INFLUENCE OF SCHOOLING AND AGE ON COGNITIVE TESTS

Influência da escolaridade e da idade em testes cognitivos

Juliana Lima Quintas[a], Einstein Francisco Camargos[a], Cláudia Velloso Silva Melo[b], Otávio Toledo Nóbrega[a]

ABSTRACT

OBJECTIVES: To identify factors that interfere with performance in cognitive tests frequently used for non-demented elderly in clinical practice. **METHOD:** Sample composed of 213 individuals, mean age 72.9 ± 6.1 years. The following assessment instruments were applied: Geriatric Depression Scale; Mini-Mental State Examination (MMSE); Verbal Paired Associates tests I and II (VPA) from the Wechsler Memory Scale (WMS); Direct and Reverse Order Wechsler Adult Intelligence Scale-III (WAIS-III); Simple Reaction Time (SRT), and Tower of Hanoi. A multiple linear regression model was used to verify interaction between dependent and independent variables. **RESULTS:** For the most part, the tests were not significantly influenced when adjusted for gender, marital status, depressive symptoms or use of psychotropic drugs. Significant interference of schooling and age on performance in applied cognitive tests was pointed out. There was a high correlation between MMSE scores and schooling, with a 1-point increase in the value obtained in the test for every four years of schooling (p < 0.0001). Results of short- and long-term memory tests were also significantly influenced by schooling (p = 0.0001, p = 0.02, respectively). Low schooling had a negative influence on attention performance according to SRT, significantly increasing reaction time (p = 0.002), error percentage (p = 0.01) and proportion of false alarms (p = 0.01). **CONCLUSION:** Our study found out a significant influence of age and schooling on performance of non-demented elderly in cognitive tests assessing overall performance, short- and long-term memory, attention, cognitive flexibility, and processing speed.

KEYWORDS: cognition; memory; aged; educational status; neuropsychological tests.

RESUMO

OBJETIVOS: Identificar fatores que interferem no desempenho de testes cognitivos frequentemente utilizados na prática clínica em idosos não dementes. **MÉTODO:** Amostra composta por 213 indivíduos, com média de idade de 72,9 ± 6,1 anos. Foram aplicados os seguintes instrumentos de avaliação: Escala de Depressão Geriátrica; Miniexame do Estado Mental (MEEM); Teste de Pares Associados I e II da Escala Wechsler de Memória; Teste de Dígitos ordem direta e inversa da Escala de Inteligência Wechsler para Adultos (WAIS-III); Teste de Tempo de Reação Simples (TEVA); e Torre de Hanói. Utilizou-se um modelo de regressão linear múltiplo para verificar interação entre variáveis dependentes e independentes. **RESULTADOS:** Em sua maioria, os testes não sofreram influência significativa quando controlados para sexo, estado civil, sintomas depressivos ou uso de drogas psicotrópicas. Observou-se significativa interferência da escolaridade e da idade sobre o desempenho nos testes cognitivos aplicados. Observou-se alta correlação entre escores no MEEM e escolaridade, com aumento de 1 ponto no valor obtido no teste para cada 4 anos de escolaridade (p < 0,0001). Resultados dos testes de memória de curto e longo prazos também sofreram significativa influência da escolaridade (respectivamente, p = 0,0001; p = 0,02). Baixa escolaridade influenciou negativamente o desempenho em atenção segundo o teste TEVA, aumentando significativamente o Tempo de Reação – TR (p = 0,002), a percentagem de erro (p = 0,01) e proporção de falsos alarmes (p = 0,01). **CONCLUSÃO:** Nosso estudo observou significativa influência da idade e da escolaridade na performance de idosos não dementes em testes cognitivos que avaliam desempenho global, memória de curto e longo prazos, atenção, flexibilidade cognitiva e velocidade de processamento.

PALAVRAS-CHAVE: cognição; memória; idosos; escolaridade; testes neuropsicológicos.

[a]Universidade de Brasília (UnB) – Brasília (DF), Brazil.
[b]Vitallis Geriatrics and Gerontology Clinic – Brasília (DF), Brazil.

Correspondence data
Juliana Lima Quintas – Programa de Pós-Graduação em Ciências Médicas, Campus Universitário Darcy Ribeiro, Universidade de Brasília – Asa Norte – CEP: 70910-900 – Brasília (DF), Brasil – E-mail: juquintas@uol.com.br
Received on: 09/20/2017. Accepted on: 09/25/2017
DOI: 10.5327/Z2447-211520171700068

INTRODUCTION

Several cognitive tests have limitations in clinical practice, especially when it comes to different age groups and levels of schooling. The Mini-Mental State Examination (MMSE)[1] has been evaluated the most as to these aspects. In a study conducted with 530 individuals divided into groups, each with 15-year intervals, Bertolucci *et al.* pointed out that age did not interfere in scores reached. However, the most important factor when determining MMSE performance was educational level. They identified the following cut-off points for diagnosis of cognitive decline, according to schooling: 13 for illiterate individuals, 18 for individuals with 1 to 8 years of study, and 26 for individuals with more than 8 years of study.[2] Such influence has also been confirmed by other studies.[3]

The literature still lacks studies evaluating age and schooling interference in other commonly used tests. A recent study by Zimmermann *et al.* identified an influence of elementary schooling in the following tests: Modified Wisconsin Card Sorting Test (MWCST), Stroop effect test with colors and words, and Five Digit Test.[4] Age, however, was found to influence only in color naming speed and color-word on Stroop test.

Baradel *et al*. evaluated the effects of schooling and age on the Kissing and Dancing Test with 74 cognitively intact individuals and found a performance significantly influenced by age and schooling.[5]

Barea *et al*. (2007), in tests of verbal fluency, naming and classification of figures, also identified significant influence of schooling on semantic knowledge for inanimate categories with 48 normal elderly people.[6]

Our aim, with a sample composed of healthy elderly individuals, was to identify factors that interfere with performance in cognitive tests often used in clinical practice, including MMSE.

METHODS

This is a cross-sectional analytical study with a convenience sample of elderly patients (60 years or older) recruited from two medical centers located in different regions of the Federal District: the Multidisciplinary Center for the Elderly (CMI), *Universidade de Brasília* (UnB), and the Hospital of *Universidade Católica de Brasília* (HUCB). The CMI is a geriatric care center inside the organizational structure of University Hospital of Brasília (HUB/UnB), located in the central region of the federal capital. HUCB is a university hospital built around clinical specialties such as geriatrics, which is located in the administrative region of Taguatinga, Federal District. Data were collected between July and December 2011. Exclusion criteria were:

1. Signs or symptoms of psychiatric disorders (schizophrenia, schizoaffective disorder, delusional or mood disorders, delirium, or intense agitation), dementia (Alzheimer's, Parkinson's, vascular, frontotemporal, Lewy bodies, or other forms of dementia) or brain diseases/events (ischemic stroke, subdural hematoma, hemorrhage, trauma or others), as recommended by the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV);[7]
2. Significant sensory deficits (visual and/or auditory);
3. Untreated sleep disorder;
4. Other active conditions that could interfere with patients' overall health (cancer, epilepsy, immobility, stroke, etc.).

The patients were invited to take part in a structured interview for sociodemographic and clinical characterization: gender (male/female), age (years), schooling (full years), marital status (married, widowed, divorced), and use of medications. Users of medications that could interfere with cognition were also controlled in the study; individuals who used central nervous system (CNS) depressants at a prescribed and stable dose for at least four weeks prior to the initial interview antipsychotics, tricyclic antidepressants, benzodiazepines, anticonvulsants and/or sleep inducers—were considered "users". This study was approved by the Research Ethics Committee of Medical School of UnB (CEP-FM 016/2009), and all patients signed an informed consent form.

Among 398 consecutive cases, five were excluded due to important auditory and/or visual deficits, and 13 due to active disease compromising the patient's overall health (such as cancer, epilepsy, immobility). In addition, 13 individuals died after the initial interview, and 147 refused to or were unable to continue the study. Data collected from one of the patients were lost.

After the initial interview, the following were applied:

1. Geriatric Depression Scale (EDG);[8]
2. MMSE;
3. Verbal Paired Associates (VPA) tests I (short-term memory) and II (long-term memory) from the Wechsler Memory Scale;[9] Direct and Reverse Order Wechsler Adult Intelligence Scale-III (WAIS-III);[10]
4. Simple Reaction Time Test (SRT) (Visual Attention Variable Testing, RT: reaction time, xpFA: proportion of false alarms, % right answers);
5. Tower of Hanoi.[12]

For the Digit Test, the sum of time of each patient obtained in DDirect and DInverse was also considered an independent variable (DTotal). Upon application of Tower of Hanoi, two training discs and three test discs were used,[13] being assessed the recording of total task execution time in seconds (HanoiT), number of errors (HanoiE), and correct movements (HanoiM). All neuropsychological tests were applied by the same examiner.

The values obtained in cognitive tests were treated as quantitative variables. The values of measures in cognitive tests were considered dependent variables; independent variables were sociodemographic measures (gender, age, schooling level, and marital status), depressive symptoms, and use of depressant drugs. For variables whose error distribution generated by covariance analysis model (ANCOVA) did not present Gaussian distribution with constant variance, a logarithmic Naperian transformation was used. Tukey's adjustment was employed to fit three multiple comparisons.

A multiple linear regression model was used to verify the effect of sociodemographic variables, depressive symptoms, and use of depressant drugs on the cognitive tests. All data were analyzed in the program SAS 9.2 for Windows, with significance level set at 5% for the analysis.

RESULTS

The final sample held 213 individuals, with mean age of 72.9 ± 6.1 years, mostly married (n = 86, 40.4%) or widowed (n = 82, 38.5%), with average study time of 5.7 ± 4.6 years, with women in larger number (n = 187, 81.2%) (Table 1).

For the most part, the tests did not suffer statistically significant influence when adjusted for gender, marital status, depressive symptoms or use of CNS depressant drugs (benzodiazepines included). However, there was significant interference of schooling and age on individuals' performance in applied cognitive tests (Table 2). There was a strong correlation between MMSE scores and schooling levels, with a 1-point increase in values obtained for every four years of schooling ($p < 0.0001$).

The performance of subjects in the short- and long-term memory (STM and LTM) tests also had a significant influence of schooling (respectively, $p = 0.0001$, $p = 0.02$): the higher the schooling level, the higher the values obtained in STM and LTM tests. In addition, for each 4-year increase in education, the score in LTM test grows by an average of 1 point. Similar association was observed in digit tests (DDirect and DInverse), which relate to attention and cognitive flexibility ($p < 0.0001$). Lower levels of schooling negatively influenced SRT, increasing the Reaction Time significantly ($p = 0.002$), as well as error percentage ($p = 0.01$), and incorrect responses (Xpfa; $p = 0.01$). These scores are all related to processing speed and to attentional and decision-making capabilities.

The power of test was afterwards calculated from the total sample size (n = 213). Coefficient of determination and size of effect were also calculated, the latter by multiple

Table 1 Sociodemographic and clinical characteristics of groups in the sample, Brasília, Federal District (n = 213).

Characteristics	Total n (%)	p-value†
Gender		
Female	187 (81.2)	0.1939
Marital Status		
Married	86 (40.4)	0.8577
Widowed	82 (38.5)	
Divorced	23 (10.8)	
Single	22 (10.3)	
GDS		
Absent	156 (73.2)	0.8956
Mild	43 (20.2)	
Moderate/severe	14 (6.6)	
Use of benzodiazepines		
No	194 (91.0)	0.4822
Yes	19 (9.0)	
Use of antipsychotics		
No	212 (99.6)	0.8431
Yes	01 (0.4)	
Use of antidepressants		
No	181 (85.0)	0.2257
Yes	32 (15.0)	
Use of TAD		
No	204 (95.7)	0.7791
Yes	09 (4.3)	
Use of anticonvulsants		
No	209 (98.1)	0.7073
Yes	07 (1.9)	
Use of other medications		
No	25 (11.7)	0.3693
Yes	188 (88.3)	

GDS: Geriatric Depression Scale; TAD: tricyclic antidepressants; †p-value calculated by χ^2 test.

regression model with 12 predictors. (Table 3). The power of our study was higher than 85%, with effect size ranging from 0.10 to 0.64.

DISCUSSION

Our findings corroborate others in the literature when it come to the significant influence of schooling and age on cognitive tests conducted with elderly people: such influence was observed in evaluations of overall performance, STM and LTM, attention, cognitive flexibility, and processing speed. Of all tests studied, only scores in Tower of Hanoi test were not influenced by these factors.

The direct association between schooling and performance in cognitive tests related to memory and attention was observed by several other authors.[14] A Brazilian study by Ribeiro et al. pointed out better performance in a word memory test and late recall in a group of elderly people with higher schooling levels.[15] Souza et al. also found a direct association between years of study and performance in tests related to decision-making and processing speed; the lower the schooling level, the slower the processing speed and the greater the difficulty in performing two or more actions in parallel.[16]

In normal aging, impaired performance is seen in attention, working memory, and processing speed,[17] functions evaluated by SRT.[11] The association found between performance in LTM test and age can be justified by the loss in capacity to learn new information, which is typical of normal aging.[18]

With regard to Tower of Hanoi test, the literature lacks evaluations of the impact of schooling. A population-based study with 1,480 subjects followed up changes in the performance of patients in Tower of Hanoi for five years (adults between 35 and 85 years) and identified a reduction in the number of correct movements and an increase in the number of errors with aging.[19] Our findings contradict these results.

Regarding the applicability of tests selected for this study, they are extensively used to assess specific cognitive functions and therefore differ from more wide-range test batches used, which aim to assess overall cognitive performance and

Table 2 Influence of schooling and age on cognitive tests, Brasilia, Federal District (n = 213).

Tests	Age		Schooling	
	Estimate	p-value	Estimate	p-value
MMSE	-0.09	0.005	0.27	< 0.0001
STM	-0.03	0.517	0.24	0.0001
LTM	-0.05	0.018	0.06	0.0240
Direct digits	-0.03	0.110	0.14	< 0.0001
Inverse digits	-0.06	0.005	0.15	< 0.0001
Total digits	-0.09	0.007	0.29	< 0.0001
HanoiT*	0.02	0.073	-0.01	0.4430
HanoiM*	0.00	0.384	0.01	0.2510
HanoiE*	0.01	0.123	-0.01	0.2890
RT	3.25	0.002	-3.88	0.0020
% SRT correct*	-0.61	< 0.000	0.45	0.0140
Xpfa*	0.02	0.138	-0.05	0.0150

MMSE: Mini-mental State Examination; STM: short-term memory; LTM: long-term memory; HanoiT – Tower of Hanoi: total task execution time in seconds; HanoiM – Tower of Hanoi: correct movements; HanoiE – Tower of Hanoi: number of errors; * logarithmic transformation was applied; SRT: Simple Reaction Time test; Xpfa: proportion of false alarms; RT: reaction time.

Table 3 Power of test calculation.

Dependent variable	Determination coefficient (R^2)*	Effect size¶	Power of test§
MMSE	0.39	0.64	1.0000
STM	0.19	0.23	0.9994
LTM	0.16	0.19	0.9960
Ddirect	0.27	0.37	1.0000
Dinverse	0.29	0.41	1.0000
Total	0.34	0.51	1.0000
Log HanoiT	0.10	0.11	0.9100
Log HanoiM	0.09	0.10	0.8660
Log_HanoiE	0.10	0.11	0.9100
RT	0.19	0.23	0.9995
% SRT correct	0.22	0.28	0.9999
Log Xpfa	0.31	0.45	1.0000

¶Effect size calculated by multiple regression model with 12 predictors and sample size n = 21; MMSE: Mini-mental State Examination; STM: short-term memory; LTM: long-term memory; HanoiT – Tower of Hanoi: total task execution time in seconds; HanoiM – Tower of Hanoi: correct movements; HanoiE – Tower of Hanoi: number of errors; * logarithmic transformation was applied; SRT: Simple Reaction Time test; Xpfa: proportion of false alarms; RT: reaction time. *R^2 calculated from a multiple linear regression model with 12 predictors (apolipoprotein E, age, schooling, Geriatric Depression Scale, benzodiazepines, antipsychotics, antidepressants, tricyclic antidepressants, ANCOVA, others, gender and marital status); Effect size calculated by multiple regression model with 12 predictors and sample size n = 213; § power of test calculated for a sample size of 213 individuals and significance level set at 5%. GDS: Geriatric Depression Scale; TAD: tricyclic antidepressants.

compensation mechanisms at the expense of each function's specific work. Despite the control for predictive variables, the selection of instruments also considered the ability of participants to understand and perform tasks regardless of their age and level of education.

Cognitive aging is not easily defined by a clear cut-off point in clinical tests or examinations, since many factors such as culture, occupation, education, environmental context, and health variables (drugs and alcohol, for example) can significantly influence human performance.[20,21]

Some limitations of this study, however, should be mentioned. The inclusion of wide age and education intervals may have caused biases. Although the power of our analyses surpasses 85%, the sample size may be considered small. Finally, the selection of patients from geriatric care centers may have resulted in a profile of subjects quite different from that observed in the community, thus limiting the external validity of the conclusions.

CONCLUSION

Our study points out a significant influence of age and schooling level on performance of non-demented older adults in specific cognitive tests that assess abilities such as overall performance, STM, LTM, attention, cognitive flexibility, and processing speed. These findings reinforce the importance, in both clinical practice and research, of considering variables such as age and schooling when discussing neuropsychological performance.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

REFERENCES

1. 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(3):189-198.
2. Bertolucci PH, Brucki SM, Campacci SR, Juliano Y. [The Mini-Mental State Examination in a general population: impact of educational status]. Arq Neuropsiquiatr. 1994;52(1):1-7.
3. Zimmermann IM, Campos Leal MC, Zimmermann RD, Marques APO, Gomes ÉCC. Factors associated with cognitive impairment in institutionalized elderly individuals: integrative review. J Nursing UFPE. 2015;9(12):1320-8.
4. Zimmermann N, Cardoso CO, Trentini CM, Grassi-Oliveira R, Fonseca RP. Brazilian preliminary norms and investigation of age and education effects on the Modified Wisconsin Card Sorting Test, Stroop Color and Word test and Digit Span test in adults. Dementia Neuropsychol. 2015;9(2):120-7.
5. Baradel RR, Silva HS, Estequi JG, Parente MAMP, Sato JR, Carthery-Goulart MT. Semantic memory for actions as assessed by the Kissing and Dancing Test: Education and age effects in cognitively healthy individuals. Dementia Neuropsychol. 2014;8:216-22.
6. Barea KS, Mansur LL. Knowledge of semantic categories in normal aged: Influence of education. Dementia Neuropsychol. 2007;1:166-72.
7. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 4ª ed. Washington, D.C.: American Psychiatric Association; 1994.
8. Yesavage JA, Brink TL, Rose TL, Lum O, Huang V, Adey M, et al. Development and validation of a geriatric depression screening scale: a preliminary report. J Psychiatr Res. 1982-1983;17(1):37-49.
9. Wechsler D. WMS-III Administration and Scoring Manual. 3ª ed. SanAntonio, Tex.: The Psychological Corporation; 1997.
10. Wechsler D. WAIS-III Wechsler adult intelligence scale. 3ª ed. San Antonio, Tex.: Psychological Corporation; 1997.
11. Córdova C. Programa Computadorizado para Registro e Processamento da Atenção Visual em Investigações com Retardados Mentais Leves. Lecturas Educación Física Deportes. 2005;10(82):1-5.
12. Sullivan JR, Riccio CA, Castillo CL. Concurrent validity of the tower tasks as measures of executive function in adults: a meta-analysis. Appl Neuropsychol. 2009;16(1):62-75.
13. Ahonniska J, Ahonen T, Aro T, Tolvanen A, Lyytinen H. Repeated assessment of the Tower of Hanoi test: reliability and age effects. Assessment. 2000;7(3):297-310.
14. Beeri M, Schmeidler J, Sano M, Wang J, Lally R, Grossman H, et al. Age, gender, and education norms on the CERAD neuropsychological battery in the oldest old. Neurology. 2006;67(6):1006-10.
15. Ribeiro PCC, Oliveira BHD, Cupertino APFB, Neri AL, Yassuda MS. Desempenho de idosos na bateria cognitiva CERAD: relações com variáveis sociodemográficas e saúde percebida. Psicologia: Reflexão Crítica. 2010;23(1).
16. Souza RO, Ignácio FA, Cunha FCR, Oliveira DL, Moll J. Contribuição à neuropsicologia do comportamento executivo: Torre de Londres e teste de Wisconsin em indivíduos normais. Arq Neuropsiquiatr. 2001;59(3A):526-31.
17. Rodríguez-Aranda C, Sundet K. The frontal hypothesis of cognitive aging: factor structure and age effects on four frontal tests among healthy individuals. The J Genetic Psychol. 2006;167(3):269-87.
18. Lindenberger U. Human cognitive aging: corriger la fortune? Science. 2014;346(6209):572-8.
19. Rönnlund M, Lövdén M, Nilsson L-G. Cross-sectional versus longitudinal age gradients of Tower of Hanoi performance: The role of practice effects and cohort differences in education. Aging, Neuropsychology, Cognition. 2007;15(1):40-67.
20. Blazer DG, Yaffe K, Karlawish J. Cognitive aging: a report from the Institute of Medicine. JAMA. 2015;313(21):2121-2.
21. Sakai APFS, Medeiros FVF, Oliveira MM. Etanol e cognição em idosos. Etanol e cognição em idosos. Geriatr Gerontol Aging. 2014;8(4):238-45.