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Diagnostic Contribution of the MMSE-2:EV in the Detection and Monitoring of the Cognitive Impairment: Case Studies

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***Abstract*—**The goal of this paper is to present the diagnostic contribution that the screening instrument, Mini-Mental State Examination-2: Expanded Version (MMSE-2:EV), brings in detecting the cognitive impairment or in monitoring the progress of degenerative disorders. The diagnostic signification is underlined by the interpretation of the MMSE-2:EV scores, resulted from the test application to patients with mild and major neurocognitive disorders. The cases were selected from current practice, in order to cover vast and significant neurocognitive pathology: mild cognitive impairment, Alzheimer's disease, vascular dementia, mixed dementia, Parkinson's disease, conversion of the mild cognitive impairment into Alzheimer's disease. The MMSE-2:EV version was used: it was applied one month after the initial assessment, three months after the first reevaluation and then every six months, alternating the blue and red forms. Correlated with age and educational level, the raw scores were converted in *T* scores and then, with the mean and the standard deviation, the *z* scores were calculated. The differences of raw scores between the evaluations were analyzed from the point of view of statistic signification, in order to establish the progression in time of the disease. The results indicated that the psycho-diagnostic approach for the evaluation of the cognitive impairment with MMSE-2:EV is safe and the application interval is optimal. In clinical settings with a large flux of patients, the application of the MMSE-2:EV is a safe and fast psychodiagnostic solution. The clinicians can draw objective decisions and for the patients: it does not take too much time and energy, it does not bother them and it doesn't force them to travel frequently.

***Keywords*—**MMSE-2, dementia, cognitive impairment, neuropsychology.

I. Introduction

AGING brings by itself not only a diminishing of the physical capacities, but also a diminishing of the cognitive performances. And, just as the process of aging "is personalized" [1], also the cognitive changes are different form one person to another, ranging from "subtle to severe" [2]. The cognitive decline compiles problems of memory, attention, language, thought, and judgment and when it is severe, it affects the independent functioning of a person in the day-to-day activities.

The cognitive impairment covers different realities, such as the complaints *expressed* by any person who observes a diminishing of his own cognitive capacities, especially the memory or the complaints *reported* by the entourage regarding the difficulties seen in a close friend and the complaints *admitted* during a thorough neuropsychological assessment. However, the most frequent complaint seen lately is the fear of the Alzheimer's disease. This determines a person to go to a doctor and ask for a memory evaluation.

Early detection of the cognitive deficit provides its control. The results obtain during the periodical cognitive monitoring sets the steps for the future therapies. Cognitive stimulation, medication or both play an important role in maintaining the cognitive reserve, active stimulating the deficient cognitive functions or developing compensatory strategies. The sooner the cognitive problem is discovered, the better it is possible to maintain the proper autonomy and social adaptation, improve the day to day functioning and optimize the possibility of social insertion.

Just as it is recommended to have a yearly medical exam regarding the physical health, it is suggested that after the age of 65 - the arbitrary marker of older adulthood [3], to have a memory evaluation once a year. Prevention is the key to physical and mental health. In this context, it is commendable the initiative of the Alzheimer's Foundation of America [4], which, in collaboration with other organizations and professional associations, coordinates and supports, one day each year, a free national program for memory screening.

Memory screening is a simple, sure, non-invasive method to verify the memory and other thinking abilities. It also can indicate if a deeper medical examination is necessary. A screening is comprised of a series of questions and/or tasks conceived to test the memory, linguistically abilities, thought process and other intellectual functions. There are several instruments used in memory screening, the MMSE-2 being one of them. It meets the requirements accepted for a memory-screening tool: efficient, easy to administer and scientifically validated.

Mini-Mental State Examination, 2nd Edition (MMSE-2) is the revised version of the original MMSE, which was one of the most used short instruments for screening for the evaluation of the cognitive impairment. The MMSE-2 has three versions, MMSE-2:BV, MMSE-2:SV and MMSE-2:EV. The extended version, MMSE-2:EV, has an improved clinical usefulness by extending the superior limit of the scores (that is of the degree of difficulty) by increasing the interval of the scores and of the sensitivity toward the screening for persons with less severe cognitive problems, subcortical dementia and mild cognitive impairment [5]. MMSE-2 was a success in Romania since his launch in 2013.

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II. Methodology and Cases Presentations

In cognitive screening, it is recommended to use more then only one test and the results of the screening are not a diagnosis. This instrument was chosen because it is validated on Romanian population. MMSE-2 instruction manual contains age groups and educational level measured in years of study. Still, it does not offer examples to read the scores.

The paper intends to be an example of the interpretation of the scores obtained after applying MMSE-2, leaving the road open for future research. The specialized literature abounds in papers and studies about the role of the original MMSE in the screening of different degenerative diseases, but the interpretation is done exclusively based on the raw scores. What MMSE-2 brings new to the table is the fact that the national standards give to the raw score a classification based on age and years of study. In the case of two subjects with the same age but with different educational levels (the first subject with 8 years in school, the second subject with over 16), the raw score of 23/30 can mean a mild cognitive loss for the first subject and a significant deterioration for the second subject.

TABLE I
Case 1, Alzheimer's Disease

	Application: Date	Age/ Education	Raw scores	M	SD	T	z	Raw scores difference/Statistical significance II-I/p	III-I/p	IV-I/p	V-I/p
MMSE-2:BV Maximum points: 16	I: May 14, 2013	79/12	10/16	14.19	1.39	20	***-3.01***	+1	+3	+3	+2
	II: June 14, 2013	79/12	11/16	14.19	1.39	27	***-2.29***				
	III: October 7, 2013	79/12	13/16	14.19	1.39	41	**-0.85**	Non-significant	Non-significant	Non-significant	Non-significant
	IV: April 15, 2014	80/12	13/16	14.06	1.44	43	**-0.73**				
	V: November 3, 2014	80/12	12/16	14.06	1.44	36	**-1.43**				
MMSE-2:SV Maximum points: 30	I: May 14, 2013	79/12	21/30	26.07	2.65	31	**-1.91**	+3	+5	+2	+3
	II: June 14, 2013	79/12	24/30	26.07	2.65	42	**-0.78**				
	III: October 7, 2013	79/12	26/30	26.07	2.65	50	**-0.02**	Non-significant	Non-significant	Non-significant	Non-significant
	IV: April 15, 2014	80/12	23/30	25.86	2.69	39	**-1.06**				
	V: November 3, 2014	80/12	24/30	25.86	2.69	43	**-0.69**				
MMSE-2:EV Maximum points: 90	I: May 14, 2013	79/12	34/90	50.21	10.40	34	**-1.55**	+1	+4	+3	+1
	II: June 14, 2013	79/12	35/90	50.21	10.40	35	**-1.46**				
	III: October 7, 2013	79/12	38/90	50.21	10.40	38	**-1.17**	Non-significant	Non-significant	Non-significant	Non-significant
	IV: April 15, 2014	80/12	37/90	48.82	10.46	39	**-1.13**				
	V: November 3, 2014	80/12	35/90	48.82	10.46	37	**-1.32**				

TABLE II
Case 2, Mild Cognitive Impairment

	Application: Date	Age/ Education	Raw scores	M	SD	T	z	Raw scores difference/Statistical significance II-I/p	III-I/p	IV-I/p	V-I/p
MMSE-2:BV Maximum points: 16	I: November 23, 2011	79/13	15/16	14.57	1.35	53	0.31	0	-1	-1	-1
	II: December 19, 2011	79/13	15/16	14.57	1.35	53	0.31				
	III: June 28, 2013	80/13	14/16	14.44	1.39	47	**-0.31**	Non-significant	Non-significant	Non-significant	Non-significant
	IV: October 23, 2013	81/13	14/16	14.44	1.39	47	**-0.31**				
	V: May 14, 2014	81/13	14/16	14.44	1.39	47	**-0.31**				
MMSE-2:SV Maximum points: 30	I: November 23, 2011	79/13	28/30	26.96	2.48	54	0.41	0	-1	0	-5
	II: December 19, 2011	79/13	28/30	26.96	2.48	54	0.41				
	III: June 28, 2013	80/13	27/30	26.75	2.52	50	0.09	Non-significant	Non-significant	Non-significant	.01
	IV: October 23, 2013	81/13	28/30	25.75	2.52	55	0.89				
	V: May 14, 2014	81/13	23/30	25.75	2.52	35	**-1.09**				
MMSE-2:EV Maximum points: 90	I: November 23, 2011	79/13	45/90	52.85	10.35	42	**-0.75**	0	-6	-3	-7
	II: December 19, 2011	79/13	45/90	52.85	10.35	42	**-0.75**				
	III: June 28, 2013	80/13	39/90	51.47	10.41	41	**-1.19**	Non-significant	Non-significant	Non-significant	.10
	IV: October 23, 2013	81/13	42/90	51.47	10.41	44	**-0.90**				
	V: May 14, 2014	81/13	38/90	51.47	10.41	40	**-1.29**				

TABLE III
Case 3, Mixed Dementia

	Application: Date	Age/ Education	Raw scores	M	SD	T	z	Raw scores difference/ Statistical significance II-I/p
MMSE-2:BV Maximum points: 16	I: February 18, 2015	58/16	12/16	15.49	1.12	19	***-3.11***	+1
	II: Mach 31, 2015	58/16	13/16	15.49	1.12	33	***-2.22***	Non-significant
MMSE-2:SV Maximum points: 30	I: February 18, 2015	58/16	24/30	28.68	2.16	28	***-2.16***	+1
	II: Mach 31, 2015	58/16	25/30	28.68	2.16	33	**-1.70**	Non-significant
MMSE-2:EV Maximum points: 90	I: February 18, 2015	58/16	41/90	61.04	10.07	30	**-1.99**	+6
	II: Mach 31, 2015	58/16	47/90	61.04	10.07	36	**-1.39**	Non-significant

TABLE IV
CASE 4, VASCULAR DEMENTIA

	Application: Date	Age/ Education	Raw scores	M	SD	T	z	Raw scores difference/ Statistical significance II-I/p	III-I/p
MMSE-2:BV Maximum points: 16	I: May 21, 2012	75/4	15/16	13.43	1.48	61	1.06	-1	-2
	II: December 6, 2013	76/4	14/16	13.43	1.48	54	0.38		
	III: January 10, 2014	76/4	13/16	13.43	1.48	47	**-0.29**	Non-significant	Non-significant
MMSE-2:SV Maximum points: 30	I: May 21, 2012	75/4	28/30	24.29	2.99	62	1.24	-5	-6
	II: December 6, 2013	76/4	23/30	24.29	2.99	46	**-0.43**		
	III: January 10, 2014	76/4	22/16	24.29	2.99	42	**-0.76**	.01	.01
MMSE-2:EV Maximum points: 90	I: May 21, 2012	75/4	43/90	44.92	10.49	48	**-0.18**	-10	-11
	II: December 6, 2013	76/4	33/90	44.92	10.49	39	**-1.13**		
	III: January 10, 2014	76/4	32/16	44.92	10.49	38	**-1.23**	.01	.01

TABLE V
CASE 5, PARKINSON'S DISEASE

	Application: Date	Age/ Education	Raw scores	M	SD	T	z	Raw scores difference/Statistical significance II-I/p	III-I/p	IV-I/p	V-I/p
MMSE-2:BV Maximum points: 16	I: May 6, 2012	69/6	16/16	14.08	1.35	64	1.42	+1	+3	+3	+2
	II: May 7, 2014	71/6	16/16	13.94	1.39	65	1.48				
	III: June 6, 2014	71/6	16/16	13.94	1.39	65	1.48				
	IV: September 11, 2014	72/6	16/16	13.94	1.39	65	1.48	Non-significant	Non-significant	Non-significant	Non-significant
	V: February 10, 2015	72/6	15/16	13.94	1.39	58	0.76				
MMSE-2:SV Maximum points: 30	I: May 6, 2012	69/6	30/30	25.59	2.74	66	1.60	+3	+5	+2	+3
	II: May 7, 2014	71/6	29/30	25.39	2.78	63	1.29				
	III: June 6, 2014	71/6	30/30	25.39	2.78	67	1.65				
	IV: September 11, 2014	72/6	30/30	25.39	2.78	67	1.65	Non-significant	Non-significant	Non-significant	Non-significant
	V: February 10, 2015	72/6	27/30	25.39	2.78	56	0.57				
MMSE-2:EV Maximum points: 90	I: May 6, 2012	69/6	42/90	50.33	10.32	42	**-0.80**	+1	+4	+3	+1
	II: May 7, 2014	71/6	48/90	48.95	10.38	49	**-0.09**				
	III: June 6, 2014	71/6	46/90	48.95	10.38	47	**-0.28**				
	IV: September 11, 2014	72/6	51/90	48.95	10.38	52	0.19	Non-significant	Non-significant	Non-significant	Non-significant
	V: February 10, 2015	72/6	42/90	48.95	10.38	43	**-0.66**				

TABLE VI
CASE 6, THE CONVERSION OF A MILD COGNITIVE IMPAIRMENT IN ALZHEIMER'S DISEASE

	Application: Date	Age/ Education	Raw scores	M	SD	T	z	Raw scores difference/Statistical significance II-I/p	III-I/p	IV-I/p	V-I/p
MMSE-2:BV Maximum points: 16	I: August 30, 2012	70/17	14/16	15.09	1.26	41	**-0.86**	0	0	-1	-1
	II: August 28, 2013	71/17	14/16	15.09	1.26	41	**-0.86**				
	III: September 27, 2013	72/17	14/16	15.09	1.26	41	**-0.86**				
	IV: May 19, 2014	72/17	13/16	15.09	1.26	33	**-1.65**	Non-significant	Non-significant	Non-significant	Non-significant
	V: February 25, 2015	73/17	13/16	15.09	1.26	33	**-1.65**				
MMSE-2:SV Maximum points: 30	I: August 30, 2012	70/17	25/30	28.05	2.27	37	**-1.34**	-5	-1	-6	-4
	II: August 28, 2013	71/17	20/30	28.05	2.27	15	***-3.54***				
	III: September 27, 2013	72/17	24/30	28.05	2.27	32	**-1.78**				
	IV: May 19, 2014	72/17	19/30	28.05	2.27	10	***-3.98***	.01	Non-significant	.01	.01
	V: February 25, 2015	73/17	21/30	28.05	2.27	19	***-3.10***				
MMSE-2:EV Maximum points: 90	I: August 30, 2012	70/17	44/90	56.88	10.25	37	**-1.25**	-13	-2	-9	-11
	II: August 28, 2013	71/17	31/90	56.88	10.25	25	***-2.52***				
	III: September 27, 2013	72/17	42/90	56.88	10.25	35	**-1.45**				
	IV: May 19, 2014	72/17	35/90	56.88	10.25	29	***-2.13***	.01	Non-significant	.05	.01
	V: February 25, 2015	73/17	33/90	56.88	10.25	27	***-2.32***				

The following steps must be taken before starting a test: write down the patient's age (the age that he gives us and the age from his ID or medical record), then the number of years in school, given by the patient and by a member of his family. The age from ID or medical record patient is considered the correct age and the number of years in school given by the

patient and his caretaker. During the subsequent examinations, the age will increase year by year and when an age group is completed, another age group will begin. The number of years in school will remain unchanged.

On tests for which standardized scores are available, a classification system is applied such that scores one standard deviation or more below the mean are considered to fall in the mild deficit range. Scores two or more standard deviation below the mean are considered to fall in the moderate deficit range. Scores three or more standard deviations below the mean are considered to fall in the sever deficit range [6]. Anderson, Murphy and Troyer say that scores that are considered normal make up a slightly larger range achieved by up to 90% of healthy individuals, or about 1.5 standard deviations from the mean. Scores falling in the bottom 5% are generally considered "impaired" and those in the top 5% are "superior" [2].

In the day-to-day practice, the following color code can be used: red, orange and yellow. The scores below a standard deviation from the average indicate a yellow code (very mild cognitive deficit), the scores between one and two standard deviations below the average indicate an orange code (mild cognitive deficit) and the scores below two standard deviations from the average indicate a warning code red (severe cognitive deficit).

The usefulness of the MMSE-2, in the detection and the monitoring of cognitive impairment, is evidenced by six case presentations related to the following diseases: Alzheimer's disease, mild cognitive impairment, Parkinson's disease, vascular dementia, mixed dementia and the conversion of the mild cognitive disorder into Alzheimer's disease.

Correlated with age and educational level, the raw scores were converted in *T* scores and then, with the mean (M) and the standard deviation (SD), the *z* scores were calculated. The differences of raw scores between the evaluations were analyzed from the point of view of statistic signification, in order to establish the progression in time of the disease.

A. Case 1

Alzheimer's disease: woman, 79 years old, complains about spatial disorientation and short-term memory loss. The computed tomography exam (CT) from May indicated a mild bilateral frontoparietal cortical atrophy. The scores obtained at the MMSE-2 test are presented in Table I. The diagnosis was Alzheimer's disease and the specific medication was administered, Donepezilum.

B. Case 2

Mild cognitive impairment: male, 80 years old, complained about memory losses, which are confirmed by the wife. The scores obtained at the MMSE-2 test are presented in Table II. The CT exam indicated a mild cerebral atrophy. The diagnosis was mild cognitive impairment and the patient is undergoing a treatment with Pramiracetamum.

C. Case 3

Mixed dementia*:* male, 58 years old, is brought to a consult by his wife concerned by the fact that he forgets a lot – by comparison to previous periods. The scores obtained at the MMSE-2 test are presented in Table III. The CT exam indicates a punctiform right frontal lesion with vascular degenerative substrate. The patient was also given Donepezilum and included in a cognitive stimulation program.

D. Case 4

Vascular dementia: woman, 76 years old, her family is requesting a memory examination because the family members have noticed that the patient started to forget things. The scores obtained at the MMSE-2 test are presented in Table IV. The CT exam indicates an ischemic focal lesion spontaneously hypodense localized left posterior parietal, mild temporal atrophy. The patient suffered from an ischemic stroke in 2007.

E. Case 5

Parkinson's disease: woman, 72 years old, was diagnosed with Parkinson's disease and she is undergoing treatment for 4 years. The scores obtained at the MMSE-2 test are presented in Table V.

F. Case 6

The conversion of a mild cognitive impairment in Alzheimer's disease: male, 73 years old, requested on his own initiative a psychological exam because the patient is not feeling too well and does not have a good emotional availability. The CT exam indicates a mild supratentorial uniform atrophy and symmetrically slightly dilated ventricular system on the midline. The patient has trouble accepting the results of the neuropsychological exam, which indicate a cognitive decline. The scores obtained at the MMSE-2 test are presented in Table VI. The patient started several times an antidepressant treatment, which it was stopped without the doctor's recommendation. For the last 6 months, the patient is undergoing a treatment with Donepezilum.

III. Conclusion

The role and diagnostic contribution of the MMSE-2 in the cognitive screening are undeniable. The psychometrics properties of the MMSE-2 recommended it to all professionals working in the mental health field, dedicated to providing care for the elderly. The paper is also an invitation for all those interested to discover the emotional and cognitive benefits of the MMSE-2 in the detection and the monitoring of the cognitive impairment.

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