The Relation Between Mini Mental State Examination and Multiple Measures of Executive Functioning

Heshmatollah Ghawami[1*], Azad Sabeti[1*], Alexander R Vaccaro[2], Vafa Rahimi-Movaghar[3]

[1] *Neuropsychology Division, Sina Trauma and Surgery Research Center, Tehran University of Medical Sciences, Tehran, Iran*

[2] *Department of Orthopedics and Neurosurgery, Rothman Institute, Thomas Jefferson University, Philadelphia, USA*

[3] *Department of Neurosurgery, Sina Trauma and Surgery Research Center, Tehran University of Medical Sciences, Tehran, Iran*

Received: 11 Feb. 2019; Accepted: 28 Aug. 2019

Abstract- Given the necessity of executive functioning to perform day-to-day activities, the capacity of widely-used cognitive screening tools to detect potential executive dysfunctions could have important meanings for health care practices. Current research on this topic, however, is still scarce and controversial. The current study is the first of its kind to assess the association between a commonly used cognitive screening tool with multiple executive measures from two wildly used batteries of executive functioning tests. The Mini Mental State Examination (MMSE) along with the Delis Kaplan Executive Function System (D-KEFS) and the Behavioural Assessment of the Dysexecutive Syndrome (BADS) were administered to 73 healthy adults aged 16-40 years (M=24.34, SD=6.53). Most of the relations between the MMSE total score and the executive measures were significant and in the moderate-to-strong range. The highest correlation of MMSE was with the BADS total profile score (r= .62, P< .01). In a secondary analysis, among the MMSE domains, the Attention and Calculation domain had the highest relations with the executive measures. As a measure of general cognitive ability, the MMSE taps on various basic- and higher-level cognitive processes interconnected with the multi-dimensional and multi-level executive processing. Thus, empirical separation of executive measures and general cognitive indices is difficult. Using multiple measures of the executive functioning could be an effective strategy to better understanding the interconnections.

Acta Med Iran 2019;57(9):537-543.

Keywords: Cognitive screening; Cognitive functions; Executive functions; Attention; Delis kaplan executive function system (D-KEFS); Behavioural assessment of the dysexecutive syndrome (BADS)

Introduction

Executive function (EF) refer to a set of higher-level cognitive processes including inhibition, working memory, cognitive flexibility (1,2), attention, reasoning, planning, problem-solving, and decision-making (3-5). Executive functions are those abilities that "enable a person to engage successfully in independent, purposive, self-directed, and self-serving behaviour" (6), and thus they have an important role in instrumental activities of daily living (IADLs) such as bathing, dressing, cooking, shopping, driving, transferring, financial management, managing medications, and social relations (7,8). As such, impairments in executive functioning can have debilitating effects on everyday activities, as seen in a variety of clinical groups, even in non-clinical populations (9). Given the necessity of clinical management for executive impairments in various populations, investigation of the capacity of widely-used screening tools to detect potential EF impairments may have clinically significant implications for neuropsychological practice.

The Mini-Mental State Examination (MMSE) (10) is one of the most widely used screening tools for global cognitive functioning. As a screening tool for dementia, the MMSE originally was developed to evaluate cognitive impairment in older adults (10,11). Current literature shows conflicting data upon the utility of using the MMSE for detecting impairments in executive functioning. While it has been criticized for its low sensitivity to EF impairment (12-14), several studies have demonstrated the association between MMSE and

Corresponding Author: V. Rahimi-Movaghar
Department of Neurosurgery, Sina Trauma and Surgery Research Center, Tehran University of Medical Sciences, Tehran, Iran
Tel: +98 915 342 2682, Fax: +98 216 6757009, E-mail address: v_rahimi@sina.tums.ac.ir

* H. Ghawami and A. Sabeti contributed equally to this work.

special domains within executive functioning (15-17). For instance, Votruba *et al*., (17) conducted a cross-sectional study in a healthy geriatric population showing cognitive flexibility and response inhibition as a predictor of higher MMSE score. Similarly, Jefferson *et al.,* (16) found a statistically significant relationship between the working memory and motor/construction domains of the MMSE with performance on tests of cognitive control.

To date, few studies have investigated the relationship between MMSE and executive functioning. To our knowledge, there is no study that has investigated the association between the MMSE and multidimensional construct of EF. Our study aimed to be the first to study the association of the MMSE with multiple domains of executive functioning using scores from two of the most commonly used batteries of executive function tests: Delis Kaplan Executive Function System (D-KEFS) (18) and Behavioural Assessment of the Dysexecutive Syndrome (BADS) (19).

Materials and Methods

Participants

Upon approval from the institutional ethics committee, a cross-sectional study of 73 healthy young men was conducted. Inclusion criteria for the study included Baluch, bilingual men matched demographically with traumatic brain injury patients in southeast Iran, with exclusion of individuals with previous medical/psychiatric conditions (20). The sample was selected through purposive-homogenous sampling from five cities in the area.

The participants were in the age range of 16 to 40 years (M=24.34, SD=6.53), with 3 to 12 years of education (M=9.33, SD=2.47). The study was conducted in compliance with the Helsinki declaration.

Instruments

Mini-Mental State Examination (MMSE) (10): MMSE is a brief cognitive screening test that was originally developed for dementia patients. A validated Persian version of the test was administered in the current study (21). The Persian MMSE consists of 19 questions, with a total score of 0 to 30, and takes 5-10 minutes to administer. The MMSE assesses six cognitive domains: orientation to time and place, registration, attention and calculation, recall, language, and visual construction.

Delis Kaplan Executive Function System (D-KEFS) (18): D-KEFS is a "greatest hits" collection of commonly used executive tests (6), composed of nine stand-alone tests for assessing children and adults aged 8 to 89 years, in both verbal and nonverbal modalities. The tests are Trail Making Test (TMT); Verbal Fluency Test (VFT); Design Fluency Test (DFT); Color-Word Interference Test (CWIT); Sorting Test (ST); Twenty Questions Test (TQT); Word Context Test (WCT); Tower Test (TT); and Proverb Test (PT). An adapted Persian version of the tests (20) was utilized in the current study. The following primary executive scores from the D-KEFS tests were included: TMT (Number-Letter Switching time), VFT (Letter Fluency, Category Fluency, and Category Switching total correct responses; Category Switching total switching accuracy), DFT (Filled Dots, Empty Dots Only, and Switching total correct designs), Color-Word Interference Test (Inhibition and Inhibition/Switching time), ST (Free Sorting confirmed correct sorts, Free Sorting description score, and Sort Recognition description score), TQT (Initial Abstraction, Total Questions Asked, and Total Weighted Achievement scores), WCT (total consecutively correct score), TT (total achievement score), and PT (Free Inquiry and Multiple Choice total achievement scores).

Behavioural Assessment of the Dysexecutive Syndrome (BADS) (19): The BADS is a test battery designed to predict everyday dysfunctions that arise from the dysexecutive syndrome. The battery possesses very high ecological validity (22); In order to address the problem of low ecological validity of traditional executive tests, it assesses executive skills and demands similar to everyday activities, while maintaining a structured format. It is composed of six tests: Rule Shift Cards, Action Program, Key Search, Temporal Judgment, Zoo Map, and Modified Six Elements. Validity and reliability of the BADS have been supported in different studies (23). Our study utilized a translated version of the BADS tests (20), including profile scores of the following tests: Rule Shift Cards (RS), Key Search (KS), Zoo Map (ZM) and Modified Six Elements Task (6E). We added up the profile scores of the four tests to obtain a BADS total profile score (BADS4t).

Data collection and Analysis

The MMSE, D-KEFS, and BADS tests were respectively administered to all the 73 participants. The participants were individually tested in a quiet, distraction-free room over a session lasting between 2-3 hours with a 20-minute break after the first five tests.

Two of the less psychometrically established D-KEFS tests were made optional (WCT and PT) and were placed at the end of the protocol, in order to alleviate the impact of cognitive fatigue and interest/effort reduction. Therefore, after administering the MMSE, the following tests were administered in the standardized order with an exception. First, the D-KEFS TMT, VFT, DFT, CWIT, ST, TQT, and TT were consecutively administered, followed by the BADS RS, KS, ZM, and 6E tests, and concluded with the optional tests: D-KEFS WCT and PT. Of the 73 participants, 28 individuals did not respond to the two optional tests. There were no significant differences between the two groups of participants on the other D-KEFS and BADS tests.

Descriptive and correlational analyses were performed on the data using SPSS software (IBM, version 24). Pearson correlation coefficients were calculated to assess relations between the MMSE measures and the selected executive measures from D-KEFS and BADS. For those measures where the data were not normally distributed (the D-KEFS PT Multiple Choice total achievement score, the profile scores of the BADS subtasks, and the MMSE domain scores), nonparametric (Spearman's rho) correlations were calculated. The correlations were interpreted according to the following general labels (24): weak ($r < .30$), moderate ($.30 \leq r < .50$), and strong ($r \geq .50$).

In a subsequent secondary/exploratory analysis, we calculated the Spearman's rho correlations of the MMSE domains with the EF measures. Of the six MMSE domains, the correlation coefficients were computed for five domains. The coefficient was not computed for the Registration domain, because of restricted range of the current sample's performance scores on this domain.

Results

The data were normally distributed for most of the primary scores. No statistically significant association for key demographic variables, such as age and education were observed. Descriptive statistics (mean and standard deviations) are presented in table 1. Table 2 shows the correlations between the MMSE measures and the selected executive measures from the D-KEFS and BADS tests.

Table 1. Descriptive statistics for MMSE, D-KEFS, and BADS

Measures		Mean	SD
D-KEFS	D-KEFS		
	Trail Making 4: Number-Letter Switching time (s)	116.49	54.31
	Verbal Fluency 1: Letter Fluency, Total Correct	26.53	9.61
	Verbal Fluency 2: Category Fluency, Total Correct	45.15	9.57
	Verbal Fluency 3: Category Switching, Total Correct Responses	15.11	3.16
	Verbal Fluency 3: Category Switching, Total Switching Accuracy	14.33	3.31
	Design Fluency 1: Filled Dots, Total Correct	9.27	3.02
	Design Fluency 2: Empty Dots Only, Total Correct	10.19	3.58
	Design Fluency 3: Switching, Total Correct	7.85	2.30
	Color-Word Interference 3: Inhibition, Mean Reaction Time (ms)	1019.09	364.66
	Color-Word Interference 4: Inhibition/Switching, Mean Reaction Time (ms)	1784.10	519.28
	Sorting 1: Free Sorting, Confirmed Correct Sorts	8.29	2.42
	Sorting 1: Free Sorting, Description Score	30.36	9.45
	Sorting 2: Sort Recognition, Description Score	30.30	8.82
	Twenty Questions: Initial Abstraction Score	29.01	11.11
	Twenty Questions: Total Questions Asked	29.86	10.57
	Twenty Questions: Total Weighted Achievement Score	14.32	3.72
	Word Context: Total Consecutively Correct	22.24	7.14
	Tower: Total Achievement Score	16.11	3.90
	Proverbs 1: Free Inquiry, Total Achievement Score	23.27	5.54
	Proverbs 2: Multiple Choice, Total Achievement Score	28.84	4.72
BADS	BADS		
	Rule Shift Cards, Profile Score	3.26	0.80
	Key Search, Profile Score	2.62	1.24
	Zoo Map, Profile Score	2.78	1.11
	Modified Six Elements, Profile Score	3.41	0.77
	BADS4t (BADS Total Profile Score–4subtest)	12.07	2.89
MMSE	MMSE		
	Orientation	9.37	0.69
	Registration	3.00	0.00
	Attention and Calculation	4.19	1.11
	Recall	2.49	0.63
	Language	7.82	0.38
	Copying	0.97	0.16
	MMSE Total	27.88	1.57

Abbreviations: D-KFES= Delis-Kaplan Executive Function System; BADS= Behavioural Assessment of the Dysexecutive Syndrome; MMSE = Mini Mental State Examination; RT= Reaction Time; s= seconds; ms= milliseconds

Table 2. Correlations between MMSE, D-KEFS, and BADS selected measures

	Measures	MMSE						
		Orientation[a]	Registration	Attention and Calculation[a]	Recall[a]	Language[a]	Copying[a]	Total
D-KEFS	D-KEFS							
	TMT 4; completion time	-.29*	.[b]	-.16	-.16	-.21	-.25*	-.48**
	VFT1, letter fluency, Total correct	.02	.[b]	.30**	.28*	.13	-.00	.37**
	VFT2, category fluency, Total correct	-.06	.[b]	-.04	.34**	.10	-.15	.14
	VFT3, category switching, Total correct responses	.02	.[b]	.05	.14	.19	-.03	.14
	VFT3, category switching, Total switching accuracy	.03	.[b]	.04	.15	.22	-.01	.18
	DFT1, filled dots, total correct	.29*	.[b]	.22	.14	.14	.23	.41**
	DFT2, empty dots only, total correct	.16	.[b]	.26*	.12	.02	.19	.36**
	DFT3, switching, total correct	.06	.[b]	.28*	.28*	.15	-.14	.31**
	CWIT3, inhibition, mean Reaction Time	-.21	.[b]	-.07	-.04	-.10	-.07	-.32**
	CWIT4. inhibition/switching, mean Reaction Time	-.08	.[b]	-.13	-.20	-.02	-.15	-.32**
	ST1, free sorting, total confirmed correct sort	.30*	.[b]	.26*	.03	.17	.03	.41**
	ST1, free sorting, total description score	.31**	.[b]	.32**	.00	.16	.11	.46**
	ST2, sort recognition, total description score	.48**	.[b]	.32**	.03	.30*	.08	.59**
	TQT, total initial abstraction score	.20	.[b]	.21	.11	.25*	.19	.38**
	TQT, total question asked	-.09	.[b]	-.28*	-.01	-.12	-.09	-.41**
	TQT, total weighted achievement score	.10	.[b]	.21	-.05	.21	.04	.36**
	WCT, total consecutively correct score	.36*	.[b]	.22	.21	.23	.20	.49**
	Tower Test, total achievement score	.29*	.[b]	.39**	.15	.24*	.096	.59**
	PT1, free inquiry, total achievement score	.08	.[b]	-.08	.13	-.15	-.11	-.00
	PT2, multiple choice, total achievement score[a]	.31*	.[b]	.29	-.15	-.14	.23	.30*
BADS	BADS							
	BADS rule shift cards, total profile score[a]	.35**	.[b]	.30*	.18	.14	.19	.46**
	BADS key search, total profile score[a]	.11	.[b]	.32**	.10	.36**	.03	.44**
	BADS zoo map, total profile score[a]	.09	.[b]	.38**	.25*	.12	-.02	.44**
	BADS modified six elements, total profile score[a]	.17	.[b]	.38**	.21	.12	-.00	.47**
	BADStotal-4subtest	.22	.[b]	.45**	.22	.29*	.05	.62**

** *P*< .01. * *P*< .05.

[a] the data were not normally distributed for these variables, and hence nonparametric (Spearman's rho) correlations were calculated

[b] the coefficient has not been computed because of restricted range of the scores for the current sample

The findings of this study showed that the relationship between the total MMSE score and associated executive measures were statistically significant and in the moderate-to-strong range. The highest correlation was between the MMSE total score and the BADS total profile score (BADS4t; *r*= .62, *P*< 0.01). Also, the MMSE total score had strong correlations with the TT achievement score (*r*= .59, *P*< .01) and the ST sort recognition (*r*= .59, *P*< .01).

Among the five MMSE domains, the greatest association with executive function measures were those of Attention and Calculation. This domain had positive, moderate associations with BADS4t (*rho*= .45, *P*< .01), and with all the BADS subtests (.30 <*rho*< .38, *P*< .01), indicating that high performance on the Attention and Calculation domain was related to high performances on the BADS measures. In addition, this domain significantly correlated with D-KEFS VFT letter fluency (*rho*= .30, *P*< .01), DFT executive conditions (conditions 2 and 3, respectively, *rho*= .26 and .28, *P*< .05), TQT total question asked (*rho*= -.28, *P*< .05), TT achievement score (*rho*= .39, *P*< .01), and all the executive measures of ST (.26 <*rho*< .33).

The Copying domain of MMSE had a weak, non-significant correlation with all but one of the EF measures. It was only significantly correlated with the TMT primary executive measure (*rho*= -.37, *P*< .01). The Orientation domain of MMSE had a weak, non-significant correlation with most of the EF measures. It had a moderate correlation with the BADS rules shift cards (*rho*= .35, *P*< .01) test, PT multiple choice (*rho*= -.31, *P*< .05) and ST (.30 <*rho*< .48, *P*< .01) primary executive measures. Likewise, the Language domain had weak, non-significant associations with most of the EF measures. It had moderate correlations only with ST sort recognition (*rho*= .30, *P*< .01) and BADS key search (*rho*= .36, *P*< .01). Finally, the Recall domain only moderately correlated with VFT category fluency (*rho*=34, *P*< .01); this domain had a weak relationship with the other EF measures (*rho*< .30).

Discussion

Recently, the sensitivity of widely-used tools of cognitive screening in detecting executive deficits have been questioned. The current study aimed to investigate the relation between the MMSE, a commonly used cognitive screening tool, and multiple measures of executive functioning. For a comprehensive assessment of the multidimensional construct of executive functioning, two well-known batteries of executive tests were applied: D-KEFS, a comprehensive set of traditional EF tests, and BADS, an ecologically valid battery of tests important for clinical neuropsychological assessment.

The results of the present study showed that most of the relations between MMSE total score and the executive measures from D-KEFS and BADS were significant and in the moderate-to-strong range. These findings are consistent with the results of studies that have found a relationship between MMSE total score and measures of executive functioning (e.g., Axelrod *et al.*, (15); Jefferson *et al*., (16); McGuinness *et al*., (25); Votruba *et al.*, (17)).

Complex executive tasks often involve multiple executive and non-executive processes, thus it is plausible to visualize the managerial role of executive functions within the global network of cognition. In this view, it is also important to consider the substantial theoretical, functional, and neuroanatomical overlaps between executive functions and general cognitive ability factors (26-29). As a measure of general cognitive ability, the MMSE taps on various basic- and higher-level cognitive processes interconnected with multi-dimensional and multi-level executive processing. Thus, empirical separation of EF measures and general-cognitive indices is difficult. Therefore, the observed relations of the executive measures of planning, organizing, reasoning, problem-solving, abstract thinking, and cognitive flexibility with the MMSE total score in the current study is not surprising. This is not consistent with the claim that MMSE lacks sensitivity to executive ability (12-14).

Specifically, among the MMSE domains, the Attention and Calculation domain had the highest association with the EF measures. Successful performance on this MMSE domain needs adequate capacity of attentional control, one of the core EF skills (30), when responding to the effortful, non-habitual task of counting backward. Researchers have argued that all executive functions share an executive attention component (31,32), strongly correlated with many tasks of higher-level cognition (33). Furthermore, some studies demonstrated a correlation between EFs and math skills such as calculation. For example, Lan *et al*., (34), found significant relations between working memory and inhibition with calculation and counting skills. Therefore, the Attention and Calculation domain of MMSE has executive components and is expected to be empirically related to measures of executive functioning. Among other MMSE domains, the Recall domain had a significant, moderate association with an executive measure having memory/recall demands: the Category Fluency condition of D-KEFS VFT. Theoretically, executive function is viewed to be a separate cognitive domain from memory, language, and visual construction; thus finding that most of the associations between EF measures and these MMSE domains were weak and non-significant in the current study were not unexpected .

As previously stated, the BADS tests were originally designed to predict everyday dysfunctions and possess very high ecological validity. Among the EF measures, the BADS scores had the highest correlations with MMSE. This indicates the clinical value of MMSE as a screening tool, given the importance of management for everyday dysfunctions in neuropsychological practice. In line with the current result, McGuinness *et al*., (25) found a strong relationship between MMSE total score and Executive Interview (Exit25) (35) as a tool for predicting impairments in self-care and functional status. Previous studies have qualified this finding, showing strong correlations between cognitive screening tools, such as the MMSE, with IADLs (36,37,38). Furthermore, these studies demonstrated that among various cognitive functions, EFs have the closest relationship to IADLs

The current study has some limitations. First, given that the normal sample in the study of Ghawami *et al*., (20) was selected based on the MMSE total score of 25 or above, as an inclusion criterion, the range of MMSE score for the current study was limited. Therefore, cautions must be taken when interpreting the results of the current study, particularly for the MMSE domains. Second, no clinical comparative groups were included in the current analyses. The inclusion of clinical samples in the future research may provide beneficial information for better discovering the nature of the relationships and also can resolve the problem of restricted range. Third, being the normative sample for an Iranian brain injured papulation, the current participants were demographically restricted, and hence generalization of

the current results to other demographic populations needs to be investigated in future studies .

Despite the limitations, our research was the first to study the relation between MMSE and multiple executive measures from two of the commonly used test batteries of executive functioning. Our results showed a statistically significant correlation between the MMSE total score and EF domains in the moderate-to-strong range. This indicates the capacity of MMSE to detect potential EFs impairments and could have important meanings for neuropsychological practice.

Conflict of Interest

We declare that there was no conflict of interest when conducting and reporting this study.

Funding

This work was supported by the Sina Trauma and Surgery Research Center, Tehran University of Medical Sciences. (Grant No: 37359)

References

1. Miyake A, Friedman NP, Emerson MJ, Witzki AH, Howerter A, Wager TD. The Unity and Diversity of Executive Functions and Their Contributions to Complex ‘‘Frontal Lobe’’ Tasks: A Latent Variable Analysis. Cogn Psychol 2000; 41: 49-100 .
2. Serpell ZN, Esposito AG. Development of Executive Functions: Implications for Educational Policy and Practice. Policy Insights Behav Brain Sci 2016; 3:203-210 .
3. Collins A, Koechlin E. Reasoning, Learning, and Creativity: Frontal Lobe Function and Human Decision-Making. PLoS Biol 2012,10:e1001293 .
4. Fuster JM. The Prefrontal Cortex. 5th ed. London, UK: Elsevier; 2015.
5. Grafman J, Litvan I. Importance of deficits in executive functions. Lancet 1999;354: 1921-23.
6. Lezak MD, Howieson DB, Bigler ED, Tranel D. Neuropsychological Assessment. 8th ed. New York: Oxford University Press; 2012.
7. Juby A, Tench S, Baker V. The value of clock drawing in identifying executive cognitive dysfunction in people with a normal Mini-Mental State Examination score. Can Med Assoc J 2002; 167: 859-64.
8. Vaughan L, Giovanello K. Executive Function in Daily Life: Age-Related Influences of Executive Processes on Instrumental Activities of Daily Living. Psychol Aging 2010;25:343-55 .
9. Chan RCK. Dysexecutive symptoms among a non-clinical sample: A study with the use of the Dysexecutive Questionnaire. Br J Psychol 2001;92:551-65.
10. Folstein MF, Folstein, SE, McHugh PR. “Mini-mental state”: A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189-98.
11. Tombaugh TN, McIntyre NJ. The mini-mental state examination: a comprehensive review. J Am Geriatr Soc 1992;40: 922-35.
12. Lam B, Middleton LE, Masellis M, Stuss DT, Harry RD, Kiss A, Black SE. Criterion and convergent validity of the Montreal cognitive assessment with screening and standardized neuropsychological testing. J Am Geriatr Soc 2013;61:2181-5.
13. Nys GM, van Zandvoort MJ, de Kort PL, Jansen BP, Kappelle LJ, de Haan EH. Restrictions of the Mini-Mental State Examination in acute stroke. Arch Clin Neuropsychol 2005;20:623-9.
14. Oliver J. Evaluating the Efficacy of the Mini-Mental State Examination (MMSE). 2007. Retrieved from University of Cape Town, Department of Psychology. (Accessed at http://www.psychology.uct.ac.za/psy/graduateprogrammes/honours/projects.)
15. Axelrod BN, Goldman RS, Henry RR. Sensitivity of the Mini-Mental State Examination to frontal lobe dysfunction in normal aging. J Clin Psychol 1992;48:68-71.
16. Jefferson AL, Cosentino SA, Ball SK, Bogdanoff B, Leopold N, Kaplan E, Libon DJ. Errors produced on the mini-mental state examination and neuropsychological test performance in Alzheimer's disease, ischemic vascular dementia, and Parkinson's disease. J Neuropsychiatry Clin Neurosci 2002; 14: 311-20.
17. Votruba KL, Persad C, Giordani B. Cognitive Deficits in Healthy Elderly Population with "Normal" Scores on the Mini-Mental State Examination. J Geriatr Psychiatry Neurol 2016;29: 126-32.
18. Delis DC, Kaplan E, Kramer JH. Delis-Kaplan Executive Function System (DKEFS). San Antonio, TX: The Psychological Corporation; 2001.
19. Wilson BA, Alderman N, Burgess PW, Emslie H, Evans JJ. Behavioural Assessment of the Dysexecutive Syndrome (BADS). London: Thames Valley Test Company; 1996.
20. Ghawami H, Raghibi M, Tamini BK, Dolatshahi B, Rahimi-Movaghar V. Cross-Cultural Adaptation of Executive Function Tests for Assessments of Traumatic Brain Injury Patients in Southeast Iran. Psicol Conductual 2016;24:531-54.

21. Seyedian M, Falah M, Noroozyan M, Nejat S, Delavar A, Ghasemzadeh H. Tahie va taiine etebere noskheye farsiye azmoone kutahe vazeiate zehni [Development and validation of Persian version of Mini-Mental State Examination]. J Med Counc Islam Repub Iran 2007;25:408-414.
22. Crawford JR, Henry JD. Assessment of executive dysfunction. In Halligan PW, Wade DT, eds. The effectiveness of rehabilitation for cognitive deficits. 1st ed. London: Oxford University Press; 2005; 233-45.
23. Kreutzer J, DeLuca J, Caplan B. (2011). Encyclopaedia of Clinical Neuropsychology. New York: Springer; 2011.
24. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale, NJ: Erlbaum; 1988.
25. McGuinness B, Barrett SL, Craig D, Lawson J, Passmore AP. Executive functioning in Alzheimer's disease and vascular dementia. Int J Geriatr Psychiatry 2010;25:562-8.
26. Barbey AK, Colom R, Grafman J. Dorsolateral prefrontal contributions to human intelligence. Neuropsychologia 2013;51:1361-9.
27. Barbey AK, Colom R, Solomon J, Krueger F, Forbes C, Grafman J. An integrative architecture for general intelligence and executive function revealed by lesion mapping. Brain 2012;135:1154-64.
28. Duncan J, Seitz RJ, Kolodny J, Bor D, Herzog H, Ahmed A, Newell FN, Emslie H. A neural basis for general intelligence. Science 2000;289:457-60.
29. Keifer E, Tranel D. A neuropsychological investigation of the Delis-Kaplan Executive Function System. J Clin Exp Neuropsychol 2013;35:1048-59.
30. Diamond A. Executive Functions. Annu Rev Psychol 2013;64:135-68.
31. Blair C. Toward a revised theory of general intelligence: Further examination of fluid cognitive abilities as unique aspects of human cognition. Behav Brain Sci 2006;29: 145-60.
32. Shallice T, Burgess P. Supervisory control of action and thought selection. In: Baddeley AD, Weiskrantz L, eds. Attention: Selection, awareness, and control. 1st ed. Oxford: Oxford University Press; 1993: 171-187.
33. McCabe DP, Roediger HL, McDaniel MA, Balota DA, Hambrick DZ. The relationship between working memory capacity and executive functioning: evidence for a common executive attention construct. Neuropsychology 2010; 24:222-43.
34. Lan X, Legare CH, Ponitz CC, Li S, Morrison FJ. Investigating the links between the subcomponents of executive function and academic achievement: a cross-cultural analysis of Chinese and American preschoolers. J Exp Child Psychol 2011;108: 677-92.
35. Royall DR, Mahurin RK, Gray K. Bedside assessment of executive dyscontrol: the executive interview (EXIT25). J Am Geriatr Soc 1992; 40:1221-6.
36. Razani J, Casas R, Wong JT, Lu P, Alessi C, Josephson K. Relationship between executive functioning and activities of daily living in patients with relatively mild dementia. Appl Neuropsychol 2007;14:208-14.
37. Marshall GA, Rentz D. M, Frey MT, Locascio JJ, Johnson KA, Sperling RA. Executive function and instrumental activities of daily living in mild cognitive impairment and Alzheimer's disease. Alzheimers Dement 2010;7:300-8.
38. Royall DR, Lauterbach EC, Kaufer D, Malloy P, Coburn KL, Black KJ. The cognitive correlates of functional status: a review from the Committee on Research of the American Neuropsychiatric Association. J Neuropsychiatry Clin Neurosci 2007;19:249-65.