Assessment of Semantic Memory in Normal Ageing Population and Patients with Mild Cognitive Impairment and Dementia

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KEYWORDS

Semantic Memory, Mild Cognitive Impairment, Dementia.

ABSTRACT

Background: An individual's risk of developing neurodegenerative diseases like dementia increases with age.
Aim and objectives: To devise an assessment tool for the assessment of semantic memory in normal aging & in patients with mild cognitive impairment & mild to moderate dementia to reach an understanding of the nature of their semantic memory difficulties.
Patients & methods: This analytical cross-sectional research was performed on 60 Egyptian, Arabic-speaking subjects aged from fifty to seventy-five years. They were separated into three groups, arranged as follows: 20 patients diagnosed with dementia, 20 patients with mild cognitive impairment (MCI), & 20 age- & sex-matched controls from the normal aging population. Patients selected from the Neurology Clinic for Memory and Neurocognitive Disorders, Cairo University, and four nursing homes and facilities for elderly care in the Greater Cairo area who were previously diagnosed with dementia and MCI. The study started in 2019 and lasted until 2021.
Results: A statistically significant variance amongst the three examined groups was found regarding the scores of the semantic memory test. The cut-off level of 72.5 in the semantic memory test could discriminate between the MCI group and the dementia group with 100% sensitivity and 100% specificity. The semantic memory test demonstrated a reliability of 0.697, 0.630, and 0.652 in the normal group, MCI, and dementia, respectively.
Conclusion: The semantic memory test designed in this study could successfully discriminate between the normal aging population, individuals with mild cognitive impairment, & individuals with dementia on semantic memory tasks.

1. Introduction

An individual's risk of developing neurodegenerative diseases like dementia increases with age, where the loss of long-term memory and language abilities is a key component of the dementia condition (1).

Semantic memory emerged as a notion in the 1970s during discussions about the structure and characteristics of long-term memory. Semantic memory is a constituent of long-term declarative memory that manages broad knowledge about the world, including words, definitions, categories, & concepts. It functions as a repository of information. It enables us to assign significance to the relentless sensory data and provides us with a basis for behavioral actions (2).

In the past, distinguishing between normal aging and dementia was sufficient. However, nowadays, the objective is to diagnose dementia at an early stage in order to facilitate timely therapies (3).

Within this particular framework, the significance of the concept of moderate cognitive impairment (MCI) grows. Mild cognitive impairment (MCI), per definition, denotes a syndrome that fails to satisfy the diagnostic criteria for dementia but is regarded as a transitional phase of cognitive decline between typical aging & dementia (4).

Speech-language pathologists (SLP) & phoniatricians can aid in mitigating risks and providing cognitive therapies. Additionally, they can play a crucial role in assisting diagnosticians in identifying minor alterations in cognitive, linguistic, & functional deficits, thereby enhancing diagnostic precision & facilitating early detection (5).

Speech-language pathologists are authorized to offer cognitive-communication training or rehabilitation to patients who have MCI & early-stage dementia. As a result, this may assist individuals with controlling their illness, optimizing their functional abilities, enhancing their quality of life, & getting ready for more deterioration. (6).

The aim of this work was to devise an assessment tool for the assessment of semantic memory in normal aging & in patients with mild cognitive impairment & mild to moderate dementia to reach an understanding of the nature of their semantic memory difficulties.

2. Patients & methods:

This analytical cross-sectional research was performed on 60 Egyptian and Arabic-speaking subjects. The participants' ages varied from fifty to seventy-five years, and they were separated into three groups arranged as follows: 20 patients diagnosed with dementia, 20 patients with MCI, & 20 age- & sex-matched controls from the normal aging population. Participants in this study were selected from the Neurology Clinic for Memory and Neurocognitive Disorders, Cairo University, in addition to four nursing homes and facilities for elderly care in the Greater Cairo area who were previously diagnosed with dementia and MCI. The controls were recruited from patients' relatives and from workers in nursing homes as well. The study started in 2019 and lasted until 2021.

Ethical consideration: An informed written consent was obtained from the cases or their caregivers and an approval from the administration of nursing homes as well, after the purpose of the study and the protocol of assessment had been explained to them.

Inclusion Criteria: Subjects and controls with ages between 50 and 75 years, subjects with mild or moderate dementia, regardless of the type, who were diagnosed according to the protocol of assessment at the Neurology Clinic of memory and neurocognitive disorders as having mild to moderate dementia. In the case of patients from nursing homes, they were previously diagnosed, and data were obtained from their medical files and records. Subjects diagnosed with mild cognitive impairment, Arabic as the first language, and literate participants who can read and write with a minimum of 5–6 years of basic elementary education.

Exclusion criteria: Subjects and controls less than 50 years of age have severe language or speech impairments, severe sensory impairments (either visual or auditory), severe dementia, a history of stroke or cerebrovascular insults, and any memory impairment resulting from debilitating health conditions or due to conditions other than neurodegenerative disease, such as traumatic or toxic causes of memory impairment or memory deficits due to mental disorders.

Methods:

All cases were subjected to the following protocol of assessment: Interview and history-taking; neuropsychological testing included:

Mini-Mental State Examination (MMSE)

The MMSE is a brief, 30-step quantitative measure of cognitive status in adults & elderly. It assesses seven aspects of cognition: orientation, registration, attention, calculation, recall, language, naming, & visuospatial through a series of questions or commands.

Montreal Cognitive Examination Basic (MoCA-Basic) -- Arabic version

The MoCA-Basic is a paper-and-pencil cognitive screening test comprising nine subsets. It evaluates various cognitive domains, such as attention, memory, executive functions, and memory, among others. The test consists of complex problem-solving tasks that are specifically designed to depict real-life scenarios. When developing the MoCA-B, various characteristics were taken into account in order to maximize its capacity for identifying MCI in individuals with limited educational attainment. Literacy-independent tasks that assessed the same cognitive function were substituted for literacy-dependent tasks that were eliminated. (7).

Clinical Dementia Rating Scale (CDR)

The CDR is a clinical interview that is semi-structured and used to assess the severity of neurocognitive problems. It asks questions on memory, orientation, judgment and problem solving, community affairs, everyday activities, and personal care of both the patient and the informant (care provider). The degree of impairment is finally categorized as follows: 0 indicates no impairment, 0.5 indicates dubious impairment, 1 indicates mild impairment, 2 indicates moderate impairment, and 3 indicates severe impairment. (8).

Assessment for Semantic memory specifically designed for this study:

The assessment battery was designed to explore knowledge that taps semantic comprehension and production using both visual & verbal input. The Cambridge Semantic Test Battery (9), the Nombela 2 Semantic Battery (10), the BAMS Semantic Memory Battery (11) and the Semantic Battery (12) served as the guides for the assembly and cultural adaptation of its 10 subtests. The colloquial Egyptian Arabic dialect was used for items and instructions in this semantic memory assessment battery to make it easier to use with subjects from different backgrounds. It also focused mainly on pictures and avoided written stimuli to make sure it could fit patients with different educational levels. A pilot study was done, and the assessment tool was carried out on five normal-age subjects: five patients

with MCI & five cases with dementia, to ensure clarity of instructions and pictures. This resulted in some modifications to the test in the form of omitting some questions and pictures that showed consistent ambiguity; also, some repeated items were discarded to avoid redundancy and unnecessary prolongation of test application time. The average duration for applying the test was calculated and found to be an average of 20 to 30 minutes to be completed in one sitting. The items were graded in difficulty; some items were modified based on the observations made in the pilot study to ensure familiarity, yet some difficult items were preserved to avoid a ceiling effect. Most of the subtests were preceded by a demonstration of the task that was not scored to ensure that the subject understood the idea of the task clearly. Clear instructions were given that repetitions were not allowed as soon as the task was applied. Questions, repetitions, and further clarification were allowed during the demonstration stage.

Subtests included: Naming, category fluency, matching pictures to spoken words, recognition of attributes, associations, generation of verbal descriptions, verbal analogies, general knowledge, one similarity and one difference, and naming in response to definitions.

3. Results

Table (1): Demographic data of the studied individuals

		Normal		MCI		Dementia		P value
		Mean	SD	Mean	SD	Mean	SD	
Age		66.35	5.35	66.30	5.35	65.20	4.84	0.732
		Normal		MCI		Dementia		P value
		Count	%	Count	%	Count	%	
Gender	F	11	55.0%	10	50.0%	11	55.0%	0.935
	M	9	45.0%	10	50.0%	9	45.0%	

Table 1 revealed that no statistically significant variance amongst the 3 examined groups was found as regard age & gender (p=0.732 & p= 0.935) correspondingly.

Table (2): Comparison between the mean scores of MOCA-B, MMSE, and CDRS among the studied groups.

	Normal		MCI		Dementia		P value
	Mean	SD	Mean	SD	Mean	SD	
MOCA-B	27.15	1.35	17.85	0.93	12.60	1.23	<0.001*
MMSE	26.10	1.71	19.75	1.33	11.80	2.09	<0.001*
CDRS	0.00	0.00	0.45	0.15	1.50	0.51	<0.001*

MOCA-B: Montreal cognitive assessment-basic, MMSE: Mini mental state examination, CDRS: Clinical dementia rating scale, SD: standard deviation, P value: Probability value, *, statistically significant at $p \leq 0.05$

Table 2 revealed that statistically significant variance amongst the 3 examined groups was found as regard MOCA-B, MMSE and CDRS (P values <0.001).

Table (3): Comparison among the three examined groups concerning the subtotal and total scores of the Semantic memory test

	Normal		MCI		Dementia		P value
	Mean	SD	Mean	SD	Mean	SD	
Naming Task	35.00	1.38	32.65	1.57	18.70	3.05	<0.001*
Category Fluency	43.10	4.17	20.90	4.90	10.00	1.78	<0.001*
Matching Pictures	8.90	0.31	8.60	0.94	5.00	1.03	<0.001*
Recognition of Attributes	23.20	1.51	13.80	2.75	7.60	3.76	<0.001*
Associations	3.65	0.49	2.65	0.49	1.20	1.51	<0.001*
Generation of Verbal Description	8.90	1.48	4.30	2.20	2.40	0.82	<0.001*
Analogies	5.35	0.75	3.15	1.53	0.80	1.01	<0.001*
General Knowledge	4.50	0.51	3.35	0.49	1.70	0.47	<0.001*
One Similarity & One Difference	8.15	2.54	4.15	1.09	1.47	0.92	<0.001*
Naming in Response to Definitions	5.65	0.67	4.65	1.27	0.27	0.46	<0.001*
Total Score	146.40	8.26	98.20	7.99	48.70	6.67	<0.001*

SD: standard deviation, P value: Probability value,

Table 3 revealed that statistically significant variance among the 3 examined groups was found as regard the subtotal and total scores of the Semantic memory test.

Table (4): Correlation of subtest scores of the Semantic memory test with age in the three studied groups.

Normal		Age (normal group)	Age(MCI group)	Age(Dementia group)
Naming Task	Correlation Coefficient	-0.139-	0.104	0.555
	P value	0.558	0.662	0.011*
Category Fluency	Correlation Coefficient	-0.053-	-0.004-	-0.549-
	P value	0.823	0.987	0.012*
Matching Pictures	Correlation Coefficient	-0.524-	-0.148-	0.624
	P value	0.018*	0.532	0.012*
Recognition of Attributes	Correlation Coefficient	0.053	-0.702-	0.624
	P value	0.825	0.001*	0.003*
Associations	Correlation Coefficient	-0.238-	-0.211-	0.711
	P value	0.312	0.372	<0.001*
Generation of Verbal Description	Correlation Coefficient	-0.363-	0.037	-0.388-
	P value	0.116	0.878	0.091
Analogies	Correlation Coefficient	0.006	0.136	0.034
	P value	0.979	0.568	0.887
General Knowledge	Correlation Coefficient	0.131	0.394	-0.388-
	P value	0.582	0.085	0.091
One Similarity & One Difference	Correlation Coefficient	0.118	-0.400-	0.207
	P value	0.620	0.080	0.380
Naming in Response to Definitions	Correlation Coefficient	-0.399-	-0.167-	0.725
	P value	0.081	0.481	0.002*
Total Score	Correlation Coefficient	-0.105-	-0.389-	0.620
	P value	0.660	0.090	0.004*

Table 4 showed that in normal aging group, there was a negative association among age & the Matching picture to spoken words task, in MCI group, there was a negative association among age & the recognition of attributes task and in dementia group, there was a negative association among age & category fluency tasks and naming in response to definitions task. Whereas there was a positive association among age & naming, recognition of attributes, and one similarity and one difference task as well as the total score of the Semantic memory test

Table (5): ROC curve for discrimination between MCI and dementia using Semantic memory test

	Area under curve	P value	95% Confidence Interval		Cutoff value	Sensitivity %	Specificity %	PPV %	NPV %	Accuracy %
			Lower Bound	Upper Bound						
Total Score	1.000	<0.001	1.000	1.000	72.5	100	100	100	100	100

Table 5 showed that the cut off level of 72.5 of the Semantic memory test could discriminate between MCI group and Dementia group with 100% sensitivity and 100% specificity.

Table (6): Showing Reliability of the Semantic memory test on the three groups under study

Cronbach's Alpha	Value	95% Confidence Interval		P value
		Lower Bound	Upper Bound	
Normal	0.697	0.454	0.861	< 0.001
MCI	0.630	0.333	0.830	< 0.001
Dementia	0.652	0.318	0.863	0.001

Table 6 showed that the Semantic memory test demonstrated a reliability of 0.697, 0.630 and 0.652 in normal group, MCI, and dementia respectively

4. Discussion

Our study showed that the age range was between 55 and 75 years. Regarding age and gender, there was no statistically significant difference (p = 0.732 and p = 0.935) among the three groups under study. Any cases at extremes of age were not included in the research to avoid the impact of extremes of age on cognitive functions.

Our results are supported by a study done by Spaan that stated that other cognitive functions may interfere with accurate assessment of semantic memory in very old age. No statistically significant distinction existed among the three categories.(13).

Our results showed statistically significant variances were noted among the three groups regarding scores of the neuropsychological testing, which was indicative of their ability to discriminate between the three groups. The tests

are widely used in successful discrimination between normal and pathological neurocognitive cognitive conditions. (14).

Our findings indicated that there was statistically significant variance among the three examined groups regarding the semantic memory test, with the normal aging group outperforming the other two groups regarding different parameters assessed, the mean being the highest among the normally aging individuals, falling gradually among the MCI group, and diminishing markedly among people with dementia.

Collectively, these findings are consistent with prior research suggesting that pathology in dementia is linked to significant impairment in semantic memory (15), as well as that this challenge is also evident in MCI.(9).

Such findings were also with respect to the results of a meta-analysis by Joubert et al. on twenty-two studies, where results show MCI cases perform significantly worse in terms of overall semantic performance in contrast to healthy age- & education-matched controls (16).

Regarding the naming test, the mean score for the normal group was 35, whereas it was 32.5 in the MCI group. In contrast to a much larger gap between normal ageing individuals and patients with dementia (mean score of 18.7 for the dementia group)

This is opposite to findings by Moreno-Martínez and Rodríguez-Rojo, where the mean performance of the MCI group was similar to that of the dementia group.(17).

Regarding the category fluency test, the MCI group showed an average score of 20.90, in contrast to an average score of 43.10 in the normal aging group.

This is consistent with Payton et al., who stated that healthy people who have relatively low semantic fluency skills may have a deterioration in episodic memory and are more likely to develop amnestic MCI. These findings highlight the usefulness of the category fluency test in the early detection of AD risk.(18).

In the normal aging group, no significant correlation was found between semantic memory test tasks and age, apart from a negative correlation between age and matching pictures to spoken words, which could be justified by the lack of attention to details in visual tasks as the person ages, making it more common to make errors, as in the study by Toril et al. (19). Otherwise, in healthy aging, semantic memory and cognitive functions are less affected by age than physical functions (20). In the MCI group, there was a negative association between age & the recognition of attributes task, and in the dementia group, there was a negative association between age, category fluency tasks, and naming in response to definitions task. Whereas there was a positive relationship among age & naming, recognition of attributes, one similarity and one difference task, as well as the total score of the semantic memory test.

Our study revealed that the cut-off level of 72.5 on the semantic memory test could discriminate between the MCI group and the dementia group with 100% sensitivity and 100% specificity. Evaluations of reliability depend on internal consistency (Cronbach's alpha), reflecting the consistency of participants' responses across a test's items at one point in time. The reliability of the assessment designed in the current study was proved to be questionable on the basis of the values of coefficient α obtained for all test items (0.69, 0.63, and 0.65). The assessment battery showed questionable reliability, and this was due to the small sample size for each group individually; therefore, we recommend it be performed on a larger sample to get a clearer picture of the results. However, the reliability of EMSA, the Semantic Memory Assessment Battery for Older Adults (EMSEA), was found to be.73, which is close to the reliability of the Semantic Memory Test defined in the current study. The EMSA contains seven tests: verbal fluency, definition of semantic categories, attribute recognition, picture naming, word matching, verification of true or false statements, and semantic analogies. It was standardized on a sample of 100 older adults.(21).

5. Conclusion

The semantic memory test designed in this study could successfully discriminate between the normal aging population, cases with MCI, and cases with dementia on semantic memory tasks. Normal aging individuals performed better than the MCI patients & dementia patients; MCI patients performed significantly better than the dementia group, & dementia patients performed the worst on all tasks of the semantic memory test.

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