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Statistical Perspective on the Psychometric Properties of the Executive Function Index

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Abstract: This study examines the psychometric properties of the Arabic version of the Executive Function Index (EFI-ARABIC). The sample consisted of 3220 participants aged between 17 and 84 years. The results indicated that the EFI-ARABIC demonstrated acceptable levels of internal consistency, ranging from 0.53 to 0.72 for the subscales and 0.76 for the total score. The correlation coefficients between the items and subscales ranged between 0.364 and 0.732, the correlation coefficients between the items and EFI-ARABIC total score ranged between 0.105 and 0.483, and the correlation coefficients between the subscales and EFI-ARABIC total score ranged between 0.438 and 0.764. The resulting 5-factor solution accounted for a 48% variance. Males scored higher in motivational drive, while females scored higher in strategic planning, impulse control, and total score. Moreover, as age and level of education increased, executive functions increased. In this regard, similarities and differences emerged compared to previous studies.

Keywords: Executive functions index, EFI-ARABIC, prefrontal, psychometric, reliability, self-rating.

1 Introduction

The executive functions are the self-control or self-regulatory processes that plan and coordinate all mental activity, emotional reactions, and overt behaviour. One way to think of executive function is as a broad umbrella word that may be used to define several related subdomains that appear behaviourally. The following are examples of the executive function domains: planning and selecting relevant task goals, initiating goal-directed behaviour, inhibiting competing actions or stimuli, organising behaviour to solve complex problems, adapting problem-solving strategies as needed, and monitoring and evaluating problem-solving behaviour. Also, working memory capacity, as one of the domains of executive functions, is essential for actively maintaining knowledge "online" while addressing issues that support these activities. [1-3] Brain injury, attention deficit hyperactivity disorder, mood disorders, Tourette's syndrome, schizophrenia, and antisocial and borderline personality disorders have all been linked to executive dysfunction. [4-6] For instance, a person with a brain injury may display executive dysfunction by acting in socially inappropriate ways, such as masturbating in front of others (see Phineas Gage). [7] Furthermore, people who are known to be violent offenders in the legal system, particularly teenagers, also tend to have poorer impulse control, which is thought to be a reflection of underdeveloped executive function [8].

Individuals suffering from difficulties regulating their behaviour and thoughts often lack a general awareness of these deficits. Even among nonclinical groups, healthy individuals can exhibit lapses in executive functioning from time to time. For example, missing an exit due to daydreaming while driving a car or placing car keys in an illogical location, such as in the refrigerator or a cupboard, are standard executive functioning lapses [9]. Executive impairments occur in most neurodegenerative diseases and many other neurological, psychiatric, and systemic illnesses [10-11].

Emotional regulation is essential for efficient problem-solving and should be considered in any definition of executive functions, which encompass more than just cognition. The primary characteristic of decisions in the many subdomains of the executive functions is emotional control, which is relevant to practical problem-solving activities and should be considered in any definition.

The executive functions are not limited to intellect alone. Although deficiencies in different executive function subdomains are

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essential for numerous developmental and acquired neurological illnesses throughout the lifespan, measuring these deficiencies can be difficult and complex. Reliance on clinic-based test performance measures may result in a limited or partial assessment, given the central role of executive functions in directing and regulating dynamic "real-world" behaviour [12-13].

Executive function assessment has traditionally been linked to performance tests conducted in a laboratory setting. Although these tests provide the benefits of strong internal validity, the ability to control extraneous variables, and the opportunity to analyse different aspects of executive function individually, such as planning and working memory, they are inherently constrained in terms of their ecological validity and predictive power in real-life situations.

Executive Function Index (EFI).

The EFI was developed by Spinella [1] to assess a person's perception of their executive functions. The index is self-rated, with 27 items covering five executive function subscales: Motivational Drive (MD), Organisation (ORG), Strategic Planning (SP), Impulse Control (IC), and Empathy (EM).

Spinella [1] reported that the Cronbach alphas for these subscales ranged from 0.69 to 0.76, and the overall score was 0.80. Three higher-order factors, which correspond to functions associated with the three main regions of prefrontal systems identified by Cummings [14], were identified: IC and EM, related to the function of the Orbitofrontal cortex; SP and ORG, associated with the function of the Dorsolateral cortex; and MD related to the function of the Medial prefrontal cortex.

Recent advances in neuroimaging have suggested that the frontal subcritical circuits are involved in EF. These circuits include dorsolateral prefrontal circuits (DLPF), which are associated with executive cognitive dysfunction; the lateral orbital prefrontal circuit (LOPFL) (which is related to disorders of self-regulation, such as inhibition; and the anterior cingulate circuit (AC), which is associated with activation and motivation problems [15-16].

Since its publication, several studies have applied the EFI in different settings [17-24]. Other studies have examined the psychometric properties of EFI [25-27].

This study aims to investigate the psychometric properties of an Arabic version of the EFI (EFI-ARABIC) in a population sample and to examine the internal structure of the EFI-ARABIC subscales through (a) analysing the internal consistencies, (b) determining if the five-factor structure in the original version can be found in the ARABIC sample, and to adapt the index to the Arabic culture.

2 Methods

2.1 Participants

The participants were a sample of 3220 (1424 females and 1796 males) from Arabian countries, and the ages of the participants ranged between 17 and 84 years (M 30 ±8.27). They volunteered to participate in the study. The educational level of 293 was high school or less, 1827 was a bachelor's, and 1100 was postgraduate. Exclusion criteria were not to include people under 17 years old, and not complete the whole index.

2.2 Data Collection

This cross-sectional study utilised an internet-based survey conducted through Google Forms. Inclusion criteria encompassed participants aged 17 years or older who provided consent, were native Arabic speakers, and completed the EFI and demographic information.

2.3 Measure

The psychometric instrument used in this study was the ARABIC translation of the Executive Function Index (EFI-ARABIC). This index was initially developed by Spinella [1] and translated into the ARABIC language so that content, order, and response styles were identical to the original English version. Also, the EFI was translated back into English by three psychology experts who use English in their teaching.

The EFI comprises 27 items in total, divided into five subscales (MD, SP, EM, ORG, IC). Items were rated according to a 5-level Likert format (1 = describes me not at all, 3 = describes me somewhat, 5 = describes me very much), and higher scores indicated better executive functioning. The negatively worded items were reversed (2, 4, 5, 6, 11, 12,13, 15, 17, 20, 22, 23, 24). The total score is calculated by summing the item scores of the five different subscales, and the total score ranges from 27 to 135.

2.4 Data Analysis

Mean, standard deviation, Cronbach's alpha, factor analysis, skewness, and kurtosis were calculated for each subscale and the total score (as applicable) using descriptive statistics using the SPSS package.

3 Results

The means, standard deviations, Skewness, Kurtosis, and Cronbach's Alpha of EFI-ARABIC are shown in Table 1.

Table 1: Descriptive statistics of the EFI-ARABIC subscales and total score

Subscales	No. of items	Mean	SD	Skewness	Kurtosis	α
MD	4	21.86	3.64	-.402	.253	0.58
ORG	5	22.56	4.59	-.249	.028	0.71
SP	7	16.77	3.82	-.305	-.101	0.72
IC	5	20.16	2.97	-.032	.739	0.53
EM	6	13.18	2.96	-.227	-.075	0.57
EFI total	27	94.52	10.86	-.146	.043	0.76

MD: motivational drive, ORG: Organisation, SP: Strategic Planning, IC: Impulse Control, and EM: Empathy.

Table 1 shows that the mean of the EFI-ARABIC total score was (94.52±10.86), while the means of the subscales ranged between (13.18 and 22.56). The subscales' reliability ranged between 0.53 and 0.72, and the total score was 0.76. The Skewness and Kurtosis of the EFI-ARABIC total score showed normal distribution (Figure 1).

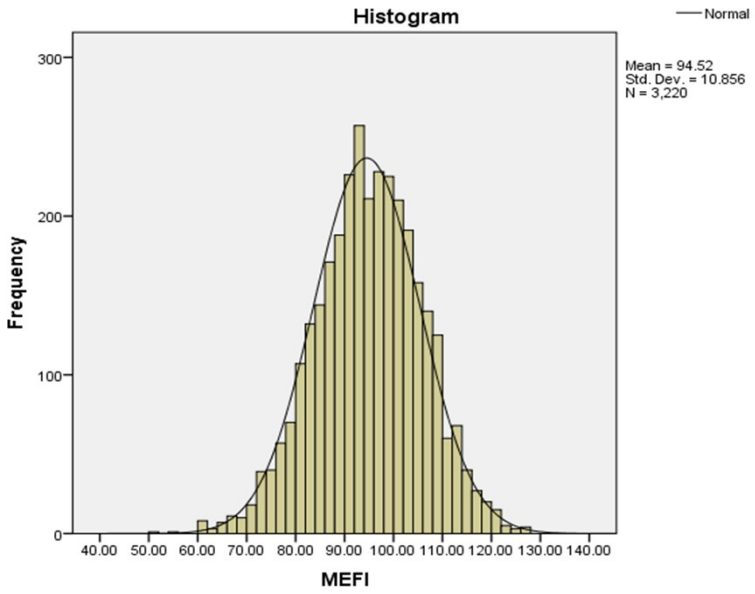

Fig. 1: Distribution of the EFI total scores

3.1 The discriminative evidence

Pearson correlation coefficient was calculated between items, subscales, and the EFI-ARABIC total score. Table 2 shows the results.

Table 2: Pearson correlation coefficient between items, subscales, and EFI total

MD			**ORG**			**SP**		
N.	**Cr sub**	**Cr total**	**N.**	**Cr sub**	**Cr total**	**N.**	**Cr sub**	**Cr total**
1	.694**	.439**	2	.652**	.420**	3	.580**	.460**
4	.532**	.339**	6	.647**	.409**	9	.660**	.557**
7	.732**	.452**	17	.722**	.415**	10	.558**	.371**
14	.721**	.477**	22	.695**	.437**	13	.598**	.481**
Sub Cr with total		.637**	23	.723**	.461**	19	.625**	.483**

			Sub Cr with total		.623**	26	.559**	.364**
IC			**EM**			27	.648**	.520**
5	.583**	.105**	8	.565**	.230**	Sub Cr with total		.764**
11	.614**	.263**	12	.364**	.123**			
15	.565**	.282**	16	.664**	.384**			
20	.551**	.299**	18	.617**	.312**			
24	.654**	.364**	21	.655**	.378**			
Sub Cr with total		.438**	25	.579**	.278**			
			Sub Cr with total		.489**			

Cr sub: Correlation with subscale, Cr Total: Correlation with EFI total score. MD: motivational drive, ORG: Organisation, SP: Strategic Planning, IC: Impulse Control, and EM: Empathy.

Table 2 shows that the discriminative evidence of the EFI-ARABIC is acceptable. The correlation coefficients between the items and subscales ranged between 0.364 and 0.732. In contrast, the correlation coefficients between the items and EFI-ARABIC total score ranged between 0.105 and 0.483, and the correlation coefficients between the subscales and EFI-ARABIC total score ranged between 0.438 and 0.764.

3.2 Factor analysis

Table 3: Parallel analysis

Component	Eigenvalues	% of Variance
1	4.31	16.0
2	3.10	11.5
3	1.96	7.3
4	1.33	4.9
5	1.19	4.4
6	1.05	3.9

A principal component analysis with varimax rotation and parallel analysis resulted in an interpretable six-factor solution with Eigenvalues of 4.31, 3.10, 1.96, 1.33, 1.19, and 1.05. These factors account for 16%, 11.5%, 7.3%, 4.9%, 4.4%, and 3.9%, respectively. Table 3 shows the results, accounting for 48% of the total variance. Table 4 shows the principal component loadings of the EFI-ARABIC items.

Table 4: principal component loadings of the EFI-ARABIC items

Item N.	F1 (ORG)	F2 (MD)	F3 (EM)	F4 (SP)	F5 (IC)	F6
2	**.638**	-.096	.067	.115	.131	.050
4 (MD)	**.457**	.176	-.024	-.146	.205	-.024
6	**.632**	.101	.115	-.094	.112	-.178
17	**.699**	-.023	-.135	.138	.088	.083
22	**.632**	.025	-.031	.180	-.032	.186
23	**.657**	.099	-.189	.208	.051	.138
1	.033	**.740**	.112	.118	.046	-.016
3 (SP)	.020	**.578**	.070	.347	-.008	.057
7	.078	**.758**	.107	.146	-.104	.064
14	.142	**.669**	.150	.161	.035	-.248
8	-.016	.171	**.463**	.031	-.338	.222
12	.021	-.099	**.655**	-.184	.177	-.112
16	-.005	.272	**.685**	.026	.001	-.014
18	.058	.113	**.638**	.059	-.179	-.094
21	-.080	-.026	**.706**	.233	.156	.013
25	-.127	.004	**.570**	.115	.165	.057
9	.347	.208	-.009	**.586**	.006	-.032
10	.056	.083	-.111	**.660**	-.070	.174
13	.254	.203	.103	**.456**	.096	-.292
19	.034	.067	.339	**.596**	.093	-.041
26	-.006	.199	.188	**.445**	-.090	-.106
27	.047	.132	.317	**.586**	.171	-.075
5	.122	-.411	-.025	.039	**.530**	-.084
11	.156	-.061	.062	-.034	**.649**	-.030

15	.079	.038	.013	.050	**.638**	.156
20	.314	.039	-.107	.089	**.539**	.183
24	.135	.164	-.007	.057	**.603**	.285

MD: motivational drive, ORG: Organisation, SP: Strategic Planning, IC: Impulse Control, and EM: Empathy.

Table 4 shows that the items are divided into five factors. Just two items were loaded on other factors: item 3 was packed with MD, and item 4 was loaded with ORG. All other items fully replicate Spinella's [1] findings.

3.3 The differences results

Independent t-tests were calculated to identify the sex differences in the EFI and its subscale levels. Table 5 shows the results.

Table 5: Independent t-test results for the differences in the EFI-ARABIC and its subscales levels due to sex.

Variables	Sex	N.	Mean	Std. Deviation	t	Sig.
MD	Male	1796	22.1	3.5	3.314*	.001
	Female	1424	21.6	3.7		
ORG	Male	1796	22.4	4.5	-1.541	.124
	Female	1424	22.7	4.7		
SP	Male	1796	16.5	3.8	-4.596*	.000
	Female	1424	17.1	3.8		
IC	Male	1796	19.7	3.0	-9.648*	.000
	Female	1424	20.7	2.8		
EM	Male	1796	13.2	2.8	-.280	.779
	Female	1424	13.2	3.1		
EFI total	Male	1796	93.9	10.6	-3.840*	.000
	Female	1424	95.3	11.1		

* $p<0.05$.

MD: motivational drive, ORG: Organisation, SP: Strategic Planning, IC: Impulse Control, and EM: Empathy.

Table 5 shows significant sex differences in the level of MD in favour of males ($t=3.314$, $p<0.01$). Also, significant sex differences in the SP, IC, and EFI total levels favour females ($t=4.596$, 9.648, and 3.840, $p<0.01$) .There are no sex differences in the levels of ORG and EM ($t= 1.541$ and .280, $p>0.05$) .Finally, the results showed significant sex differences in the EFI total score (t 3.840, $p<0.01$); the female average was higher.

Differences in performance between the EFI-ARABIC and the Dutch version are shown in Table 6.

Table 6: Descriptive statistics of the EFI

Subscales	N. of items	Mean	SD	Skewness	Kurtosis	α
MD	4	21.86*	3.64	-.402	.253	0.58
ORG	5	22.56*	4.59	-.249	.028	0.71
SP	7	16.77**	3.82	-.305	-.101	0.72
IC	5	20.16*	2.97	-.032	.739	0.53
EM	6	13.18**	2.96	-.227	-.075	0.57
EFI total	27	94.52**	10.86	-.146	.043	0.76

* The Arabian sample scored significantly higher than the Dutch sample

** The Dutch sample scored significantly higher than the Arabian sample

MD: motivational drive, ORG: Organisation, SP: Strategic Planning, IC: Impulse Control, and EM: Empathy.

It can be seen from the table that the Arabian sample had higher scores than the Dutch sample in motivational drive, organisation, and impulse control; however, the Dutch sample did higher in strategic planning, empathy, and the total score. It is worth noting the differences between the Arabian and the Dutch samples. The Arabian sample comprised 3220 adults aged between 17 and 84 years, whereas the Dutch sample comprised 376 college students.

3.3 Linear regression

Table 7: Linear regression of demographic variables predicting the total score of EFI-ARABIC

	B	SE	Beta	Sig.
Age	.086	.024	.066	.000
Education	1.394	.323	.078	.000

Table 7 shows that the demographic variables predicting the total score of EFI were: Beta for age (.066, P<.0001) and Beta for education (.078, P<.0001). Age and educational level increase the EFI.

4 Discussion

The study aimed to investigate the psychometric properties (reliability and internal structure) of an Arabic version of EFI [1]. The EFI-ARABIC's descriptive statistics and internal consistencies are similar to those obtained by Spinella**Error! Bookmark not defined.** and those obtained by Janssen [26].

The Arabic version of the EFI showed acceptable levels of internal consistency (see Table 1), ranging between 0.53 and 0.72 for the subscales and 0.76 for the total score. In Spinella's results, the internal consistency for the total score was 0.82, and for the subscales ranged between 0.69 and 0.76. Similar results were also obtained by Janssen [26], except for IC, which was 0.41. Consider the cultural differences and the sample size; in the EFI-ARABIC, the sample size was 3220 (1424 females and 1796 males) participants. Spinella's [1] sample was 188 adults (81 male, 107 female); in Janssen's [26], the sample was 376 college students, a homogeneous group. One would expect more substantial statistical power for the larger sample.

The results showed sex differences in motivational drive: males obtained higher scores, while females scored higher in strategic planning, impulse control, and the total score of the EFI-ARBIC. Still, there are no sex differences in organisation and empathy subscales. In this regard, different results were obtained compared to those of Spinella [1] and Janssen [26]. In the results of Janssen [26], the sex differences were in impulse control and empathy; females scored higher in these subscales but not in the total score. On the other hand, the results of Spinella [1] showed significant sex differences in impulse control and empathy but not in the total score.

Comparing the results of the ARABIC and the Dutch sample performance, the subscales of motivational drive, organisation, and impulse control were higher among the ARABIC sample than the Dutch sample. In contrast, the Dutch sample showed higher performance in strategic planning, empathy subscales, and the total score. Due to a lack of information, the comparison between the Arabic and Spanella samples cannot be performed.

Looking at principal component loadings of the EFI-ARABIC items (Table 4), all items are grouped into their corresponding factors, except item 4 (I can sit and do nothing for hours), which was loaded to factor 1 (organisation); in contrast, it was loaded into the motivational drive factor of Spinella's study [1]. Also, item 3 (I try to plan for the future) is loaded to factor 2 (motivational drive) in the EFI-ARABIC, which was loaded to strategic planning in Spinella's study [1]. Considering the content of the organisation subscale, item 4 could mean that people who do not have organisation will sit for hours doing nothing. The factor organisation of the subscales parallels the functional organisation of prefrontal circuits. Item 3, loaded to the motivational drive in EFI-ARABIC, may align with the content of this subscale, which involves people planning for the future to have a motivational drive. The linear regression analysis showed that as the level of education increased, executive functions increased, and as age increased, executive functions increased.

5 Conclusions

In conclusion, we believe that the EFI-ARABIC has proved to be a valuable and valid instrument for assessing executive functioning. The discriminative evidence was acceptable and consistent, partially with Spinella's [1] and Janssen [26] results. Also, the EFI-ARABIC showed satisfactory levels of internal consistency. Furthermore, the results were not limited to specific age groups and were similar to the Spinella1 sample to some extent. However, the current study sample is much larger than his, suggesting more statistical power. Further studies could investigate the reliability of the EFI-ARABIC and study the index in clinical samples.

6 Data Availability:

The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

7 Conflict of Interest:

The authors declare no conflicts of interest in this study.

8 Funding:

This research received no specific grants from funding agencies.

9 Consent to Participate:

Participants provided informed consent to participate in this study.

10 Ethics approval:

This study followed the principles of the Committee on Publication Ethics (COPE).

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Appendix A

The EFI-ARABIC

أمامك عدة عبارات التي قد تنطبق عليك أو لا تنطبق. المطلوب إعطاء وجهة نظرك وإعطاء درجة تقييمك امام عبارة من هذه العبارات حول مدى انطباقها عليك باستخدام مقياس يتكون من 5 درجات كالآتي:

5– تنطبق بدرجة كبيرة جداً 4 – تنطبق بدرجة كبيرة 3 – تنطبق بدرجة متوسطة 2 – تنطبق بدرجة قليلة 1 – لا تنطبق أبداً

(ـــــــ) 1. عندي الكثير من الحماسة لعمل الأشياء.

(ـــــــ) 2. عندما أعمل عدة أشياء بترتيب معين فإني أخطئ بالترتيب* .

(ـــــــ) 3. أحاول أن أخطط للمستقبل.

(ـــــــ) 4. أستطيع أن أجلس دون أن أعمل شيء لساعات* .

(ـــــــ) 5. أقوم بعمل المخاطرات أحياناً للمتعة* .

(ـــــــ) 6. عندي مشكلة في أن أقوم بعملين في نفس الوقت* .

(ـــــــ) 7. أنا مهتم بعمل أشياء جديدة.

(ـــــــ) 8. أهتم كثيراً برفاهية الآخرين .

(ـــــــ) 9. أنا شخص منظم في حياتي.

(ـــــــ) 10. أوفر النقود بشكل منتظم.

(ـــــــ) 11. أقوم بأعمال أو أقول أشياء يراها الآخرين محرجة* .

(ـــــــ) 12. برأيي الأشخاص الذين يتم استغلالهم من قبل الآخرين أغبياء ويستحقون ذلك* .

(ـــــــ) 13. خطأ واحد كافي لكي أتعلم منه* .

(ـــــــ) 14. أميل إلى أن أكون شخص عنده الكثير من الطاقة.

(ـــــــ) 15. أقوم بعمل محاولات غزل أو تقرب إلى الجنس الآخر بطرق غير مناسبة* .

(ـــــــ) 16. عندما يكون أحدهم بمشكلة فإني أشعر بالحاجة إلى مساعدته.

(ـــــــ) 17. أحياناً أفقد مسار (خطوات) ما كنت أقوم به* .

(ـــــــ) 18. أشعر أنني أحمي صديقي الذي أُسيئت معاملته.

(ـــــــ) 19. أفكر بنتائج أعمالي قبل أن أقوم بها.

(ـــــــ) 20. أفقد أعصابي عندما أنزعج* .

(ـــــــ) 21. آخذ بالحسبان مشاعر الآخرين عندما أقوم بعمل ما.

(ـــــــ) 22. عندي مشكلة في تلخيص المعلومات من أجل استعمالها في اتخاذ القرار* .

(ـــــــ) 23. أبدأ بعمل أشياء ثم أفقد اهتمامي بها فأعمل شيئاً آخر* .

(ـــــــ) 24. أنا أسب وأشتم وأستعمل كلمات فاجرة* .

(ـــــــ) 25. لا يعجبني عندما تؤذي كلماتي أو أفعالي شخصاً آخر.

(ـــــــ) 26. أستعمل استراتيجيات من أجل أن أتذكر الأشياء.

(ـــــــ) 27. أقوم بمراقبة نفسي لكي لا أرتكب الأخطاء.

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*هذه الفقرات تعكس عند تصحيح المقياس

الدافعية ويمثلها الفقرات (1،3،7،14)، التنظيم ويمثله الفقرات (2،14،6،17،22،23)، التقمص العاطفي ويمثله الفقرات (8، 12، 16، 18، 21، 25)، التنظيم الاستراتيجي ويمثله الفقرات (9، 10، 13، 19، 26، 27)، وأخير ضبط الاندفاعات ويمثله الفقرات(5 ، 11، 15، 20، 24)