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Review Article

Cognitive Neurodevelopment: Will Knowing and Measuring it Prevent Many Problems?

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Received: August 16, 2024; **Published:** August 30, 2024

DOI: 10.31080/ECPE.2024.13.01482

Abstract

Cognitive neurodevelopment is a dynamic and ongoing process that becomes increasingly specialized with each stage of life. This process requires multiple variables to achieve optimization and consolidation at the right time, as a not consolidated cognitive function in its time will affect subsequent functions. Measuring each age range through neuropsychological batteries and analyzing both intrinsic and extrinsic factors will help us generate an optimal diagnosis and ensure the therapeutic approach to be implemented, and avoid problems in the patient and the family quality of life.

Keywords: *Cognitive Neurodevelopment; Neurocognitive Assessment; Early Cognitive Diagnosis*

Introduction

Cognitive neurodevelopment refers to the neuronal organization during different stages of life, ranging from synaptogenesis, myelination, and lamination, leading to the consolidation of brain cortices that host various cognitive processes, which may or may not make a human adaptable to environmental challenges [1,2]. This is because one cognitive process precedes another, and when consolidated at the right time, it will provide the processing skills to solve problems that the environment demands. The epidemiology of cognitive deficiencies is unclear, as it is not a frequent practice, however, it is estimated that 11.4% of the population from 0 to 14 years old presents neurodevelopmental disorders [3].

Between 0 and 2 years, motor control (praxias) and the integration of gnosias from neuro-sensory processing begin, related to the primary motor cortex and somatosensory cortex [4,5]. During motor development, gross motor skills (cephalocaudal) and fine motor skills (proximal-distal) will be observed first, meaning that the child will first achieve balance, sitting, crawling, walking, and grasping, which will later lead to fine pincer skills for drawing, writing, tying shoelaces, and buttoning buttons [6].

This will lead to the generation of two systems: the vestibular system for balance and proprioception for body awareness, thus having the basic ability of visuospatial control [7]. The suggested scales for these stages are observational development scales, since they are non-invasive for the patient and are answered by the parents based on what they have observed in each of the sub-processes, adding clinical history, screenings, and observations made by the specialist. If these skills are not consolidated at this stage, dyspraxias and dysgnosias may occur [8,9].

Another important process within this age range is language, closely related to the motor cortex [5], due to phonetic-articulatory processing and social interaction with the environment, leading to imitation and production of pre-words, and later simple words. It is expected that by 18 months, the child can evoke 15 to 20 words; if this doesn't happen, it will be important to evaluate them to rule out developmental dysphasia [9].

When motor skills, neurosensory integration, vestibular system, proprioception, and basic language are consolidated, from 3 to 5 years old, the consolidation of basic processes such as perception, attention, memory, and basic frontal functions will take place, each one preceding the next, optimizing the processing of the subsequent one [6,7,10].

According to this, perception integrates somatosensory stimuli and encodes them through the PTO (Parietal, Temporal, and Occipital Cortex) [4] towards the prefrontal cortex, allowing it to assign a definition or concept to objects, people, environment, etc. This cognitive ability not only integrates concepts but also helps to interact with the environment in a spatial way, as well as to improve coordination and solve complex visuospatial problems, giving greater ability to encode letters and numbers. In the case of a developmental perceptual deficit, dyslexia may present itself in the school stage [8].

Therefore, the development of perception will foster attentional processing, which generates the ability to sustain and direct ourselves to a striking stimulus in the environment. This ability can be selective or divided, depending on the type of stimulus or problem to be solved [9]. It is related to the parietal cortex, temporal cortex, cerebellum, striatum, reticular system, and the limit of the sulcus with the prefrontal cortex, for subsequent administration as plasticity and cerebral complexity develop [10]. This function is dynamic, so at each stage of specialization, it will lead to greater capacity. Presenting alterations in this network can generate developmental attention deficits [8].

The memory process is associated with the temporal and hippocampal circuit and the participation of other structures such as the cerebellum and entorhinal cortex [11]. This processing, like the attentional network, will increase the capacity for information registration with age, for its correct recognition and recovery. In the case of alterations, it can generate dysmnesias [8].

Finally, one of the cortices that takes the longest to consolidate, until the age of 30, is the prefrontal cortex, associated with executive functions. These give us the ability to solve simple or complex problems based on our previous experiences and to manage behavior [13]. These processes appear when the basic processes are consolidated, leading from 5 to 6 years old to the consolidation of the orbitomedial cortex, with the ability to select risks, maintain positive responses and inhibition that will connect with the dorsolateral cortex to achieve working memory, sequential planning and visuospatial skills, progressive and regressive calculation, generating hypotheses, which will finally evoke metafunctions, associated with the anterior prefrontal cortex [14,15]. These provide the maximum capacity for processing everything learned throughout life to manage and make use of that information in situations with more abstract problems (Figure 1).

For the neuro-cognitive evaluation of these processes, there are neuropsychological batteries for each stage of development. These evaluations contain physical stimuli presented to the patient, such as Iowa cards, Tower of Hanoi, card games, templates for the Stroop effect, among others, which are qualified according to natural data over time, execution errors, perseverations, or mistakes that are later translated into coded and standardized ranges for the age range. Each country has standardized batteries and exercises to evaluate each process as a cognitive sub-process [16,17].

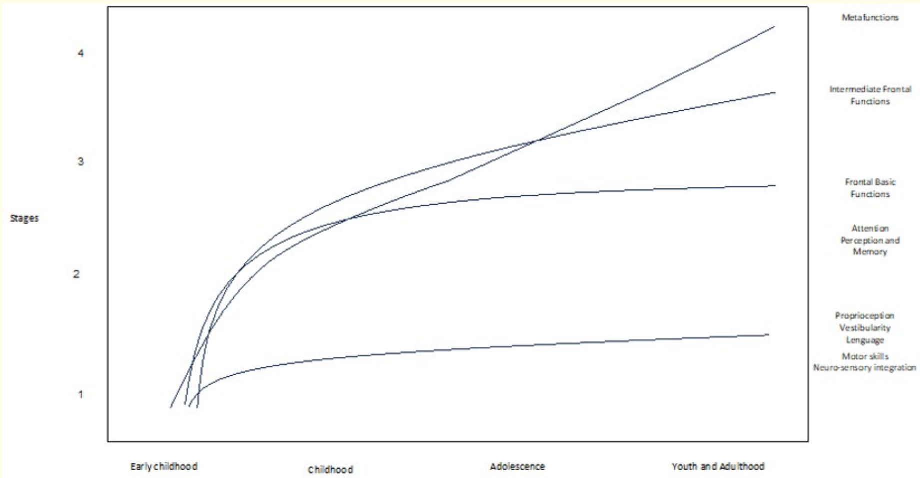

Figure 1: *Stages of cognitive development and functions according to the stages of consolidation by process. Early Childhood (0 to 5 years), Childhood (6 to 11 years), adolescence (12 to 16), youth and adulthood (17 to 30 years).*

Conclusion

Evaluating and knowing the developmental ranges of pediatric patients can prevent complications, since each cognitive function precedes the next; if any of them are skewed, it will generate an important deficit that will affect each stage. Therefore, if a patient does not achieve motor consolidation and sensory integration, it will impact language development, altering the sequence of perception, memory, and attentional network, which will limit the timely consolidation of basic and intermediate frontal functions and skew learning processes such as calculation and reading-writing. When altered, it will be very difficult to achieve high-level abstract processing. This type of cognitive problems can generate academic frustrations in both the child and the family, as these processes are not easy to observe and children are forced to try to understand school content. Having these cognitive problems, which limit academic abilities, can lead to rejection of study and school dropout, as well as behavioral problems that in adolescence can lead to approaching risky reference groups where acceptance is sought and obtained. Therefore, it is of the utmost importance to monitor each stage of cognitive development, with or without any disease, that may compromise each stage.

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Volume 13 Issue 9 September 2024