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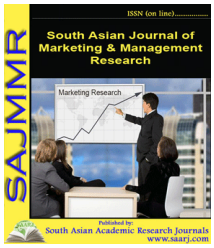

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AN OVERVIEW ON ASSESSMENT AND DEVELOPMENT OF EXECUTIVE FUNCTION (EF) DURING CHILDHOOD

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ABSTRACT

The difficulties surrounding the evaluation of executive function (EF) in children and teens are discussed in this review article, as well as the developmental pattern of executive functions throughout childhood. EF is defined first, followed by a description of the cognitive and behavioral deficits associated with cognitive deficits (EDF). A developmental model of EF is suggested, which includes four distinct but interconnected executive subdomains (selective attention control, mental abilities, goal planning, and information processing), all of which work together to allow ‘‘executive control." The characteristics that make up conventional EF measurements, as well as the issues with test interpretation, are addressed. The ecological validity of EF tests and neurological assessment techniques is investigated, and additional measuring methods are given to allow a more complete and reliable EF evaluation. The maturity of executive domains is mapped based on developmental and normative research. Attentional control seems to develop quickly in early life, beginning in infancy. Cognitive flexibility, goal planning, and information processing, on the other hand, go through a crucial phase of development between the ages of 7 and 9, and are reasonably mature by the age of 12. At the start of adolescence, there is believed to be a transitional phase, following which ‘‘executive control" is expected to develop. Longitudinal studies combining structure and function neuroimaging are needed to validate our present knowledge of EF development and to further improve our understanding of thinking abilities.

KEYWORDS: *Cognitive, Development, Evaluation, Executive Function.*

1. INTRODUCTION

The phrase "executive function" refers to a group of interconnected systems that are accountable for goal-directed, intentional action. These executive functions are involved in the synthesis of external stimuli, the formulation of objectives and strategies, the planning for action, and the confirmation that plans and activities have been carried out properly. Anticipating, goal identification, planning, start of action, self-regulation, cognitive agility, deployment of attention,

and feedback use are just a few of the processes involved with EF. Executive functions develop during infancy and adolescence and are crucial to a child's cognitive functioning, behavior, emotional regulation, and social interaction. Because executive skills impairments often accompany injury to the prefrontal cortex, the anterior areas of the brain are believed to mediate executive functioning. Functional brain scans have shown substantial activity in the prefrontal brain in those who take EF tests, corroborating this theory. The prefrontal cortex is reliant on efferent and sensory connections with nearly all other brain areas, such as the brain stem, occipital, frontal, and parietal lobes, as well as emotional and subcortical areas, to support EF. Cognitive and/or behavioral impairments may arise from damage or loss of function at any level of one of these brain systems. Executive dysfunction is not necessarily linked to prefrontal disease as a result of this complex neural network, but it may be linked to network disconnections such as white matter injury or impairment in other brain areas. In conclusion, it may be claimed that prefrontal cortex integrity is a required but not necessary precondition for intact impulse control[1].

1.1 Executive Dysfunction (EDF):

Executive dysfunction (EDF) isn't a single condition. It denotes EF deficiencies in one or more components, and it may manifest in a number of ways. Low impulse control, problems able to monitor or trying to regulate performance, management and organizational issues, poor reasoning ability, problems able to generate and/or implement a strategy, perseverance and mental inflexibility, poor feedback utilization, and reduced working memory are some of the cognitive issues associated with EDF in children. Some of these actions may not be deemed "deviant" in a developmental context, such as in the instance of a baby or young kid. As a result, it's essential that executive procedure development expectations be clearly defined. EF is involved in more than just cognitive processes; it's also involved in emotional reactions and behavioral behaviors. In children and adults with EDF, mood, affect, energy level, initiative, moral and social conduct may all be disturbed. Children with EDF may be apathetic, uninspired, and unresponsive, yet they can also be impetuous and combative. Some children with executive dysfunction ask humiliating or socially incorrect questions and make harmful remarks, indicating a lack of awareness and intuition. They may also find it difficult to appreciate comedy or make offensive jokes. EDF may also be identified by a disregard for the repercussions of one's conduct as well as a disregard for societal norms and customs. Resistance to alter activities, difficulty to adjust previously acquired habits, and failure to learn from errors are all signs of inflexibility and rigidity in youngsters. Many children with EDF, predictably, have poor interpersonal skills and have difficulty sustaining meaningful social connections[2].

1.2 Conceptualization of EF:

EF has traditionally been thought of as a single entity, with the central executive being in charge of multimodal processing and high-level cognitive abilities. EF, on the other hand, has been conceived as a collection of interconnected, interconnected process-related systems that work as a single supervisory or control system. Given that global executive impairment is uncommon, various executive functions are believed to be linked with different frontal systems, and executive processes have varied developmental histories, the latter paradigm is probably more realistic[3].

Interpretation of the Test: The majority of contemporary EF tests include complicated, demanding, and multi-faceted activities that engage both executive and non-executive processes, making them susceptible to cognitive impairment. However, it is difficult to separate the effects of distinct cognitive processes when evaluating task performance, and as a result, these tests

often fail to distinguish particular cognitive impairments. Because personal and environmental variables, as well as essential task behaviors, are not taken into consideration, an over-reliance on quantitative data when evaluating performance may restrict a test's diagnostic usefulness. To overcome this limitation, test performance can be assessed using a segments and sub approach that combines quantitative (e.g., success/failure, latency, number of errors, etc.) and qualitative (e.g., motivation, energy, attention, distractions, etc.) methodologies with intellectual (e.g., process, strategies, actions, etc.) methodologies. The diagnostic usefulness of EF tests is expected to be improved by "scoring systems" designed to capture as much information about task performance as feasible[4].

1.3 Evaluation of EF:

Executive abilities are believed to be engaged in novel or difficult activities because they demand the person to develop new plans and tactics and evaluate their efficacy, while easy or routinized tasks are carried out intuitively and without the need of executive processes. Walsh (1978) agrees with this assumption, stating that in order to evaluate EF, a test must be new, complicated, and entail the integration of data. Defining a job as routine, overlearned, complicated, or new, on the other hand, is not always easy, since what is complex or novel for one individual may be simple or regimen for another. Furthermore, some theories argue that executive functioning is involved in all cognitive assessments to some degree[5].

1.4 Ecological Validity:

Discrepancies between conventional EF performance and real-life behavior are often reported. Patients with a history of significant behavioral difficulties, for example, may behave perfectly in clinic or properly answer questions on social and moral challenges, but lack judgment and self-control in real-life circumstances. The sheer nature of EF tests' design, which necessitates novelty, calls into doubt their ecological validity. Furthermore, neuropsychological tests are usually conducted in well-structured, calm situations with little distractions, and are unlikely to be reflective of home, school, or social contexts. The examiner frequently becomes the patient's "frontal lobes" throughout the evaluation process, providing support and encouragement as well as planning and initiating tasks. The BRIEF is a newly created questionnaire that offers a profile of EF behaviors in the home, school, and social settings for parents and teachers of school-aged children. The degree of agreement between the BRIEF and very well EF mental performance is at best moderate, indicating that each kind of evaluation offers distinct information[6].

1.5 Pediatric Population Assessment:

Executive processes appear in infancy and evolve throughout infancy and into early adulthood, according to new research. Because these abilities are susceptible to early brain injury and are critical for continuing cognitive development and academic success, standardized EF assessments that are appropriate for children and relevant for particular developmental stages are needed[7].

Several tests have been developed in the past decade for various age groups throughout childhood. It's tough to create activities for children that are appropriate for all stages of growth. When evaluating the results of neuropsychological tests in children, additional variables such as the maturation rate of particular abilities and the impact of brain damage on future development must be considered. As a result, validating assessment instruments in a developmental context is typically more challenging than doing so with adult populations[8].

1.6 The evolution of EF:

One of the difficulties in understanding EF in children is that these abilities grow quickly during infancy, with evidence suggesting development is not always linear but may occur in bursts. Furthermore, it seems that various components of EF have diverse developmental paths, adding to the domains' complexity. Given that executive functions rely on the integrity of frontal lobe systems, it's probable that these abilities will show functional improvements that may be linked to prefrontal cortex neurobiological changes. The growth of the frontal lobes continues throughout maturity, which is unusual. Claims that executive functions did not develop functionally until the neural pathways matured in the second decade of life have been debunked[9].

1.7 Controlling Your Attention:

Newborns under the age of nine months have difficulties suppressing previously acquired responses, but by the age of twelve months, most infants can block specific behaviors and transition to a new response set. By the age of three, children have a good handle on ‘‘instinctive" habits, but they still make the odd perseverative mistake. Up to 6 years of age, there are improvements in speed and accuracy on impulse control activities. Children aged 9 and above are more likely to be able to control and monitor their activities, but there is a brief rise in impulsivity around the age of 11.

1.8 Processing of Information:

Increases in reaction speed and verbal fluency are seen in early infancy, particularly between the ages of 3 and 5. Processing speed and fluency continue to increase throughout middle childhood, with substantial improvements in processing speed seen between the ages of 9–10 and 11–12. Improvements in efficiency and fluency occur throughout adolescence, but beyond 15 years of age, the gains are likely to be minor.

1.9 Flexibility of Thought:

Persistent behavior is frequent in early childhood, decreases in early and middle childhood, and is uncommon in puberty. Between the ages of 3 and 4, children have the ability to switch quickly between two basic answer sets, but when the rules grow more complicated, children in this age range have trouble switching. When switching behavior is dependent on many dimensions, seven-year-olds struggle, but their ability to deal with these multi-dimensional switching tasks increases dramatically between the ages of seven and nine. Throughout middle childhood and throughout puberty, switching fluency improves. Early infancy promotes the ability to learn from errors and create alternate methods, which continues throughout middle childhood[10].

1.10 Setting Objectives:

4-year-olds demonstrate basic planning abilities, while younger children struggle to plan and arrange activities in advance. Similarly, basic conceptual thinking is too complex for 3-year-olds, yet youngsters may generate new ideas by the age of four. Planning and organizing abilities grow quickly between the ages of 7 and 10, and then progressively throughout puberty. Young children use basic tactics that are typically inefficient, unplanned, or fragmented, but strategic behavior and reasoning skills grow more structured and efficient between the ages of 7 and 11. Despite having access to a larger repertoire of tactics, regression from conceptual to piecemeal methods may occur between the ages of 12 and 13, indicating a developmental phase when cautious and conservative strategies are favored.

1.11Gender Disparities:

According to the majority of studies, males and girls develop executive functions at the same pace throughout infancy. On certain tasks, minor gender differences have been discovered, but these results have not been reliably reproduced in subsequent research. Verbal fluency, information processing, and spatial organization are among the areas where females have been found to outperform guys. On the other hand, males outperformed girls in a spatial reasoning/working memory test.

2. DISCUSSION

According to research, the executive domains develop at various speeds. Proposed developmental pathways for executive domains are shown using results from developmental and normative research. These profiles are just estimates that will need to be confirmed in overall development research. Throughout infancy and early childhood, mechanisms in the attentional control domain seem to develop rapidly, and by middle childhood, self-control and self-regulation procedures appear to be quite sophisticated. Although information processing, cognitive flexibility, and goal planning are all reasonably mature by the age of 12, several executive functions are not completely ‘‘established" until mid-adolescence or early adulthood, albeit following somewhat different developmental paths. Between the ages of 11 and 13, developmental regressions have been observed, especially in the domains of self-regulation and strategic decision making. This regression may be linked to a developmental transition stage, resulting in conflicts between growing cognitive processes. The execution of self-regulatory procedures, for example, conflicts with the implementation of conceptual and ‘‘holistic" methods, which demand careful monitoring of performance and favor the ‘‘de-construction" of activities. Balancing and prioritizing these conflicting needs requires "executive control," which may be only feasible after each executive domain has reached a particular degree of maturity. The long-term development of executive domains is likely linked to neurophysiological changes in the prefrontal cortex, especially synaptogenesis and myelination. Five episodes of fast development in the frontal lobes, based on EEG data, have been recorded, indicating an increase in the number and/or strength of frontal lobe connections. From birth to five years of age, the frontal lobe has its first growth spurt, which coincides with substantial developmental improvements in attentional control processes. The other comprising three domains (information processing, cognitive flexibility, and goal planning) develop rapidly between the ages of 7 and 9, which coincides with the frontal lobe's second growth surge. Between the ages of 11 and 13, the third development spurt occurs, during which all four executive domains mature and ‘‘executive control" develops. Furthermore, myelination of prefrontal connections happens progressively during early infancy, middle childhood, and puberty, according to the findings. Progressive myelination is expected to result in faster and more efficient nerve impulse transmission, better information processing, and increased cognitive coherence and executive control.

3. CONCLUSION

The foundation for developing assessment procedures, interpreting test performance and adaptive functioning, and formulating treatment and management strategies is provided by conceptual models for psychological variables such as EF. Large-scale exploratory and confirmatory factor analytic research are needed to uncover common executive components and investigate their inter-relationships in order to validate or alter current EF models. Executive functioning includes both cognitive and behavioral components; yet, cognition and behavior may often be at odds. The functions of distinct prefrontal systems may play a role in the dissociation between cognitive performance and behavior/personality traits. Behavioral manifestations of

EDF, for example, seem to be more strongly connected with orbital and ventral medial parts of the prefrontal cortex, whereas cognitive elements of EF appear to be firmly related with dorsolateral sections of the prefrontal cortex. To establish the differences and overlap between the neuroanatomical correlates of cognitive and behavioral components of EF, further research is needed. Measures that are both ecologically sound and developmentally appropriate are required. EF measurements for children have lacked sufficient validation and trustworthy normative data in the past. Children's exams must be more selective, ensuring that they are relevant, have undergone sufficient standardization, and have been validated in suitable childhood settings. Given that most cognitive activities involve some level of executive functioning, identifying performance characteristics linked to EF rather than labeling particular measurements as executive or non-executive may be more useful. Finally, a micro-analytic approach to assessment, combining quantitative, qualitative, and cognitive-process methods, should be used to improve the diagnostic usefulness of EF measurements. The majority of EF research is focused on cross-sectional studies. Longitudinal studies are more accurate and reliable for evaluating developmental changes, but they are uncommon since they are expensive, need years of follow-up, and are hampered by sample attrition and "learning effects." Prolonged studies will be needed in the future to confirm our knowledge of EF development. We can now monitor the development of neural systems and cognitive functioning at the same time thanks to structural and functional neuroimaging, significantly improving our knowledge of brain-behavior connections.

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