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Psychometric Properties of The Brain Executive Functions Scale for Adolescent Students Prepared

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Abstract:

The study aimed to prepare a scale for measuring executive brain functions for adolescent students within the Arab environment, with a particular focus on its suitability for the Saudi environment. The goal was to provide a standardized tool that researchers in the fields of psychometrics and behavioral sciences could benefit from. The study adopted a descriptive psychometric methodology. The final version of the scale consists of 24 items, distributed across four the oretically identified dimensions: planning and organization, working memory, Control and Monitoring, and Cessation and conversion.The samplecomprised (181) male and female students from public schools, aged between (12 – 18) years, with a mean age of (16.14) years and a standard deviation of (1.4). The results indicated high validity, including discriminant validity, internal consistency, and confirmatory factor validity, reflecting the appropriateness of the theoretical structure of the scale. The reliability indicatorsalso showed good results, with both Cronbach's alpha coefficient and composite reliability (CR), confirming that the scale possesses an adequate level of validity and reliability.

Keywords: Executive Functions Scale - Adolescent Students.

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Intodcution:

Executive functions are a cognitive construct widely recognized by cognitive psychologists, neuropsychologists, and clinical psychologists. Researchers define the concept of executive functions as essential functions for monitoring, organizing, and adjusting behavior to achieve specific goals, helping individuals solve problems in creative ways (Verdejo, G. &Bechra, 2010). Executive functions are understood as mental processes that enhance an individual's ability to reach their objectives. These brain functions encompass several skills, including working memory updating, planning, attention control, task shifting, delay of gratification, decision-making, self-regulation, and emotional regulation. These are sub-skills that involve controlling impulses and automatic responses (AbdAlgfar, et al., 2019). Mulder, et, al. (2017) stated that executive functions are brain control functions that assist students in learning, adapting to their environment, and achieving success socially, academically, and professionally. Additionally, executive functions clarify self-organized cognitive processes, including the ability to plan and exhibit mental flexibility to achieve desired goals. Basharpoor, et, al. (2022) also confirmed that brain regions responsible for critical thinking, creativity, memory, and attention can be stimulated using brain-based learning strategies in children and adolescents, leading to enhanced cognitive abilities and improved academic performance.

Executive functions of the brain:

Clements and Sarama (2019) defined executive functions of the brain as a critical component of the cognitive processes necessary for an individual's learning. They contribute to the development of social and emotional aspects and help regulate human behavior by organizing thoughts, controlling impulses,

and planning to achieve desired goals. In this regard, Ahrens et al. (2019) emphasized that executive functions lead to higher cognitive processes (p 765).

Zelazo, Carlson, and Kesek (2007) explained that self-regulation of emotions and behavior is an executive function that begins developing in infancy and continues throughout childhood, adolescence, and early adulthood. Cumming et al. (2022) identified that self-regulation and executive functions are essential for academic, emotional, and behavioral achievement in children and adolescents.

By reviewing some previous studies that have measured executive functions of the brain, it was observed that they rely on various scales. For example, the study by Fernandez, Gonzalez, Perez, Garcia, and Garcia (2014) indicated that the Behavioral Assessment Battery for Executive Functions is composed of well-structured items with internal correlations between the subcomponents of the battery, suggesting that the battery possesses acceptable standard characteristics. In the study by Shweikh (2022), the findings highlighted acceptable levels of construct, convergent, and discriminant validity for the final version of the Behavioral Assessment Battery for Executive Functions, as well as acceptable reliability coefficients. The study also found acceptable differentiation coefficients for the battery according to age. The clinical measures included in the battery were: planning, working memory, inhibition, shifting, emotional regulation, self-monitoring, initiative, performance control, and organization of objects. The validity measures included: negativity, rarity, and inconsistency or instability. The study by Abd al-Ghafar (2015) indicated that the results of the standard characteristics indicators for the final version of the Behavioral Assessment Scale for Executive Functions showed acceptable levels of construct, convergent, and discriminant validity for the dimensions of the scale, along with acceptable reliability coefficients. The study also demonstrated the ability to distinguish between normal individuals and those with attention difficulties. The study by Welsh and Pennington (1988) found that executive functions of the frontal lobe appear in the first year of life and continue to develop into adulthood and beyond. In the study by Al-Shuqayrat (2015), which relied on the Behavioral Rating Scale for Executive Functions in adults, the results revealed a high degree of executive function in university students. Meanwhile, the study by Abdullah and Ibrahim (2023) used the Executive Function Rating Scale for both typical children and children with special needs, developed by "Abdulaziz Al-Shakhs and Hayam Fathy, 2013." This scale included 72 items distributed across dimensions such as inhibition, shifting, emotional regulation, initiative, working memory, planning, organizing tools, and monitoring. The results showed that the scale had a high degree of validity and reliability. The study by Al-Dhafiri, Al-Kayal, and Al-Sheikh (2020) focused on the construction of a scale for executive functions, including working memory, problem-solving, planning, emotional regulation, and initiative. The results revealed that the scale had high levels of validity and reliability. Similarly, the study by Gioia, G., et al.(2005) aimed to design the BRIEF Battery to measure executive functions through an individual's ability to think abstractly, plan, demonstrate flexibility, organize, initiate, monitor, and evaluate behavior, and use working memory positively. It also included the ability to control performance, inhibit responses, and adapt to changes in different situations and problem-solving. The results showed that the scale had high levels of validity and reliability.

It has been found from the previous studies presented that they relied on scales to measure executive functions of the brain, some of which include the Behavioral Rating Scale for Executive Functions or the BRIEF Battery designed to measure executive functions. The majority of these studies were conducted on individuals with special needs, particularly those with autism. However, there is no scale designed to measure executive functions of the brain that is suitable for adolescent students in the Saudi environment (to the best of the researchers' knowledge). Thus, the issue of the current research lies in the severe scarcity of studies focusing on executive functions of the brain in typically developing individuals, and there is no tool used to measure executive functions of the brain in typical individuals, particularly adolescent students.

Therefore, there is an urgent need to construct and design a scale to measure brain functions among adolescent students in the Saudi environment. Hence, the research problem crystallizes in the following main question: Is it possible to construct a scale to measure brain functions that has the appropriate

psychometric properties for the Arab environment in general, and Saudi Arabia in particular, and for the sample of adolescent students?

To answer this question, the current research sought to verify the following two hypotheses: construct and design a scale to measure brain functions in adolescent students within the Saudi environment.

To answer this question, the current research aims to verify the following two hypotheses:

1- The scale for measuring executive brain functions in adolescent students possesses validity.

2- The scale for measuring executive brain functions in adolescent students possesses reliability.

Therefore, the aim of the current research is to construct and design a scale to measure executive brain functions in adolescent students within the Saudi environment and to verify the psychometric properties (validity and reliability) of the scale using appropriate statistical methods. This is because the previous studies that aimed to measure executive brain functions were designed for samples that differ in nature and characteristics from the current sample.

The significance of this study lies in designing a scale to measure brain functions in adolescents within the Saudi environment that is valid, reliable, and suitable for scientific use in research and studies related to its content. It aims to provide a practical and valuable measurement tool for research on executive brain functions in adolescent students. This means that a measurement tool for examining executive brain functions in typically developing adolescents will be available, supporting the field of psychological measurement. Consequently, this will contribute to enriching the Arabic literature with a scale for brain functions and benefit future studies in this area.

In light of the literature and previous studies, the researchers have defined executive brain functions operationally as a system of cognitive skills that help an individual control their thoughts, emotions, and behaviors. This is achieved through their ability to plan based on attention and perception, as well as the capacity of their working memory to process and recall information accurately, considering these as the "cold" components of executive brain functions. Additionally, it includes the ability to regulate emotions and organize behaviors and relationships with others, which are considered the "hot" components of executive brain functions. Any disruption in these components—whether cold or hot—due to psychological disorders or various types of addiction can lead to the destruction of different areas of an individual's life.Based on this definition, the most common dimensions in previous studies for measuring executive brain functions are: (planning, organization, working memory, emotional regulation, performance and task control, self-monitoring of behavior, inhibition, shifting, and response modification). These dimensions can be summarized into four main categories as follows:

Planning and Organization: This refers to an individual's ability to set achievable goals and determine appropriate steps to implement a specific skill or activity, as well as their ability to estimate the appropriate time required for its completion. It also involves organizing information, tools, and objects in a way that facilitates the achievement of desired goals.

Working Memory: This refers to an individual's ability to comprehend and retain information after it has been cognitively processed and to retrieve it when needed. It involves recalling information largely intact when performing any task or activity, with the aim of completing it effectively.

Control and Monitoring: This refers to an individual's ability to control impulsive reactions, regulate self-control, and respond emotionally in an appropriate manner to different situations. It also involves the ability to self-monitor and regulate behaviors that impact relationships with others, demonstrating emotional and self-regulation.

Cessation and conversion: This refers to an individual's ability to inhibit impulsive behavior at the appropriate time, as well as their capacity to transition from one activity or task to another according to the demands of different situations. This involves the ability to shift attention and refocus from one

subject to another, thereby adapting their behavior both cognitively and behaviorally by making flexible adjustments in responses across various situations.

Methodology :

The descriptive psychometric approach was adopted, and the participants were volunteers from middle and high school students in some schools in the Kingdom of Saudi Arabia. The total number of participants was (181) students, consisting of (115) females and 66 males, with ages ranging from 12 to 18 years, and an average age of (16.14) years with a standard deviation of (1.4). The participants provided their consent for this study, and the scale was administered to these volunteer students during the academic year of 2024.

Executive FunctionScale Description:

By referring to the literature and previous studies such as those by Hassan (2024), Shweikh (2022), Al-Shuqayrat (2015), Abd al-Ghafar (2015), Fernandez, Gonzalez, Perez, Garcia & Garcia (2014), and Welsh & Pennington (1988), the researchers were able to design this scale according to the operational definition of executive brain functions. This was done by reviewing the previous studies that addressed this concept and the scales used to measure it. In light of this definition, the main dimensions were identified and relied upon in constructing the Executive Brain Function Scale.

The scale items were formulated and categorized under each dimension, with the scale consisting of (24) items distributed across (4) dimensions as follows:

• **Planning and Organization**: This dimension includes 6 items (1–6).

• **Working Memory**: This dimension includes 7 items (7–13).

• **Control and Monitoring**: This dimension includes 6 items (14–19).

• **Cessation and conversion**: This dimension includes 5 items (20–24).

It is important to note that all items are positively worded.

To correct the scale, the researchers relied on a three-point graded response scale for the items of the scale as follows:

The researchers used the "Likert" method to design the scale items, placing them in a list with a three-point response scale for each item, which includes: **Applicable**(3 points), **To some extent applicable** (2 points), and **Not applicable** (1 point). The highest possible score on the scale is (72), indicating a high level of executive brain functions among the participants. The lowest possible score is (24), indicating a low level of executive brain functions.

Results:

The Psychometric Properties of the Executive Functions of the Brain Scale:

Validity:

A. Content Validity (Expert Judgment):The initial version of the Executive Functions of the Brain Scale was submitted to a panel of (9) experts specializing in psychology, mental health, psychological counseling, and curriculum and instruction. The purpose was to evaluate the items based on their appropriateness for each dimension of the scale, their validity in representing the underlying construct, the clarity of their wording, their linguistic accuracy, and their cultural relevance to the Saudi environment. Minor modifications were made in light of the experts' feedback. The evaluation process resulted in the final version of the scale, comprising (24) items distributed across four dimensions.

B. Internal Consistency Validity:The internal consistency of the scale was verified by calculating the correlation coefficients between each item's score and the total score of the dimension to which the item belongs. Additionally, the correlation coefficients between each dimension's score and the overall scale score were computed. Tables (1) and (2) present the results of these analyses:

Table 1: Correlation Coefficients Between Each Item Score and the Total Score of Its Corresponding Dimension

Dimension	Item No.	Correlation Coefficient	Dimension	Item No.	Correlation Coefficient
Planning and Organization	1	**0.51	Working Memory	1	**0.60
	2	**0.61		2	**0.68
	3	**0.57		3	**0.53
	4	**0.73		4	**0.68
	5	**0.71		5	**0.49
	6	**0.69		6	**0.65
	——	——		7	**0.57
Control and Monitoring	1	**0.77	Cessation and conversion	1	**0.65
	2	**0.80		2	**0.54
	3	**0.80		3	**0.78
	4	**0.66		4	**0.73
	5	**0.57		5	**0.68
	6	**0.67		——	——
	——	——		——	——

. **** indicates statistical significance at the (0.01) level**

Table 2: Correlation coefficients between the sum of each dimension and the total sum of the scale

Dimension	Correlation coefficient of the scale
Planning and Organization	**0.73
Working Memory	**0.84
Control and Monitoring	**0.79
Cessation and conversion	**0.77

. **** indicates statistical significance at the (0.01) level**

Tables 1 and 2 present the verification of the internal consistency validity of the scale. The correlation coefficients between each item and its corresponding dimension indicate statistically significant

relationships at the (0.01) level, with values ranging from (0.49) to (0.80). This suggests that the items align well with the theoretical dimension they are designed to measure, and there are no items with weak correlations that would necessitate deletion or revision.

C. Discriminant Validity: Discriminant validity was assessed by calculating the correlation coefficients between the score of each dimension and the other dimensions, as shown in Table (3) which presents the results.

Table 3 Correlation coefficients between scale dimensions:

Dimension	Planning and Organization	Working Memory	Control and Monitoring	Cessation and conversion
Planning and Organization	———	**0.60	**0.36	**0.36
Working Memory	**0.60	———	**0.48	**0.50
Control and Monitoring	**0.36	**0.48	———	**0.59
Cessation and conversion	**0.36	**0.50	**0.59	———

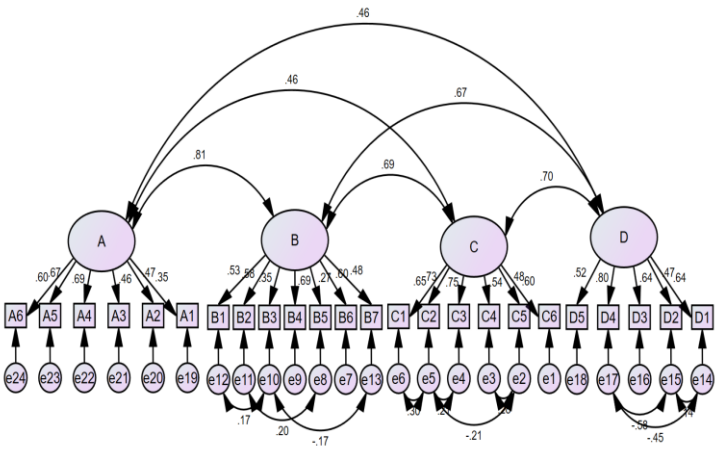
. ** indicates statistical significance at the (0.01) level

The results from Table (3) show that the correlation coefficients between the scale dimensions did not exceed (0.85), indicating the presence of discriminant validity for the scale. The literature suggests that correlation coefficients lower than (0.85) between latent dimensions are considered an acceptable indicator of discriminant validity (Brown, 2015; Hair et al., 2019; Kline, 2015).

D. Construct Validity (Confirmatory Factor Analysis):

To assess construct validity, the researchers directly applied Confirmatory Factor Analysis (CFA) without resorting to Exploratory Factor Analysis, based on the existence of a pre-established theoretical framework that defines the proposed dimensions of the scale and classifies the items associated with each dimension. The indicators of expert validity, discriminant validity between dimensions, and internal consistency coefficients supported this classification and contributed to confirming the theoretical construct of the scale.

The following figures and tables present the results of the Confirmatory Factor Analysis:



First: Model fit quality indicators:

Table 4: The quality indicators of conformity with the assertive factor analysis of the brain's executive functionsScale

The indicator	Chi-square/df	RMSEA	CFI	IFI	TLI
Value	1.436	0.049	0.913	0.916	0.899

Table (4) reflects a high degree of agreement between the hypothesized model and the empirical data, as the fit indices fall within the standard thresholds commonly cited in the scientific literature. This provides strong evidence for the adequacy of the proposed structural model and supports the theoretical framework upon which the scale was developed. The low value of χ^2/df, along with the high values of the fit indices (CFI, IFI, TLI) and the low value of RMSEA, collectively serve as statistical evidence reinforcing the factorial construct validity of the scale. These results indicate that the relationships between the dimensions and the items accurately represent the proposed structure of the measured construct.

Second: Standardized Measurement Coefficients (**Standardized Estimates**):

Table (5): Standard measurement coefficients

Dimension	**Item No.**	**Factor Loadings**	**Dimension**	**Item No.**	**Factor Loadings**
Planning and Organization	1	***0.354	**Working Memory**	1	***0.532
	2	***0.471		2	***0.578
	3	***0.458		3	***0.349
	4	***0.691		4	***0.689
	5	***0.668		5	***0.267
	6	***0.597		6	***0.604
	——	——		7	***0.481
Control and Monitoring	1	***0.653	**Cessation and conversion**	1	***0.639
	2	***0.726		2	***0.469
	3	***0.749		3	***0.639
	4	***0.538		4	***0.795
	5	***0.483		5	***0.518
	6	***0.599		——	——
	——	——		——	——

**** indicates statistical significance at the (0.01) level**

The results presented in Table (5) indicate that all items demonstrated statistically significant standardized factor loadings at the (0.001) level, reflecting strong associations between the items and

their respective dimensions, and confirming the internal construct validity of the scale. Although Item (5) under the "Working Memory" dimension recorded the lowest factor loading (0.267), it still falls within the statistically significant range.

Reliability:

The researchers assessed the reliability of the scale by calculating Cronbach's alpha coefficients for the sub-dimensions and for the overall scale. Additionally, the Composite Reliability (CR) was computed for each sub-dimension separately. Table (6) presents the results of these analyses.

Table (6): Reliability coefficients of the brain's executive functions scale

Dimensions		Reliability coefficient (Cronbach's alpha)	Composite stability coefficient (CR)
1	Planning and Organization	0.71	0.72
2	Working Memory	0.70	0.71
3	Control and Monitoring	0.81	0.80
4	Cessation and conversion	0.71	0.75
The scale as a whole		0.88	--

The results from Table (6) indicate that the Cronbach's alpha coefficients ranged from (0.70) to (0.81) for all dimensions, with the overall scale demonstrating a Cronbach's alpha of (0.88). Additionally, the Composite Reliability (CR) values for the sub-dimensions ranged from (0.71) to (0.80), which are alsoconsidered acceptable based on the recommended minimum of (0.60), as suggested by Hair et al. (2019). These results support the structural consistency of the factors within the Confirmatory Factor Analysis model. Furthermore, they reinforce the reliability of the scale in accurately and consistently measuring brain executive functions.

Discussion:

It is clear from Tables 1 and 2 that: The correlation coefficients between the dimension scores and the total score of the scale also indicate strong statistically significant relationships at the (0.01) level, with values ranging from (0.73) to (0.84). This reflects the alignment of the subdimensions with the overall construct of the scale, thereby enhancing the general construct validity of the scale.

These results support the findings of Hair et al. (2019) and DeVellis (2016), who stated that good correlation coefficients between an item and its corresponding dimension, as well as between the dimensions and the total scale, are important indicators of internal consistency validity and contribute to confirming the soundness of the theoretical construct of the instrument.

These results are consistent with the findings of (Fernandez et al., 2014), (Shweikh, 2022), (Abd Al-Ghaffar, 2015), (Al-Shuqayrat, 2015), (Abdullah & Ibrahim, 2023), and (Gioia et al., 2005), which demonstrated that the measurement instruments used in those studies possessed standard psychometric properties, indicating acceptable levels of validity and reliability and confirming their suitability for application.

Conclusion:

The Brain Executive Functions Scale was developed and designed to measure the executive functions of the brain in adolescent students, enhancing the understanding of the psychometric properties of the scale ~~with specific~~ dimensions. It was standardized on a sample of volunteer participants from several schools

in the Kingdom of Saudi Arabia, comprising 181 students (115 females and 66 males) from both middle and high school levels. The participants' ages ranged from (12 to 18) years, with a mean age of (16.14) years and a standard deviation of (1.4). Validity and reliability coefficients were calculated, ensuring that the final version of the scale has high validity and reliability, making it suitable for application with adolescent students in both middle and high school levels.

The importance of this psychometric study lies in the fact that there is no specific research tool available to measure the brain's executive functions in adolescent students, which is a gap in the existing literature and knowledge on the subject. Furthermore, this study provides a reference point for future independent studies in this area. The implications of the results of the current study suggest that researchers should utilize this scale in conducting studies related to brain executive functions in adolescent students. It is recommended that this scale be used in the field of psychological measurement and that further scientific research be conducted on the topic of brain executive functions in adolescent students. This would help expand the understanding of executive functions in this age group and contribute to the development of more accurate and reliable tools for assessing these functions.

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Appendix

Brain Executive Functions Scale

Prepared

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Preliminary Data:

Age:

Gender: ( ) Male ( ) Female

Educational level: ( ) Intermediate ( ) Secondary

Grade: ( ) First ( ) Second ( ) Third

Place of residence: ( ) City ( ) Village

Instructions:

Please read the statements carefully and answer them based on your perspective with accuracy and attention to detail. Note that there are no right or wrong answers. We assure you that the information will be used solely for scientific research purposes. We sincerely thank you in advance for your cooperation.

The Researchers,,,

Dimensions	**No.**	**Items**	**Applicable**	**To some extent applicable**	**Not applicable**

Planning and Organization	1	I can set achievable goals in reality.			
	2	When I make a plan for a task, I ensure that it is flexible, clear, and easy to implement.			
	3	I can estimate the appropriate time required to complete any task or activity.			
	4	I can organize my thoughts, information, and tasks in a way that aligns with my goals.			
	5	I can organize my time and priorities to achieve success in my studies and social life.			
	6	I take care of arranging tools, things and tasks to achieve my life goals.			
Working Memory	7	I absorb the academic and life information easily.			
	8	I can focus my attention for long periods when carrying out tasks.			
	9	I can easily remember certain things.			
	10	I can easily concentrate on academic tasks to complete them to the best of my ability.			
	11	I can retain information for a short period.			
	12	I remember my academic assignments to complete them without delay.			
	13	I use strategies such as note-taking or repetition to help me retain information.			
Control and Monitoring	14	I can control my impulsive reactions.			
	15	I can regulate myself and control my emotions in difficult situations.			

	16	I manage my emotions to ensure they are appropriate in many situations.			
	17	I monitor myself to ensure my behavior is appropriate with others.			
	18	I try to control my behavior because of its impact on my relationships with others.			
	19	I think about the consequences of my actions before carrying them out.			
Cessation and conversion	20	I can stop myself from being impulsive and change my behavior according to the situation.			
	21	I try to refrain from responding incorrectly in different situations.			
	21	I can divide my attention between more than one situation at the same time.			
	23	I can shift my thinking and focus from one topic to another easily without getting distracted.			
	24	I can quickly and appropriately change my response when the situation changes.			