each brain area (Farmer-Dougan & Alferink, 2013). Because, as Gerdes, Durden, and Poppe (2013) state, each region of the brain has different responsibilities. Each region controls different academic functions (Farmer-Dougan & Alferink, 2013). Ensuring a balance of cognitive, social, emotional, and physical stimulation maximizes learning potential.

Knowledge about children's development and learning is essential, as are age-appropriate characteristics of what experiences should be offered to best promote children's learning and development. It is also very important to have knowledge about how best to adapt and respond to children's individual differences (NAEYC, 2009). Therefore, teachers should first have knowledge about how the brain perceives, processes, stores, and remembers information. Knowledge about the structure and functions of the brain will help teachers in creating and using brain-based strategies (Enz & Stamn, 2013).

Schiller and Willis (2008) examined brain-based strategies to maximize children's learning in early childhood education.

- Providing a safe environment for children (not including anything that might frighten children, starting the day with familiar and safe rituals, and ensuring that children remain in the teacher's protection zone),
- Using emotions as effective tools (starting the day with a joke, singing a few songs together, giving daily activities in order and step by step, making children feel that they are in control of their own learning and being active and developing their social and emotional intelligence),
- Providing opportunities for children to engage in multi-sensory practices (using the natural environment and real materials, using songs and rhymes, making songs, dances, or games fun),
- Supporting children with individualized teaching practices (focusing on practices that attract children's attention, teaching knowledge in small pieces, using individualized practice and combining approaches),
- Preparing plans to meet the specific needs of children (presenting concepts in simple steps, exploring and using different ways of organizing tools and materials, recognizing signs of developmental delays, and setting appropriate goals); and

- It is seen that emotions should be felt, and the semantic relations of the information given to children should be established (reviewing the related prior knowledge before new information, using organizers, making individual applications, giving children time to reflect on what they have learnt).

Brain-Based Strategies for Teachers

Learning is most successful when new experiences are built upon children's prior knowledge confirming the constructivist view. Teachers must understand how the brain perceives, processes, and stores information to effectively utilize brain-based strategies (Enz & Stamn, 2013). Effective learning is achieved when teaching practices are aligned with the brain's natural operating principles. According to Enz and Stamn (2013), teachers' core strategies, learning principles and their supporting scientific rationale are summarized below:

Table 1

Teachers' Brain-Based Strategies

Teachers' Practices	Learning Principles	Causes
Presenting children with new objects, new words, new concepts	Prior knowledge is critical for linking the new with the old to help future learning and knowledge retention.	Nerves are connected by pathways that connect with similar ideas in neural connections that stimulate schemas.
Conducting revision sessions, repeating the main idea often	Repetition improves memory.	Again, it accelerates the energy flow of the brain by reducing resistance. Thus, its effectiveness increases.
Creating positive environments, including positive verbal situations, an atmosphere of trust, flexibility, and moderation	Emotion-attention-memory	The brain constantly checks the external environment to maintain a sense of safety and trust.
Incorporating curiosity and fun into classroom activities	Emotion-attention-memory	The brain looks for satisfaction and repetitive, pleasant experiences.
Planning activities that enable multifaceted experiences with knowledge (listening, talking, moving)	Active participation enables the child to remember the information. The versatility of encoding also ensures recall.	Unnecessarily encoded information has multiple ways of recall.
Organize new information by outlining and sequencing	Organizing information helps to store information effectively.	The brain has information processing constraints to overcome when grouping information in the information storage process.

The curriculum should be sequenced according to the different types of learning and experiences at different ages.	Readiness is an important point in skill acquisition.	The brain develops dynamically and follows a development process that influences competences.
Creating rituals and improving routines in the organization of class expectations	Routines provide the system needed to focus on new information.	The brain is constantly trying to find a new schema within the experiences.
Using pictures, diagrams, maps and symbols to teach many concepts	Visual pictures help memory.	Pictures help to overcome information processing constraints. Visuals are easier to remember than written words.
Helping learners to present information in a variety of ways and to create links with previous experiences	Learners construct their own meanings for the information they encounter.	The brain reacts to incoming stimuli depending on its previous connections. The brain searches for explanations of cause and effect. Believers create meanings when necessary.

It is explained why each of the strategies given in Table 1 is important for brain development. Strategies that support brain development should be included in early childhood education programs to contribute to the development of children's capacities and competencies. A neuroscience-informed approach to curriculum design can enhance the effectiveness of early childhood education programs.

Opportunities for children to participate in decision-making processes should also be created to enable them to demonstrate their capacities. The more children participate, the more they can develop their competences. Children who develop their skills also experience a sense of self-efficacy (Landsdown, 2005). This is because they recognize themselves by realizing in which areas their skills are sufficient and which skills need to be developed.

Conclusion and Recommendations

This review outlines why neuroplasticity and synaptic connectivity are essential in early childhood and examines the ways in which teachers and enriched environments foster their growth. Early childhood period is a critical period in terms of brain development. The most important reason for this is that the early childhood period is the period when children's brains are most open to learning. In this period, the environment and experience have a great impact on synaptic connections. For this reason, children can be positively or negatively affected by environmental stimuli depending on whether they are positive or negative. Therefore, any positive stimulus given to children during this period has a great impact on their lives. In this period, children's brain development is positively affected by being in a safe and supportive environment and being exposed to multifaceted sensory stimuli. Considering the permanent effects of early experiences on brain development, the activities to be implemented in early childhood education should support brain development in general. At this point, it is important to be able to offer children an education program that addresses the brain, considering the age group. In other words, an education program, learning environment, and materials should be prepared for these children by paying attention to the learning methods they need such as play and movement in accordance with their age group.

Early childhood is a critical period for brain development, as the brain undergoes rapid structural and functional changes during this time. Synaptic connections are formed and strengthened through repeated neuronal activity, illustrating the fundamental principle that "neurons that fire together, wire together" (Costandi, 2019). Research has shown that early stimulation, both cognitive and social, has long-term effects on intelligence, emotional regulation, and overall well-being. The Kingston, Jamaica study, for instance, demonstrated that children who received early psychosocial stimulation showed higher cognitive abilities and lower engagement in risky behaviors even in adulthood (Grantham-McGregor et al., 1997; Walker et al., 2011). These findings emphasize the importance of early interventions in shaping cognitive and socio-emotional development.

Brain development in early childhood is influenced by a combination of genetic and environmental factors. While genetics provide the blueprint, environmental experiences shape the brain's structural and functional maturation (Hermann, 2017). Sensory stimulation, caregiver interactions, and educational opportunities contribute significantly to neuroplasticity. The experiences children encounter during this period determine the strength of their neural pathways, affecting their ability to learn, remember, and regulate emotions later in life. This highlights the necessity of providing enriched and stimulating environments to foster optimal brain development.

Environmental stimuli, particularly in the form of early education and caregiving practices, play a crucial role in cognitive and emotional growth. Studies on sensory system development indicate that experience-dependent plasticity is essential for normal brain function (Costandi, 2019). This means that exposure to diverse and meaningful experiences—such as play-based learning, storytelling, and interactive socialization—can strengthen neural networks, enhancing children's ability to process information effectively. Conversely, a lack of stimulation or exposure to adverse environments can hinder cognitive and emotional development, making early intervention crucial.

This study generally focuses on the effect of environmental stimuli affecting brain development in early childhood and strategies that teachers can apply for brain development. But it is limited in terms of other factors such as genetic factors that affect brain development and parental practices. In conclusion, the early years are a critical window for brain development, influenced by both biological and environmental factors. Providing stimulating experiences, reducing risk factors, and fostering strong caregiver-child interactions can significantly enhance a child's cognitive and emotional growth. Implementing policies that prioritize early childhood education and support systems will help ensure that all children can reach their full potential, leading to a more capable and resilient future generation. Moreover, in this study, environmental factors affecting the brain development of children in early childhood and recommendations for the prevention of negativities on children are included.

Recommendations

Based on the findings discussed, several key recommendations can be made to optimize early childhood brain development:

Recommendations for Educators

1. **Enhancing Early Childhood Education Programs:** Governments and educational institutions should invest in high-quality, evidence-based early childhood education programs that incorporate play-based learning, sensory stimulation, and social interaction. These programs should be designed to support cognitive flexibility, problem-solving skills, and emotional regulation from an early age.

2. **Reducing Environmental Stressors:** Chronic stress and adverse childhood experiences negatively impact brain development, particularly in regions responsible for emotion regulation and executive functioning. Policies that address childhood poverty, parental mental health, and access to healthcare can mitigate these risks and create more stable environments for optimal development.

3. **Integrating Neuroscience into Early Childhood Education Training:** Educators should be trained in neuroscience-informed teaching strategies to better understand how children's brains develop and how to create learning environments that align with developmental needs. Individualized instruction, scaffolding, and interactive teaching techniques can enhance learning outcomes.

4. **Encouraging Multisensory Learning Approaches:** Given the role of sensory experiences in shaping neural pathways, educational settings should provide diverse sensory-rich activities. Music, movement, hands-on exploration, and visual storytelling can enhance memory retention and cognitive engagement in young children.

5. **Longitudinal Monitoring and Research:** Continued research on early childhood interventions and their long-term effects on cognitive, social, and emotional outcomes is essential. Governments and research institutions should support longitudinal studies to refine early childhood policies and practices.

Recommendations for Parents

1. **Parental Education:** Parents play a crucial role in shaping their children's cognitive and emotional development. Providing parents with knowledge about early brain development and practical strategies for stimulating their child's learning environment can have long-term benefits. Workshops, home-based programs, and digital resources can help parents create enriching experiences for their children.

2. **Encouraging Interaction with Nature:** Interaction with the natural environment provides both physical activity and emotional relaxation. Nature walks and plays with natural materials such as stone, soil and water allow the child to be enriched both sensorially and mentally. Such experiences lower stress hormones and increase brain plasticity.

3. **Delivering Rich and Intuitive Play Environments:** The brain makes learning more permanent with multiple sensory stimuli such as movement, touch, sound, and image. Creative play environments can be provided by using simple materials in the home (e.g. rhythm keeping with pots, imitation play with colorful fabrics, tactile exploration with dry foods). Such plays develop both fine and gross motor skills, as well as imagination.

4. **Establishing Safe and Predictable Routines:** Children feel safe through predictability. Morning, noon and evening routines proceed in a certain order; Regular activities such as sleep, food and play reduce the child's stress level and create a brain state that is open to learning. Routines improve the brain's planning, attention, and self-regulation skills, which are referred to as executive functions.

Ethical Statement

This study was conducted in accordance with ethical research standards but the formal ethical approval was not required for this type of research.

For this study	☒ There is no need for ethical permission.
	☐ The ethical permission was received …… University.
	Tarih: …./…./….. Sayı: ………

References

Ahmad, A. M., Sabidi, F. N., & Hussain, W. S. E. C. (2012). *Exploiting hermann brain dominance theory in students' performance.* (Unpublished Research Reports), https://ir.uitm.edu.my/id/eprint/20157/

Al Ghraibeh, A. M. A., & Al-Zahrani, A. A. (2013). Learning and thinking styles based on whole brain theory in correlation to sensory-motor integration. *Research in Neuroscience, 2*(1), 1-10.

Anderson-McNamee, J. (2010). *The importance of play in early childhood development.* Montana State University.

Bartling, B., Fehr, E., & Schunk, D. (2011). Health effects on children's willingness to compete. *SSRN Electronic Journal.* SOEP paper No. 381, https://doi.org/10.2139/ssrn.1844291

Bondi, C. O., & Alaynick, W. A. (2014). Environmental enrichment as a viable neurorehabilitation strategy for experimental traumatic brain injury. *Journal of Neurotrauma, 31*(7), 614–628.

Boyce, W., Sokolowski, M., & Robinson, G. (2020). Genes and environments, development and time. *Proceedings of the National Academy of Sciences, 117*(38), 23235-23241. https://doi.org/10.1073/pnas.2016710117

Bonnier, C. (2007). Evaluation of early stimulation programmes for enhancing brain development. *Acta Pædiatrica, 97*, 853-858.

Branchi, I. (2023). Uncovering the determinants of brain functioning, behavior and their interplay in the light of context. *Frontiers in Psychology. https://doi.org/10.31234/osf.io/ndc4p*

Bruel-Jungerman, E., Davis, S., Rampon, C., & Laroche, S. (2006). Long-term potentiation enhances neurogenesis in the adult dentate gyrus. *Journal of Neuroscience, 26*(22), 5888-5893. https://doi.org/10.1523/jneurosci.0782-06.2006

Burdette, H. L., & Whitaker, R. C. (2005). Resurrecting free play in young children: looking beyond fitness and fatness to attention, affiliation, and affect. *Archives of Paediatric and Adolescent Medicine, 159*, 46-50.

Canals, S., Beyerlein, M., Merkle, H., & Logothetis, N. (2009). Functional MRI evidence for LTP-induced neural network reorganization. *Current Biology*, *19*(5), 398-403. https://doi.org/10.1016/j.cub.2009.01.037

Cano-De-La-Cuerda, R., *et al.* (2021). Proverbs and aphorisms in neurorehabilitation: A literature review. *International Journal of Environmental Research and Public Health, 18*(19), 9240.

Ċastrén, E., & Rantamäki, T. (2010). The role of bdnf and its receptors in depression and antidepressant drug action: reactivation of developmental plasticity. *Developmental Neurobiology,* 70(5), 289-297. https://doi.org/10.1002/dneu.20758

Caulfik, S. (2004). *Exceeding expectations: a guide to brain research applications in learning the 3rd book*. Dhahran Private Schools, Trans. Dammam: Educational Book Store.

Cherici, C. (2006). Vincenzo Malacarne (1744–1816): A researcher in neurophysiology between anatomophysiology and electrical physiology of the human brain. *Comptes Rendus Biologies, 329*(2), 137–143.

Churchland, P. S. (2017). Neurophilosophy: the early years and new directions, *Functional Neurology,* 22(4), 185-195.

Claessens, S., Daskalakis, N., Veen, R., Oitzl, M., Kloet, E., & Champagne, D. (2010). Development of individual differences in stress responsiveness: an overview of factors mediating the outcome of early life experiences. *Psychopharmacology, 214*(1), 141-154. https://doi.org/10.1007/s00213-010-2118-y

Costandi, M. (2019). *Neuroplasticity*. Ş. Taş (Transl.) Pan.

Dandi, A., Achuthan, A., & Kaur, S. (2023). The neuroprotective role of environmental enrichment against behavioral, morphological, neuroendocrine and molecular changes following chronic unpredictable mild stress: A systematic review. *European Journal of Neuroscience, 58*(6), 885–902.

De Michael, K. (2016). *Sensory Processing Handbook for Early Childhood Educators*. New York: Bank Street College of Education. Retrieved from: http://educate.bankstreet.edu/independent-studies/161

Early Childhood Intervention/Texas Department of Assistive and Rehabilitative Services. (2013). Promoting cognitive development. *Texas Child Care Quarterly,* 37(3).

Enz, B., & Stamn, J. (2013). Effective Strategies to Help Teachers Learn about Brain Development. In Leslie Haley Wasserman & Debby Zambo (Eds.) *Educating the Young Child 7: Early Childhood and Neuroscience-Links to Development and* Learning (pp. 171-189). Springer.

Farmer-Dougan, V., & Alferink, L. A. (2013). Brain development, early childhood, and brain-based education: A critical analysis. In Leslie Haley Wasserman & Debby Zambo (Eds.) *Educating the Young Child 7: Early Childhood and Neuroscience-Links to Development and Learning* (pp. 55-76). Springer.

Fernandes, D., & Carvalho, A. (2016). Mechanisms of homeostatic plasticity in the excitatory synapse. *Journal of Neurochemistry,* 139(6), 973-996. https://doi.org/10.1111/jnc.13687

Ferrucci, L., Cantando, I., Cordella, F., Angelantonio, S., Ragozzino, D., & Bezzi, P. (2023). Microglia at the tripartite synapse during postnatal development: implications for autism spectrum disorders and schizophrenia. *Cells,* 12(24), 2827. https://doi.org/10.3390/cells12242827

Fox, S. E., Levitt, P., & Nelson, C. A. (2010). How the timing and quality of early experience influence the development of brain architecture. *Child Development, 81*, 28-40.

Gelb, M. J., & Howell, K. (2012). *Brain power:improve your mind as you age*. New World Library.

Gerdes, J., Durden, T. R., & Poppe, L. M. (2013). Brain development and learning in the primary years. G2198. *Faculty Publications from CYFS*. 77.

Ginther, D. (2010). An interview with james j. heckman. *Macroeconomic Dynamics, 14*(4), 548-584. https://doi.org/10.1017/s1365100510000611

Goldman, R., Chavez-Noriega, L., & Stevens, C. (1990). *Failure to reverse long-term potentiation by coupling sustained presynaptic activity and n-methyl-d-aspartate receptor blockade*. Proceedings of the National Academy of Sciences, *87*(18), 7165-7169. https://doi.org/10.1073/pnas.87.18.7165

Grantham-McGregor, S. M, Powell, C. A., Walker, S. P., & Himes, J. H. (1991). Nutritional supplementation, psychosocial stimulation and mental development of stunted children: the Jamaican study. *Lancet*, *338*, 1-5.

Grantham-McGregor, S. M, Walker, S. P., Chang, S. M., & Powell, C. A. (1997). Effects of early childhood supplementation with and without stimulation on later development in stunted Jamaican children. *Am J Clin Nutr., 66*(2), 247-253.

Greenough, W. T., Black, J. E., & Wallace, C. S. (1987). Experience and brain development. *Child Development, 58*(3), 539–559.

Gunnar, M. R., & Quevedo, K. (2007). The neurobiology of stress and development. *Annual Review of Psychology, 58*, 145-173.

Jensen, E. (2001). Fragile brains-damage to the brain and environmental influences can account for certain learning problems. *Educational Leadership, 59*(3).

Hermann, N. (2017). *HBDI and whole brain thinking*. Hermann Global.

Heynen, A., Abraham, W., & Bear, M. (1996). Bidirectional modification of ca1 synapses in the adult hippocampus in vivo. *Nature, 381*(6578), 163-166. https://doi.org/10.1038/381163a0

Humble, J., Hiratsuka, K., Kasai, H., & Toyoizumi, T. (2019). Intrinsic spine dynamics are critical for recurrent network learning in models with and without autism spectrum disorder. *Frontiers in Computational Neuroscience,* 13. https://doi.org/10.3389/fncom.2019.00038

Huttenlocher, P. R. (2002). *Neural plasticity: The effects of environment on the development of the cerebral cortex*. Harvard University.

Johansen, J., Díaz-Mataix, L., Hamanaka, H., Ozawa, T., Ycu, E., Koivumaa, J., Kumar, A., Hou, M., Deissoroth, K., Boyden, E. S., & LeDoux, J. (2014). Hebbian and neuromodulatory mechanisms interact to trigger associative memory formation. *Proceedings of the National Academy of Sciences*, *111*(51). https://doi.org/10.1073/pnas.1421304111

Kaplan-Sanoff, M. (2002). Stimulating environments. In M. Jellinek, B. P. Patel, & M. C. Froehle (Eds.). *Bright Futures in Practice: Mental Health*. Arlington, VA: National Center for Education in Maternal and Child Health.

Kearns, K. (2017). *Frameworks for learning & development*. Cengage Learning Australia.

Kuhl, P. K. (2010). Brain mechanisms in early language acquisition. *Neuron, 67*(5), 713-727.

Landsdown, G. (2005). *The Evolving Capacities of the Child.* Florence: UNICEF Innocenti Research Centre.

Lazari, A., Salvan, P., Cottaar, M., Papp, D., Rushworth, M., & Johansen-Berg, H. (2022). Hebbian activity-dependent plasticity in white matter. https://doi.org/10.1101/2022.01.11.473633

Krageloh-Mann, I., Lidzba, K., Pavlova, M. A., Wilke, M., & *Staudt, M.* (2017). Plasticity during early brain development is determined by ontogenetic potential. *Neuropediatrics, 48*(5), 319–328.

Luna, B., Garver, K., Urban, T., Lazar, N., & Sweeney, J. (2004). Maturation of cognitive processes from late childhood to adulthood. *Child Development, 75*(5), 1357-1372. https://doi.org/10.1111/j.1467-8624.2004.00745.x

Lupien, S. J., McEwen, B. S., Gunnar, M. R., & Heim, C. (2009). Effects of stress throughout the lifespan on the brain, behaviour and cognition. *Nature Reviews Neuroscience, 10*(6), 434-445.

Manjila, S., Alkhresani, N., & Patil, J. J. (2009). The departmental chair in Western medicine: Tale of the first and foremost. *Journal of Neurosurgery, 111*(6), 1091–1097.

McClelland, J. L., McNaughton, B. L., & O'Reilly, R. C. (1995). Why there are complementary learning systems in the hippocampus and neocortex: Insights from the successes and failures of connectionist models of learning and memory. *Psychological Review, 102*(3), 419–457. https://doi.org/10.1037/0033-295X.102.3.419

Miller, D. J., Duka, T., Stimpson, C. D., Schapiro, S. J., Baze, W. B., McArthur, M. J., Fobbs, A. J., Sousa, A. M. M., Šestan, N., Wildman, D. E., Lipovich, L., Kuzawa, C. W., Hof, P. R., & Sherwood, C. C. (2012). Prolonged myelination in human neocortical evolution. *Proceedings of the National Academy of Sciences*, *109*(39), 15927–15932. $https://doi.org/10.1073/pnas.1117943109$

Mustard, J. F. (2006). *Early child development and experience-based brain development: The scientific underpinnings of the importance of early child development in a globalised world.* The Brookings Institution.

National Assosication for the Education of Young Children [NAEYC]. (2009). *Developmentally Appropriate Practices in Early Childhood Programs Serving Children from Birth through Age 8.* https://www.naeyc.org/sites/default/files/globally-shared/downloads/PDFs/resources/position-statements/PSDAP.pdf

National Centre for Education in Maternal and Child Health (2007). *Early brain development: Implications for early childhood education*. Encouraging Connections.

Nelson, C. A. (2000). The neurobiological bases of early intervention. In J. Shonkoff & S. Meisels, (Eds.) *Handbook of Early Childhood Intervention* (2nd ed.) (pp. 204-228). New York: Cambridge University Press.

Novkovic, T., Mittman, T., & Manahan-Vaughan, D. (2015). BDNF contributes to the facilitation of hippocampal synaptic plasticity and learning enabled by environmental enrichment. *Hippocampus, 25*, 1-15.

Othman, A. I., & Mulyono, H. G. (2022). Morris water maze: A versatile and pertinent tool for assessing spatial learning and memory. *Experimental Animals, 71*(3), 229-246.

Perry, B. D., & Szalavitz, M. (2017). *The child raised like a dog.* B. S. Haktanır (Trans.). Koridor.

Pfeiffer, F., & Reuß, K. (2008). Age-dependent skill formation and returns to education. *Labour Economics, 15*(4), 631-646. https://doi.org/10.1016/j.labeco.2008.04.008

Praticò, A. D., Leotta, M., Cavallaro, P., Sciuto, L., Vecchio, M., Napoli, C., Polizzi, A., & Ruggieri, M. (2024). At the basis of brain malformations: brain plasticity, developmental neurobiology, and considerations for rehabilitation. *Journal of Pediatric Neurology, 22*(02), 096-107. https://doi.org/10.1055/s-0044-178678

Pozo, K., & Goda, Y. (2010). Unraveling mechanisms of homeostatic synaptic plasticity. *Neuron, 66*(3), 337-351. https://doi.org/10.1016/j.neuron.2010.04.028

Rowley, S. and Williams, J. (2015). *Multisensory stimulation and infant development. Research Review.* Johnson & Johnson Pacific.

Save the Children. (2018). *Buildıng brains: Early stimulation for children from birth to three.* https://www.savethechildren.org/content/dam/usa/reports/ed-cp/building-brains-brief-2018.pdf

Schiller, P., & Willis, C. A. (2008). Using brain-based teaching strategies to create supportive early childhood environments that adress learning standards. *Beyond the Journal: Young Children on the Web.*

Semrud-Clikeman, M. & Ellison, P. A. T. (2009). *Child neuropsychology: assessment and interventions for neurodevelopmental disorders.* Springer.

Shonkoff, J. P. and Philips, D. A. (2000). *From neurons to neighbourhoods: The science of early childhood development.* Report of the National Research Council and Institute of Medicine. Washington, DC: National Academies Press.

Sprenger, M. (1999). *Learning and Action: The Brain in Action.* Alexandre, Virginia: Association for Supervision and Curriculum Development.

Sroufe, L. A. (2005). Attachment and development: A prospective, longitudinal perspective. *Attachment & Human Development, 7*(4), 349-367.

Squire, L. R., & Zola-Morgan, S. (1991). The medial temporal lobe memory system. *Science, 253*(5026), 1380-1386. https://doi.org/10.1126/science.1896849

Stack, N. (2013). Making a case for early intervention: The role of developmental neuroscience. In Leslie Haley Wasserman & Debby Zambo (Eds.) *Educating the Young Child 7: Early Childhood and Neuroscience-Links to Development and Learning* (pp. 157-170). Springer.

Steif, M. A., & Alishah, A. R. (2020). The brain lateralisation and learning styles, *Journal of Global Scientific Research*, 5, 543-549.

Stiles, J., & Jernigan, T. (2010). The basics of brain development. *Neuropsychology Review,* 20(4), 327-348. https://doi.org/10.1007/s11065-010-9148-4

Swaab, D. (2018). *We are what our brains are: Neurobiography of the brain from the womb to Alzheimer's.* Akılçelen.

Xia, K., Zhang, J., Ahn, M., Jha, S., Crowley, J., Szatkiewicz, J., Li, T., Zou, F., Zhu, H., Hibar, D., Thompson, P., Enigma Consortium, Sullivan, P. F., Styner, M., Gillmore, J. H., & Knickmeyer, R. (2017). Genome-wide association analysis identifies common variants influencing infant brain volumes. *Translational Psychiatry,* 7(8), e1188-e1188. https://doi.org/10.1038/tp.2017.159

Teffer, K. and Semendeferi, K. (2012). Human prefrontal cortex: Evolution, development and pathology. *Progress in Brain Research*, 195, 191-218.

Tully, K., & Bolshakov, V. (2010). Emotional enhancement of memory: how norepinephrine enables synaptic plasticity. *Molecular Brain,* 3(1), 15. https://doi.org/10.1186/1756-6606-3-15

UNESCO. (2007). *Philosophy: A school of freedom: Teaching philosophy and learning to philosophise: Status and prospects.* United Nations Educational, Scientific and Cultural Organization.

Walker, S. P., Chang, S. M., Powell, C. A., & Grantham-McGregor, S. M. (2005). Effects of early childhood psychosocial stimulation and nutritional supplementation on cognition and education in growth-stunted Jamaican children: prospective cohort study. *Lancet. 366* (9499), 1804-1807.

Walker, S. P., Chang, S. M., Vera-Hernandez, M., & Grantham-McGregor, S. (2011). Early childhood stimulation benefits adult competence and reduces violent behaviour. *Pediatrics,* 127(5), 848-857.

Walker, S. P, Grantham-McGregor, S. M, Powell, C. A., & Chang, S. M. (2000). Effects of growth restriction in early childhood on growth, IQ, and cognition at age 11 to 12 years and the benefits of nutritional supplementation and psychosocial stimulation. *J Pediatr.* 137(1), 36-41.

White, A. and Pulla, V. (2012). Strengthening the Capacity for Resilience in Children. In Venkat Pulla, Andrew Shatte, & Shane Warren (Eds.). *Perspectives on Coping and Resilience* (pp. 122-153). Author.

Zanatta, L., & Bazzani, L. (2018). Vincenzo Malacarne (1744–1816) and the first description of the human cerebellum. *The Cerebellum, 17*(6), 602–611.

Zhang, M., Huo, G., Cheng, J., Zhang, Q., Li, N., Guo, M., Qing, L., Xu, G., Zhu, J., Li, C., Zhou, F., & Yi, L. (2022). Gypenoside xvii, an active ingredient from gynostemma pentaphyllum, inhibits c3ar-associated synaptic pruning in stressed mice. *Nutrients,* 14(12), 2418. https://doi.org/10.3390/nu14122418

Zhou, C., Lippman-Bell, J., Sun, H., & Jensen, F. (2011). Hypoxia-induced neonatal seizures diminish silent synapses and long-term potentiation in hippocampal ca1 neurons. *Journal of Neuroscience,* 31(50), 18211-18222. https://doi.org/10.1523/jneurosci.4838-11.2011