Validation of the Brief International Cognitive Assessment for Multiple Sclerosis (BICAMS) in Greek population with multiple sclerosis.

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Abstract

Background: Cognitive impairment is experienced by about 50% of patients with Multiple Sclerosis (MS) worldwide and affects their employment, disease management and quality of life in general. The Brief International Cognitive assessment for MS (BICAMS) is a brief, practical and potentially universal battery for cognitive impairment in MS patients. It consists of three tests: the Symbol Digit Modalities Test (SDMT), the California Verbal Learning Test-2 (CVLT-2) and the Brief Visuospatial Memory Test-Revised (BVMT-R).
Objective: The objective of this study was to validate the BICAMS in Greek MS patients and controls.
Methods: Forty four MS patients and seventy nine healthy control (HC) participants were recruited and tested. They were group matched for age, education, gender and also premorbid cognitive reserve. All of them completed the three tests of the BICAMS battery. Instead of CVLT-2, the Greek validated form (Greek Verbal Learning Test, GVLT), was used. In addition, cognitive reserve was assessed using the Cognitive Reserve Index questionnaire (CRIq) standardized for the Greek population.
Results: Significant difference was found in the performance of the two groups in all tests ($p<0.0001$, $p<0.02$, $p<0.009$ for SDMT, GVLT and BVMT-R respectively). Test-retest reliability was good for all the tests. Based on the criterion of 1 or more tests below the 5th percentile of healthy controls performance, 47% of patients were found impaired.

Conclusions: The study provides validation of BICAMS in Greek population and therefore facilitates the use of this battery in clinical practice and in future studies of MS patients in Greece.

1. Introduction

There is increasing evidence that Multiple Sclerosis (MS), one of the most known inflammatory diseases of the central nervous system CNS, causes cognitive decline apart from physical disability (Compston and Coles, 2008). Approximately half of patients with MS present with cognitive impairment that negatively impacts aspects of everyday life (Chiaravalloti and DeLuca, 2008). This cognitive inefficiency and memory decline affects patient's employment, communication, disease management and quality of life in general (Langdon, 2011), regardless the stage or type of the disease (Patti et al., 2009). Cognitive deficits may be undetected at consultation (Romero et al., 2015).

Various neuropsychological batteries have been proposed for the assessment of cognitive impairment in MS as the interest in this area has been increased over the last years. In 2012, an expert committee proposed the Brief International Cognitive Assessment for Multiple Sclerosis (BICAMS) as the tool for brief cognitive monitoring for MS patients in clinical settings with limited resources (Langdon et al., 2012). The committee concluded in the use of three tests with good psychometric properties, that could adequately evaluate information processing speed, verbal and visual memory; cognitive domains that are commonly found impaired in MS. Tests that were brief and easy to administer, without the need of special equipment, were preferred. The BICAMS battery is a tool which has been validated and applied in many countries. The aim of the present study was to validate the BICAMS in Greek MS patients and controls.

2. Materials and Methods

A total of 44 MS patients (mean age 40.279.9 years, 27 females) and 79 healthy control (HC) participants (mean age 36.2710.6 years, 48 females) were recruited from January 2014 to January 2015. Healthy individuals were age, education, gender and premorbid cognitive reserve - matched controls. The mean years of education were 14.174.8 for patients and 15.475.5 for HC. All patients (RRMS, SPMS and PPMS) were diagnosed for MS according to the 2010 revised Mc Donald criteria (Polman et al., 2011) and were included regardless of any Disease Modifying Treatment (DMT) they may have taken. Patients with Clinically Isolated Syndrome (CIS) were included in the MS group, as previous studies have reported cognitive impairment even in the initial stages of the disease (Glanz et al., 2007; Štecková et al.). Demographic data and disease characteristics of the patient group are presented in Table 1. All patients

and all HC provided written informed consent for participation in the study and the research project has been approved by the Ethics Committee of Aristotle University of Thessaloniki. All patients and HC were Caucasian Greek individuals free of any major psychiatric illness or disease that could affect cognition (other than MS). MS patients had to be free of relapses or any disease progression for the last three months. All subjects had adequate vision and hearing ability to undergo examination with the BICAMS battery. Moreover, 19 MS patients and 24 HC underwent assessment with alternate forms of the tests three weeks after the first examination in order to assess test-retest reliability. This study was non-interventional and was not obligatory for safety data to be collected. Nevertheless, if an adverse event had occurred during the study, and was suspected to be associated with any pharmaceutical substance that the patient had received, it had to be reported to the local Health Authority.

3. Neuropsychological Assessment

All patients and HC underwent neuropsychological assessment using the BICAMS battery which includes the following tests:

The Symbol Digit Modalities Test (SDMT) (Smith, 1982) is a measure of information processing speed. It consists of a series of nine symbols, each in association with a single digit. Participants enunciate the digit related to each symbol in a randomized sequence, as fast as they can, in a 90s session. The total score is derived from the number of correct answers. We used the SDMT alternate forms created by Benedict et al. (2012). These two forms are equivalent to the original version and provide good test-retest reliability. Alternate form one was used for the assessment and alternate form two was used for the retest session.

The California Verbal Learning Test-II (CVLT-II) (Delis et al., 2000) is a measure of verbal memory. It consists of a list of 16 words that the subject must learn. The procedure is repeated five times. Instead of the CVLT-II, the Greek adaptation Greek Verbal Learning Test (GVLT) (Vlachou et al., 2013) was used in this study. GVLT provides the same number of words and number of trials as used in CVLT-II. Words are culturally adapted for the Greek population. GVLT provides three alternate forms with satisfactory psychometric properties. Total score is derived from the total number of words recalled over five trials, just like CVLT-II recommended primary outcome for BICAMS battery. Form A was used for the assessment and form B for the retest session.

The Brief Visuospatial Memory Test-Revised (BVMT-R) (Benedict, 1997) is a measure of visuospatial memory. The subjects are asked to remember a page with six designs for ten seconds. The procedure is repeated three times. Each design is scored with zero, one or two points, depending on accuracy and location. Total recall score is the sum of the individual scores of the three trials. BVMT-R comes with 6 equivalent alternate forms. We used form one for the assessment and form two for the retest session. The above procedure was performed by neurologists in the neuropsychology unit of the MS center of B' Department of Neurology, AHEPA University Hospital.

Examiners had previously attended training sessions, in order to ensure uniform administration, while scoring was performed by two blinded observers, in order to avoid interrater variability. For SDMT and BVMT-R, Instructions for administration and scoring, were properly translated in Greek language, back translated and checked for errors by two independent English speaking neuropsychologists. The BICAMS battery was performed in a standardized way in order to ensure stable operating conditions without noise or fatigue factor impact. In addition, all participants were assessed with the Greek adaptation of Cognitive Reserve Index questionnaire (Nucci et al., 2012; Maiovis et al., 2016) (CRIq) in order to quantify their cognitive reserve. It is a questionnaire that takes into account education, professional activity and participation in activities that require cognitive effort, and provides a representative result of cognitive reserve of the individual.

4. Statistical analysis

Statistical analysis was performed with the use of GraphPad Prism 5 and the SPSS 18 software packages. To account for normality in our populations, the Shapiro–Wilk test was used. In cases where many identical values were identified, the Kolmogorov–Smirnov served as the test of choice. A one-way ANOVA between groups analysis of variance was conducted to explore the differences among examined population as measured by SDMT, GVLT and BVMT-R tests. Group differences were examined also with Student's t-test and measurements of the linear correlation (dependence) between groups were assessed using Pearson's r coefficient. These r values for test-retest correlation were considered adequate if > 0.70 and good if > 0.80. Participants in the study were divided into HC ($n = 79$) and MS patients ($n = 44$).

5. Results

Descriptive statistics for the SDMT, GVLT and BVMT-R of both groups are presented in Table 2. We found no significant difference between MS patients and HC in matters of age (40.2 ± 9.9 and 37.2 ± 10.6, respectively; $p = 0.11$), years of education (13.9 ± 4.2 and 15.6 ± 5.5, respectively; $p = 0.13$) and gender (females 61.3% and 60.7% respectively). There was a statistically significant difference at the $p < 0.05$ level in all three tests of the BICAMS for the two groups. The results indicated that HC had significantly higher SDMT test score compared to MS patients (61.4 ± 13.1 vs 45.0 ± 17.2, $p < 0.0001$, $r = 0.47$, $d = 1.07$). As predicted, HC group had also higher GVLT test score than MS patients (60.5 ± 10.7 vs 55.5 ± 12.3, $p = 0.02$, $r = 0.21$, $d = 0.43$). Finally, HC had also higher BVMT-R test score compared to MS patients (22.1 ± 6.5 vs 18.5 ± 8.3, $p = 0.009$, $r = 0.23$, $d = 0.48$). Test-retest reliability was very good for all 3 tests (Table 3) in both groups. The CRIq results, revealed no significant difference between the two groups (P value = 0.5593). There was a positive correlation between the two variables CRI and education years in HC ($r = 0.85$, $p < 0.0001$) and also in MS patients ($r = 0.73$, $p < 0.0001$).

In order to evaluate how many MS patients were found impaired on each of the three components of BICAMS, we identified the 5th percentile on each performance of the HC group. Based on the proposed criterion of one or more tests performance below the 5th percentile of healthy controls performance, we found that 47% of patients presented cognitive dysfunction. Table 4 summarizes the results and the estimation of impaired MS patients on one, two, and three tests.

6. Discussion

Evaluation of cognition in MS is necessary for appropriate rehabilitation, vocational counseling, and quantification of disability. Many diagnostic batteries have been used for this purpose in large MS centers worldwide. The most commonly used batteries of neuropsychological tests in MS are the Brief Repeatable Battery of Neuropsychological tests (BRB-N) (Rao, 1990) and also the Minimal Assessment of Cognitive Function in MS (MACFIMS) (Benedict et al., 2006). Although accurate, these batteries may be time consuming (BRB-N takes about 45 min; MACFIMS takes about 90 min) and therefore not suitable for everyday clinical practice, especially in centers without a neuropsychologist. There is a need for a brief cognitive assessment tool with adequate reliability, validity, specificity and sensitivity, which can provide widespread, accurate cognitive evaluations (Langdon et al., 2012). The BICAMS battery can be used in small MS centers, without staff trained in neuropsychology (Goverover et al., 2016). After reaching international validation (Benedict et al., 2012), it may contribute in the progress of understanding the natural history of MS. It may also assist in the disease prognosis, management and treatment decisions by informing physicians about the memory and mental state of the patient.

Previous studies about cognitive dysfunction in MS, have taken into account age, education and gender in order to evaluate patients' performance. In the present study, we felt that including patient's lifestyle, would provide more insight about their

cognitive reserve, therefore we also included the Cognitive Reserve Index questionnaire (CRIq). This is a new standardized tool for cognitive reserve assessment. CRIq can be used in both experimental research and in clinical practice, and could be taken into consideration in the validation of many psychometric tests (Nucci et al., 2012; Maiovis et al., 2016).

According to the results and the statistical analysis of the current study, MS patients performed worse in all three tests of BICAMS battery. Particularly, in SDMT and BVMT-R the patients exhibited the lowest scores. The findings are in accordance with previous studies (Dusankova et al., 2012; Sandi et al., 2015) where SDMT and BVMT-R presented better sensitivity in discriminating patients from healthy controls. In this study, 47% of our patients exhibited cognitive dysfunction, thus indicating a slightly lower percentage from other studies (Dusankova et al., 2012; O'Connell et al., 2015), presumably due to the inclusion of CIS patients. Indeed, such an interpretation may be easily speculated particularly on the basis of previous studies, where 47.5% of Greek MS and CIS patients, exhibited cognitive dysfunction (Potagas et al., 2008), whereas similar impairment was noticed in up to 53.75% of MS patients, none of which was a CIS case (Papathanasiou et al., 2014). Nevertheless, we anticipate more enriched and solid results as this study progresses and the number of participants is increased.

Unfortunately, we were not able to determine the relation of BICAMS to employment in Greece, since, the overall increase of unemployment due to the austerity measures and financial deterioration in the country makes hard to identify whether MS-related cognitive impairment may, per se, have a clear impact on unemployment among patients.

Moreover, the use of BICAMS in everyday clinical practice, might potentially aid to the disease and drug management in general, disease prognosis and treatment decisions. Relevant prospective studies would largely clarify such a possibility. Nevertheless, such a brief cognitive tool, could help physicians detect cognitive deficits as early as possible, in order to ensure more detailed evaluation and proper management of long term cognitive decline for all MS patients (Benedict, 2005). However, although this battery could provide access for all MS centers to cognitive study and management (Dusankova et al., 2012), it may by no means replace more comprehensive evaluation of the cognitive function (Goretti et al., 2014). BICAMS should be used as a helpful instrument for both big and small MS centers in order to maximize the international assessment of cognitive impairment (Eshaghi et al., 2012; Morrow et al., 2010; Spedo et al., 2015). This study for the Greek validation of the BICAMS highlights the scale as a reliable and valid short cognitive tool that can be used for evaluation of people with MS in Greece.

Author declaration

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We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.
We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property. We further confirm that any aspect of the work covered in this manuscript that has involved either experimental animals or human patients has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript.
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References

Compston, A., Coles, A., 2008. Multiple sclerosis. Lancet 372 (9648), 1502–1517.

Chiaravalloti, N.D., DeLuca, J., 2008. Cognitive impairment in multiple sclerosis. Lancet Neurol. 7, 1139–1151.

Langdon, D.W., 2011. Cognition in multiple sclerosis. CurrOpin Neurol. 24 (3), 244–249.

Patti, F., Amato, M., Trojano, M., et al., 2009. Cognitive impairment and its relation with disease measures in mildly disabled patients with relapsing-remitting multiple sclerosis: baseline results from the Cognitive impairment in Multiple Sclerosis (COGIMUS) study. Mult. Scler. 15, 779–788.

Romero, K., Shammi, P., Feinstein, A., 2015. Neurologists' accuracy in predicting cognitive impairment in multiple sclerosis. Mult. Scler. Relat. Disord. 4 (4), 291–295.

Langdon, D.W., et al., 2012. Recommendations for a Brief International Cognitive Assessment for Multiple Sclerosis (BICAMS). Mult. Scler. 18 (6), 891–898.

Polman, C.H., Reingold, S.C., et al., 2011. Diagnostic criteria for multiple sclerosis: 2010 revisions to the McDonald criteria. Ann. Neurol. 69 (2), 292–302.

Glanz, B.I., Holland, C.M., Gauthier, S.A., et al., 2007. Cognitive dysfunction in patients with clinically isolated syndromes or newly diagnosed multiple sclerosis. Mult. Scler. 13, 1004–1010.

Štecková, Tereza et al. Thalamic atrophy and cognitive impairment in clinically isolated syndrome and multiple sclerosis. Journal of the Neurological Sciences, Volume 342, Issue 1, 62–68.

Smith, A., 1982. Symbol Digit Modalities Test: Manual. Western Psychological Services, Los Angeles.

Benedict, R.H., Smerbeck, A., Parikh, R., Rodgers, J., Cadavid, D., Erlanger, D., 2012. Reliability and equivalence of alternate forms for the Symbol Digit Modalities Test: implications for multiple sclerosis clinical trials. Mult. Scler. 18 (9), 1320–1325.

Delis DC, Kramer JH, Kaplan E, Ober BA: California Verbal Learning Test Manual: Second Edition, Adult Version. Psychological Corporation, San Antonio, TX; 2000.

Vlachou, C., Kosmidis, M., et al., 2013. Development of the Greek verbal learning test: reliability, construct validity, and normative standards. Arch. Neuropsychol. 28, 52–64.

RHB Benedict: Brief Visuospatial - Memory Test Revised: Professional Manual. Psychological Assessment Resources, Inc., Odessa, Floriday; 1997.

Nucci, M., Mapelli, D., Mondini, S., 2012. The Cognitive Reserve questionnaire (CRIq): a new instrument for measuring. Aging Clin. Exp. Res. 24 (3), 218–226.

Maiovis, P., Ioannidis, P., Nucci, M., Gotzamani-Psarrakou, A., Karacostas, D., 2016. Adaptation of the Cognitive Reserve Index Questionnaire (CRIq) for the Greek population. Neurol. Sci. 37 (4), 633–636.

Rao, S., 1990. A Manual for the Brief Repeatable Battery of Neuropsychological Tests in, Multiple Sclerosis. Medical College Of Wisconsin, Milwaukee, WI, USA.

Benedict, R.H., et al., 2006. Validity of the minimal assessment of cognitive function in multiple sclerosis (MACFIMS). J. Int. Neuropsychol. Soc. 12 (4), 549–558.

Goverover, Y., Chiaravalloti, N., DeLuca, J., 2016. Brief International Cognitive Assessment for Multiple Sclerosis (BICAMS) and performance of everyday life tasks: actual reality. Mult. Scler. 22 (4), 544–550.

Benedict, et al., 2012. Brief International Cognitive assessment for MS (BICAMS): international standards for validation. BMC Neurol. 12, 55.

Dusankova, J.B., Kalincik, T., Havrdova, E., 2012. Cross cultural validation of the Minimal Assessment of Cognitive Function in Multiple Sclerosis (MACFIMS) (and the Brief International Cognitive Assessment for Multiple Sclerosis (BI- CAMS). Clin. Neuropsychol. 26, 1186–1200.

Sandi, D., Rudisch, T., Füvesi, J., Fricska-Nagy, Z., et al., 2015. The Hungarian validation of the Brief International Cognitive Assessment for Multiple Sclerosis (BICAMS) battery and the correlation of cognitive impairment with fatigue and quality of life. Mult. Scler. Relat. Disord. 4 (6), 499–504.

O'Connell, K., Langdon, D.W., Tubridy, N., Hutchinson, M., McGuigan, C., 2015. A preliminary validation of the brief international cognitive assessment for multiple sclerosis (BICAMS) tool in an Irish population with multiple sclerosis (Ms). MSARD 4 (6), 521–525.

Potagas, C., Giogkaraki, E., Koutsis, G., Mandellos, D., Tsirempolou, E., Sfagos, C., Vassilopoulos, D., 2008. Cognitive impairment in different MS subtypes and clinically isolated syndromes. J. Neurol. Sci. 267 (1–2), 100–106.

Papathanasiou, A., Messinis, L., Georgiou, V.L., Papathanasopoulos, P., 2014. Cognitive impairment in relapsing remitting and secondary progressive multiple sclerosis patients: efficacy of a computerized cognitive screening battery. ISRN Neurol., 151379

Benedict, R.H., 2005. Integrating cognitive function screening and assessment into the routine care of multiple sclerosis patients. CNS Spectr. 10, 384–391.

Goretti, B., Niccolai, C., Hakiki, B., et al., 2014. The brief international cognitive assessment for multiple sclerosis (BICAMS): normative values with gender, age and education corrections in the Italian population. BMC Neurology 14, 171.

Eshaghi, A., Riyahi-Alam, S., Roostaei, T., Haeri, G., Aghsaei, A., Aidi, M.R., Pouretemad, H.R., Zarei, M., Farhang, S., Saeedi, R., Nazeri, A., Ganjgahi, H., Etesam, F., Azimi, A.R., Benedict, R.H., Sahraian, M.A., 2012. Validity and reliability of a Persian translation of the Minimal Assessment of Cognitive Function in Multiple Sclerosis (MACFIMS). Clin. Neuropsychol. 26 (6), 975–984.

Morrow, S.A., Drake, A., Zivadinov, R., Munschauer, F., Weinstock-Guttman, B., Benedict, R.H., 2010. Predicting loss of employment over three years in multiple sclerosis: clinically meaningful cognitive decline. Clin. Neuropsychol. 24 (7), 1131–1145.

Spedo, C.T., Frndak, S.E., Marques, V.D., et al., 2015. Cross-cultural adaptation, reliability and validity of the BICAMS in Brazil. Clin. Neuropsychol. 29 (6), 836–846.

Table 1. Descriptive data of the patient group.

Disease type	**n**	**females**	**Mean age**	**Median EDSS (min-max)**	**Mean years from diagnosis**	**Mean Years of education**
CIS	3	66.6%	21.3 ± 3.2	2.0 (1.0-2.0)	1.6 ± 0.5	13.6 ± 1.5
RRMS	34	61.7%	40.6 ± 8.7	3.0 (1.5-5.0)	9.6 ± 3.7	14.9 ± 3.7
PPMS	3	66.6%	47.3 ± 5.5	4.0 (3.0-4.5)	6.0 ± 2.6	13.0 ± 3.6
SPMS	4	50.0%	47.0 ± 8.7	5.5 (4.0-6.0)	7.5 ± 3.7	14.7 ± 5.9
Total	**44**	**61.3%**	**40.2 ± 9.9**	**3.5 (1.0-6.0)**	**9.1 ± 4.1**	**14.1 ± 4.8**

Table 2. Group characteristics and BICAMS performance

	Patients	**Healthy controls**	**P value**
Age	40.2 ± 9.9	37.2 ± 10.6	0.11
Education	13.9 ± 4.2	15.6 ± 5.5	0.13
SDMT	45.0 ± 17.2	61.4 ± 13.1	<0.0001
GVLT	55.5 ± 12.3	60.0 ± 10.7	0.02
BVMT-R	18.5 ± 8.3	22.1 ± 6.5	0.009

Table 3. BICAMS Test-retest reliability assessment

Test/Group	**r**	**p**
SDMT/HC	0.97	<0.0001
GVLT/HC	0.88	<0.0001
BVMT-R/HC	0.94	<0.0001
SDMT/MS	0.96	<0.0001
GVLT/MS	0.97	<0.0001
BVMT-R/MS	0.95	<0.0001

Table 4. Prevalence of cognitive impairment in MS patients according to the 5th percentile value of HC on BICAMS tests.

	5th Percentile value for HC on each test	Percentage of patients with lower score
SDMT	**40**	**43 %**
GVLT	**43**	**20 %**
BVMT-R	**13**	**22 %**
	MS patients impaired on tests of BICAMS	
On 1 test	**47 %**	
On 2 tests	**25 %**	
On 3 tests	**11 %**	