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A model of cognitive evaluation battery for diagnosis of mild cognitive impairment and dementia in educated and illiterate Egyptian elderly people

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Abstract

Background: The high illiteracy rates in the North African and Middle Eastern region make direct cognitive testing challenging. Validated instruments for dementia in Arabic language are lacking specially those targeting low-educated subjects.

Objectives: The aim of this study was to develop a cognitive evaluation battery suitable for both educated and illiterate Egyptian elderly people.

Design: A cross-sectional study was conducted. Setting: Ain-Shams University geriatric and ophthalmology wards, geriatrics outpatient clinic, and geriatric clubs. Participants: 159 male and female participants aged ≥ 60 years were recruited.

Measurements: Cut-off points were determined according to DSM-IV criteria for dementia and MMSE scores which divided the participants into 3 quadrants as normal, having mild cognitive impairment and having dementia then application of the new battery test was done.

Results: Test re-test reliability ranged from adequate to high in most of its tests with $r \geq 0.7$. There was a statistical significance between all battery tests when divided into normal and dementia according to DSM IV criteria except in digit span forward length, digit span backward length, stimulus cue of confrontation naming and judgment. Means and standard deviations were calculated for each battery subset, for the whole sample, for low-educated group and group with > 9 years education according to three quadrants of MMSE.

Conclusion: A new valid and reliable neurocognitive evaluation battery that can differentiate between normal, mild cognitive impairment, and dementia in both educated and illiterate subjects under the name of Ain Shams Cognitive Assessment (ASCA) scale is now available.

Keywords: Dementia, Neuropsychological assessment, Elderly, Egyptians

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Introduction

The word cognition comes from the Latin verb cognosco (con "with" and gnōscō "know"), which means to conceptualize or to recognize [1].

Cognitive decline is a normal process of aging [2]. Some cognitive abilities, such as vocabulary, may improve with age, while others such as memory and speed processing, decline gradually over time [3]. However, there is a significant heterogeneity among older adults in the rate of decline in those abilities [4].

With aging of the population, dementia became a public health problem increasing health care costs. It affects about 5–10% of elderly population above the age of 65 with doubling prevalence each 5 years till reaching about 50% at the age of 85 [5, 6]. The world Alzheimer's report in 2018 stated that every 3 s, there is a new case of dementia [7] which needs our attention regarding this devastating problem.

In the USA, the prevalence of dementia from all causes was between 5 and 7% of adults above age of 60 years [8]. Crude prevalence rates of dementia in European Union countries in subjects over 65 years varied between 5.9 and 9.4% [9]. Regarding Asian countries, the most recent national survey conducted in Japan stated the prevalence of dementia in people aged ≥ 65 years to be 15.75% [10], while in Korea it was 8.7% [11].

In North Africa and the Middle East, studies about dementia prevalence are scarce. In a pilot study in Lebanon, dementia prevalence was 7.4% [12]. In Egypt, there is insufficient data about dementia prevalence all over the country; however, a systematic review including 6 studies from Assiut, New Valley, Red Sea, and Qena governorates reported that the prevalence was between 2.01 and 5.07% [13].

Literacy is strongly reflected in the performance of subjects in neuropsychological evaluations. Education influence visual perception, logical reasoning, learning, and recall strategies. The process of learning to read and write may train specific additional abilities, such as explicit phonological awareness and spatial perception. The inability of an illiterate subject to perform cognitive tasks, present in current neuropsychological test batteries, does not necessarily mean abnormal brain function. Even though people with lower educational levels have a higher rate of developing dementia, cognitive function cannot be accurately assessed due to the limitations of current available tools [14].

Tests that have already been standardized on illiterates in different countries are the Mini Mental State Examination (MMSE), the abbreviated neuropsychologic battery (NEUROPSI), Attention and Memory, verbal fluency tests, visual and spatial tests, executive function tests, and calculation and number processing. However, additional research is needed to determine their sensitivity to brain impairment and their prediction of functional abilities [15]. In 2015, Julayanont and colleagues developed the Montreal Cognitive Assessment-Basic (MoCA-B) to be the first assessment to screen for mild cognitive impairment (MCI) in illiterate elderly adults and those with low levels of education [16].

There is a significant diversity in literacy rates among countries and according to the Central Agency for Public Mobilization and Statistics (CAPMAS), Egypt has 18.4 million illiterate people with 6.9% of youths and 63.4% of the elderly are illiterate [17]. The high illiteracy rates in the North African and Middle Eastern region make direct cognitive testing challenging. Validated screening instruments for dementia in Arabic language are lacking [18].

Neuropsychological assessment is a performance-based method to evaluate cognitive functioning. Typically, it is performed with a battery approach, which involves tests of different cognitive ability areas such as memory, attention, processing speed, spatial, reasoning, judgment, language, and problem-solving functions. Neuropsychological assessment provides general and specific information about current levels of cognitive performance [19].

Inhabitants of the Arab world are 370 million, in addition to eight million Arab immigrants living outside their country of origin [20]. Egypt's population alone makes up 23.6% of the Arabic-speaking population, and although Arabic is the fourth most commonly spoken language in the world [21], the availability of standardized neuropsychological tests in Arabic is scarce. This gives rise to the need of developing valid neuropsychological tests for these populations [22].

MMSE, MOCA, Wechsler memory scale, and Addenbrooke's cognitive examination are available in Arabic; however, MMSE does not assess executive function and other tests are not suitable for illiterates.

Aim of the study

The aim of this study was to develop a cognitive evaluation battery for the diagnosis of MCI and dementia and the battery should be applicable for illiterates, low educated, and highly educated Egyptian elderly people and so, several neuropsychological batteries were reviewed including the National Institutes of Health Executive Abilities: Measures and Instruments for Neurobehavioral Evaluation and Research (NIH EXAMINER) [23], MOCA [24], and The Arabic version of Addenbrooke's cognitive examination (ACE III) [22] before developing this battery.

Subjects and methods

Study design

This is a cross-sectional study.

Study population

One hundred and seventy community dwelling elderly participants were recruited during the period between May 2017 and July 2018 from relatives of patients in the geriatric and ophthalmology wards, patients attending geriatrics outpatient clinic, and geriatric clubs.

Inclusion criteria

Males and females aged 60 years or more and written consent was taken from all participants.

Exclusion criteria

Severe dementia, depression, people who had severe visual or hearing impairment, and functional impairment limiting participation in the study.

Participants were asked about their age, handedness, educational level, and family history of cognitive impairment, and then the following steps were done:

Step I: clinical diagnosis

1. National Institute of Neurological and Communicative Disorders and Stroke-Alzheimer's Disease and Related Disorders Association (NINC DS-ADRDA) Core Clinical Criteria for dementia diagnosis [25]: These criteria imply that for dementia diagnosis, cognitive impairment needs to be confirmed by neuropsychological testing (bedside mental state examination or neuropsychological testing). Two or more of the following cognitive domains must be impaired for diagnosis: memory and learning, executive functions, language, visuospatial abilities, personality, and behavior, which significantly affect function.
2. Peterson's clinical criteria for diagnosis of MCI [26] as follows:
   1) Memory complaint, preferably corroborated by an informant
   (2) Objective memory impairment for age
   (3) Relatively preserved general cognition for age
   (4) Essentially intact activities of daily living, and
   (5) Not demented

Step II: neuropsychological testing

I) Mini Mental State Examination (MMSE) [27]

- This 28 point-scale was administered evaluating orientation, registration, attention and calculation, recall, language (repetition and complex command), and visuospatial functions.
- For illiterate and low-educated subjects, attention was measured by reverse days of the week instead of serial calculations. Reading, writing, and drawing were scored as zero if the subject could not perform them.

II) DSM IV criteria for dementia

- According to the American Psychiatric Association Diagnostic and Statistical Manual of Mental Disorders IV (DSM-IV) [28], participants were asked about the following:

1. Memory impairment plus at least one of the following:
2. Aphasia, apraxia, agnosia, or disturbance in executive functioning.
   - Participant were considered positive for dementia if the above domains were positive, affecting them socially or functionally and after the exclusion of having delirium at the present time.

After application of clinical and DSM IV criteria, participants were classified statistically into 3 quadrants according to results of MMSE after using the cutoff points for diagnosing dementia in Egyptian population defined previously [29]. Dementia was diagnosed if MMSE score ≤ 22 for participants > 9 years education and ≤ 21 for illiterate participants and those with < 9 years education. Clinical criteria were correlated with statistical classification before application of the battery.

III) New battery tests which include the following:

1. Verbal paired associated test

(a) Verbal learning (VL)

Paired-associate learning test from Wechsler memory scale was used to measure the ability to form new links between two items and retrieval [30].

Following the test from original Wechsler [31, 32], a list of six related and four unrelated pairs was read followed by presentation of the first word in each pair; the participants provided the paired word and the number of correctly recalled pairs were scored over three learning trials.

(b) Distractor interval

Following the previous learning trials, the participants were asked to count from 100 backwards, stopped after 28 s, and then asked about the previous pairs as before; the first word in each pair was introduced and the participants were asked to provide the paired word. The correctly recalled words were scored.

(c) Delayed recall

- Ten minutes following the 28-s recall, participants were given the first word in each pair and were asked to provide the paired word. The correctly recalled words were scored.
- The 10 min were filled by non-verbal tests as not to act like intrusions in the recall [33].

(d) Word recognition test

- Participants were given a set of words and were asked to recognize if they were present in the paired associate or not.
- Nine words were chosen from the paired associate and inserted among other 18 words from the same category to act as a novel prototype

2. Bender Gestalt (BG) copy and memory

- Participants were asked to copy a figure to measure visual-motor skills [34] and then to copy it from their memory 10 min later to measure visual memory.

3. Digit forward and digit backward span length

- Digit forward: to test short-term memory, participants were asked to repeat the number in the order told [35] and the correct span length recalled was scored.
- Digit backwards: to test working memory, participants were asked to repeat the numbers told in a reverse order [36] and the correct span length was scored.
- In both digits forward and digit backward, participants were given a second trial with the same span length but different numbers in each step if they failed to recall the correct order in the first time.

4. Set shifting

Trail making test B is a test to evaluate the part of executive functioning considered with the ability to quickly switch attention while inhibiting automatic responses [37]. The test consists of both numbers and letters, and participants are asked to connect numbers and letters alternatively [38], to make the test more suitable for illiterates a new trail making test was used with changes to suit illiterates under the name of Ain Shams Set Shifting for Illiterates (ASTI).

5. Letter/Lexical fluency

According to the Egyptian–Arabic ACE III [22], participants were asked to name items that start with the letter (sh); validated in ACE III in 60 s and 1 point was given for each correct answer.

6. Verbal fluency (spherical)

Participants were asked to name as many spherical shapes as possible in 60 s. One point was given for each correct item.

7. Verbal fluency test/category

According to the Egyptian–Arabic ACE III [22], participants were asked to name as many animals as possible in 60 s and 1 point was given for each correct item.

8. Language object naming test

- Participants were asked to name 12 pictures with scoring of 0–12.
- The test was adapted from Egyptian–Arabic ACE III [22].
- Stimulus cues (describing what the item is about) if the participant misperceives the item.
- Phonemic cuing (saying the phonetic sound of the word beginning) was given if the participant could not recognize the picture even after stimulus cue or if he/she seems to recognize it but cannot put the right name to it.
- The correct items (identified without cuing) out of 12 was scored once and then total correct items (correct+ stimulus cue) out of 12 were scored.

9. Abstraction

- Participants were asked about popular Egyptian metaphors.

– Answers were scored according to the well-known base in Egyptian culture, e.g., in "Cut your coat according to your cloth" if the participant explained that someone should do as well as possible with the limited money they have is considered right. The metaphors were:

ال ق رش ال اب ن ف ف ال وم ال اس ود – ل
ق د ل اف م د رج ل

10. Judgment

– Participants were asked

"If you find a stamped, addressed envelope lying on the sidewalk, what would you do?"

– Answers were scored according to the well-known base in Egyptian culture, e.g., the answer is considered right if the participant answered that he/she would put the stamped envelope in the mailbox or deliver it by him/herself.

Step III: cultural adaptation

When designing the battery, the following modifications were done to some battery tests to suit illiterates and culture:

1. Word recognition test

– The 18 novel words were chosen from a list that includes the most frequent 50 words in Arabic language [39].

Words are:
"ان – دول اب- ور - درج- اب - ب روا ز- ن ب -
ف ـل ا - ه د - ورق - د ب وس- ف ـر ش - م- ش ول-
م ر- رس - س ر ر- راب ز - راد و- خ ال -
" ب -خ روف-م ف ـت ا - ت ـل م - ق - ف ـل- ا م ل

2. Bender Gestalt copy and memory

– This figure was chosen as it is known to be free from cultural influence [40] and as it is more simplified to illiterates.

3. Ain Shams Set Shifting for Illiterates (ASTI)

– Participants were asked to shift between triangles and the corresponding number of circles starting from small numbers to bigger ones.
– Numbers and letters were avoided to suit illiterates.
– No colors were used to avoid Stroop effect.
– Time and number of correct lines were scored.

4. Language object naming test

Three items were changed to suit illiterate and low-educated Egyptian population:

Violin, oud, and crocodile were changed to pot, glasses, and scissors.

Step IV: pilot study

– Battery tests were first conducted on 15 participants.
– The participants were mixed between educated and illiterates to make sure that the tests are well understood, could be applied on different levels of education, to evaluate feasibility of the battery, and to adjust study design before applying it on other participants.

Step V: applying battery tests

Battery tests were applied on participants along with MMSE and DSM IV criteria for dementia to validate the battery and measure its ability to differentiate between normal, MCI, and dementia patients according to 3 quadrants of MMSE (scores were divided into normal, MCI and dementia).

Step VI: psychometrics

(a) Validity

Criterion group validity was done to compare battery tests of the current study with DSM-IV dementia and MMSE as they are already valid.

(b) Reliability

Test re-test reliability was done for 20 participants by the same clinician with 28 days separating the two tests.

Statistical analysis

The statistical analysis was carried out with the *Statistical Package for the Social Sciences* for Windows version 16.0 (SPSS Inc., Chicago, IL, USA.).

Sensitivity, specificity, positive and negative predictive values, and their 95% confidence interval levels for cutoff points were calculated for MMSE. ROC curve was conducted to determine MMSE cut off points.

Descriptive statistics (mean and standard deviation) were calculated for battery tests. *F* value and post hoc tests were done to compare variations inside groups.

Results

Demographics

One hundred seventy community dwelling elderly; 78 males and 92 females were recruited, both cognitively intact and impaired; including 64 illiterate and low educated (≤ 9 years education) and 106 with higher education (> 9 years education). Eleven were dropped in application of DSM IV criteria for dementia, so defining cut off points of MMSE was based on 159 participants: 58 illiterate and low educated (≤ 9 years education) and 101 with higher education (> 9 years education).

Some participants had clinical diagnosis; ten vascular cognitive impairment, five traumatic brain injuries, three Alzheimer's disease, one behavioral frontotemporal dementia, one posterior cortical atrophy, three space occupying lesion, two carbon monoxide poisoning, and three post arrest.

Table 1 showed that test re-test reliability ranged from adequate to high in most tests except distractor interval easy, visuospatial copy and recall, digit span forward and backward, and spherical and letter fluencies. Table 2 compared significance between each battery test in normal and dementia patients diagnosed according to DSM IV criteria for dementia. There was statistical significance between normal and dementia patients in all battery tests except digit span forward length, digit span backward length, stimulus cue of confrontation naming, and judgment. Table 3 presented means and standard deviations of each test according to three quadrants of MMSE in illiterate and low-educated group. High significance between the 3 groups was found for semantic fluency, VL hard total score& 2nd trial, BG recall, CN total score, and with stimulus cue. Table 4 presented means and standard deviations of each test according to three quadrants of MMSE in the group with ≥ 9 years education. There is high significant difference between the 3 groups for all domains except digit span forwards and backwards, confrontation naming phonemic cues, and abstraction. No significance for judgment was found between groups. Table 5 presented correlation between education and battery tests. There was no statistical significance between both groups regarding education except in lexical fluency and backward digit span which are both influenced by education.

Table 1 Test-retest reliability (N = 20).

Variable	Reliability coefficient	
	Pearson Correlation	Spearman's rho
MMSE	0.97	0.78
DSMIV dementia	1.0	1.0
Semantic fluency	0.86	0.94
Verbal learning	0.96	0.90
VL total easy	0.98	0.83
VL total hard	0.85	0.81
VL 1st trial total	0.92	0.93
VL 1st trial easy	0.83	0.82
VL 1st trial hard	0.78	0.77
VL 2nd trial total	0.94	0.88
VL 2nd trial easy	0.83	0.99
VL 2nd trial hard	0.88	0.86
VL 3rd trial total	0.86	0.86
VL 3rd trial easy	0.87	0.99
VL 3rd trial hard	0.80	0.82
DI total	0.94	0.91
DI. easy	0.45	0.19
DI. hard	0.81	0.79
DR total	0.90	0.72
DR easy	0.91	0.71
DR hard	0.90	0.66
Word recognition	0.89	0.75
WRNP	----	----
BG copy	0.10	0.10
BG recall	0.34	0.45
Set shifting lines	----	----
Set shifting time	0.88	0.66
DS forward	0.69	0.64
DS backward	0.65	0.59
Semantic spherical	0.21	0.12
Lexical fluency	0.63	0.58
CN total	1.0	1.0
CN correct	0.92	0.82
CN stimulus cue	0.91	0.71
CN phonemic cue	1.0	1.0
Abstraction	----	----
Judgment	----	----

VL verbal learning, *DI* distractor interval, *DR* delayed recall, *WRNP* word recognition novel prototype, *BG* Bender Gestalt, *DS* digit span, *CN* confrontation naming

Discussion

The objective of this study was to introduce a new battery for cognitive assessment in Egyptian elderly and to present the rationale behind its construction. This new neuropsychological battery was designed to overcome defects in existing dementia screening instruments and their inability to detect early cognitive impairment by assessments of verbal learning, short- and long-term memory, cued memory, short-term and working memory, visuospatial functions, executive functions, verbal fluency, and confrontation naming, assessing the effect of depression on those tests and to apply tests that are less affected by education.

MMSE is one of the most widely used tests for cognitive screening all over the world and though conflicts

Table 2 Significant T test for independent groups according to DSMIV dementia (*N* = 159)

Variable	No dementia (*N* = 100)		Dementia (*N* = 59)		*T* value	Sig. (two-tailed)
	Mean	Std. deviation	Mean	Std. deviation		
Semantic fluency	15.53	5.39	8.58	4.61	8.13	0.000
VL total	18.74	5.80	12.61	4.57	6.72	0.000
VL total easy	14.81	3.13	11.70	3.89	5.32	0.000
VL total hard	3.93	3.46	0.92	1.12	6.33	0.000
VL 1st trial total	5.06	2.01	3.45	1.80	4.89	0.000
VL 1st trial easy	4.27	1.31	3.34	1.64	3.77	0.000
VL 1st trial hard	0.79	1.03	0.11	0.31	4.80	0.000
VL 2nd trial total	6.61	2.07	4.36	1.73	6.81	0.000
VL 2nd trial easy	5.17	1.16	4.07	1.42	5.07	0.000
VL 2nd trial hard	1.44	1.25	0.29	0.46	6.68	0.000
VL 3rd total	7.08	2.16	4.80	1.86	6.52	0.000
VL 3rd trial easy	5.38	0.94	4.32	1.55	5.12	0.000
VL 3rd trial hard	1.70	1.47	0.48	0.63	5.86	0.000
DI total	7.06	2.12	4.68	1.85	6.92	0.000
DI easy	5.32	1.04	4.29	1.63	4.71	0.000
DI hard	1.73	1.43	0.43	0.66	6.42	0.000
DR total	7.05	2.31	4.17	2.38	7.12	0.000
DR easy	5.20	1.08	3.82	2.06	5.27	0.000
DR hard	1.84	1.55	0.35	0.62	6.72	0.000
Word recognition	8.74	0.58	7.69	1.74	5.18	0.000
WRNP	0.23	0.54	1.65	2.80	-4.68	0.000
BG copy	4.03	1.18	3.53	1.50	2.26	0.000
BG recall	3.37	1.71	2.37	1.85	3.28	0.000
Set shifting lines	7.98	2.04	5.50	3.21	5.66	0.000
Set shifting time	56.98	22.77	99.62	58.05	6.15	0.000
DS forward	6.14	1.22	5.64	1.38	2.29	0.024
DS backward	3.57	1.63	3.34	1.47	0.85	0.397
Semanticspherical	5.16	2.31	2.94	2.16	4.87	0.000
Lexical fluency	5.93	3.75	3.91	2.16	3.59	0.000
CN total	11.48	1.13	9.95	3.41	4.20	0.000
CN correct	10.65	1.48	8.78	3.97	4.14	0.000
CN stimulus cue	0.85	0.96	1.25	2.19	-1.55	0.123
CN phonemic cue	0.14	0.35	0.89	1.49	-4.60	0.000
Abstraction	1.07	0.25	1.22	0.42	-2.68	0.008
Judgment	1.0	0.00	1.08	0.28	-2.90	0.004

VL verbal learning, *DI* distractor interval, *DR* delayed recall, *WRNP* word recognition novel prototype, *BG* Bender Gestalt, *DS* digit span, *CN* confrontation naming

exist regarding its accuracy, the American Academy of Neurology in its guidance and the Alzheimer's Association in their guidance suggested MMSE as an important tool for cognitive screening [41], so it was used in this study as a standard test using the cut off points ≤ 22 for participants > 9 years education and ≤ 21 for illiterate participants and those with < 9 years education [30].

For the validity and reliability of the new battery, test retest reliability of each battery subset was done. Significance between battery tests and DSMIV dementia was calculated, then the sample was divided into two groups; participants who are illiterates till ≤ 9 years education and another one with participants > 9 years education. Each group was divided into normal, mild cognitive impairment (MCI), and dementia according to MMSE scores.

Table 3 Significant *F* test for between groups accordingly to three quadrants of MMSE within illiterates and low educated (*N* = 64)

Variable	Lower (dementia)		Mediate (MCI)		Upper (normals)		*F* value	Post hoc (LSD)
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.		
Semantic fluency	7.25	1.58	12.44	3.95	15.00	0.89	9.62***	2&3>1
Verbal learning	13.40	3.57	15.17	3.57	19.67	4.93	5.42**	3>1&2
VL total easy	12.00	2.98	13.43	3.03	15.33	2.58	2.37	–
VL total hard	1.40	0.84	1.74	1.27	4.33	2.88	9.04***	3>1&2
VL 1st trial total	3.20	0.79	4.17	1.07	4.67	1.37	4.46*	2&3>1
VL 1st trial easy	3.20	0.79	4.00	1.00	4.33	1.03	3.40	–
VL 1st trial hard	0.00	0.00	0.17	0.38	0.33	0.52	1.68	–
VL 2nd trial total	4.80	1.81	5.09	1.31	7.33	2.25	6.10**	3>1&2
VL 2nd trial easy	4.20	1.40	4.46	1.12	5.33	1.03	1.88	–
VL 2nd trial hard	0.60	0.52	0.63	0.60	2.00	1.55	9.08***	3>1&2
VL 3rd total	5.20	1.23	5.91	1.58	7.67	1.86	4.84*	3>1&2
VL 3rd trial easy	4.40	1.08	4.97	1.12	5.67	0.52	2.68	–
VL 3rd trial hard	0.80	0.42	0.94	0.64	2.00	1.55	5.62**	3>1&2
DI total	5.00	1.49	5.69	1.57	7.67	1.37	5.90**	3>1&2
DI easy	4.20	1.40	4.83	1.04	6.33	0.52	7.47**	3>1&2
DI hard	0.80	0.42	0.86	0.85	1.33	1.37	0.88	–
DR total	4.50	0.93	5.77	2.16	6.33	1.03	1.88	–
DR easy	4.25	1.17	4.66	1.41	5.67	0.52	2.13	–
DR hard	0.25	0.46	1.11	1.02	0.67	0.52	3.18	–
Word recognition	8.33	1.03	8.60	0.60	9.00	0.00	1.70	–
WRNP	0.67	0.52	0.22	0.53	0.00	0.00	2.89	–
BG copy	2.33	1.86	3.59	1.22	4.33	0.52	4.00*	2&3>1
BG recall	1.33	1.37	2.51	1.65	4.67	0.52	7.47***	3>1&2
Set shifting lines	4.67	3.14	6.57	2.98	8.00	1.55	2.05	–
Set shifting time	93.33	31.41	74.06	24.89	53.33	5.16	4.05*	3>1
DS forward	5.67	0.52	5.68	1.27	5.67	0.52	0.001	–
DS backward	2.33	0.52	2.59	1.28	2.33	0.52	0.22	–
Semantic spherical	2.33	0.52	4.36	1.56	5.67	0.52	8.66	1>2>3
Lexical fluency	1.00	1.16	3.49	2.08	4.00	1.55	3.27	-----
CN total	10.17	1.85	11.37	1.11	11.67	1.85	4.78*	2&3>1
CN correct	8.83	1.64	10.46	1.21	11.67	0.52	11.93***	3>2>1
CN stimulus cue	1.33	0.99	0.95	0.50	0.00	0.00	9.75***	1&2>3
CN phonemic cue	0.50	0.52	0.15	0.37	0.33	0.52	3.28	–
Abstraction	1.00	0.00	1.20	0.40	1.00	0.00	1.37	–
Judgment	1.00	0.00	1.00	0.00	1.00	0.00	–	–

VL verbal learning, *DI* distractor interval, *DR* delayed recall, *WRNP* word recognition novel prototype, *BG* Bender Gestalt, *DS* digit span, *CN* confrontation naming
1 = Dementia; 2= mild cognitive impairment; 3 = normal < 0.05 (*), < 0.01 (**), < 0.001 (***)
Level of significance among subgroups (normal, MCI and dementia) was expressed by *F* value. Post hoc test to measure the variations between subgroups in each battery test

MMSE was divided into three quadrants to measure normal, MCI, and dementia and to compare battery tests to it and mean and standard deviation for each battery subset in each group was determined. Then *F* value and post HOC were calculated to measure significance and to confirm where the differences occurred between groups using criterion group validity.

Following the measures taken by Morrison and colleges in 2015 [42] to test reliability, 20 participants were included in the pre-post sample to test reliability of the

Table 4 Significant *F* test for between groups accordingly to three quadrants of MMSE within educated (*N* = 106)

Variable	Lower (dementia)		Mediate (MCI)		Upper (normals)		*F* value	Post hoc (LSD)
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.		
Semantic fluency	8.44	6.64	10.02	3.84	18.95	5.60	40.5***	3>1&2
VL total	9.80	3.86	13.78	4.59	22.98	3.92	84.2***	3>1&2
VL total easy	9.60	3.84	12.49	3.39	16.86	1.37	49.8***	3>2>1
VL total hard	0.20	0.62	1.29	1.87	6.12	3.27	55.8***	3>1&2
VL 1st trial	2.80	1.44	3.73	2.09	6.29	1.76	31.6***	3>1&2
VL 1st trial easy	2.80	1.44	3.44	1.67	4.95	1.13	19.5***	3>1&2
VL 1st trial hard	0.00	0.00	0.29	0.72	1.33	1.10	23.8***	3>1&2
VL 2nd trial	3.20	1.36	4.95	1.64	8.10	1.23	94.1***	3>2>1
VL 2nd trial easy	3.20	1.36	4.44	1.23	5.98	0.15	59.5***	3>2>1
VL 2nd trial hard	0.00	0.00	0.51	0.75	2.12	1.17	52.1***	3>2>1
VL 3rd trial total	3.80	1.77	5.10	1.66	8.60	1.55	76.0***	3>2>1
VL 3rd trial easy	3.70	1.72	4.61	1.28	5.93	0.26	28.1***	3>2>1
VL 3rd trial hard	0.10	0.31	0.49	0.68	2.67	1.41	66.2***	3>1&2
DI total	3.70	2.11	5.20	1.72	8.55	1.23	75.0***	3>2>1
DI easy	3.60	1.96	4.76	1.34	5.74	0.50	20.7***	3>2>1
DI hard	0.10	0.31	0.49	0.81	2.81	1.09	98.8***	3>1&2
DR total	2.78	2.10	4.76	2.20	8.64	1.48	74.3***	3>2>1
DR easy	2.67	1.94	4.34	1.78	5.74	0.46	28.6***	3>2>1
DR hard	0.11	0.32	0.42	0.81	2.91	1.28	83.0***	3>1&2
Word recognition	7.00	2.42	7.95	1.18	8.91	0.37	14.9***	3>2>1
WRNP	2.88	3.63	1.12	2.08	0.10	0.28	11.7***	3>2>1
BG copy	2.13	1.96	4.29	0.64	4.55	0.50	40.4***	3&2>1
BG recall	0.88	1.20	3.10	1.86	4.33	0.76	35.5***	3>2>1
Set shifting lines	3.44	3.03	7.44	2.07	8.93	0.26	56.1***	3>2>1
Set shifting time	102.14	70.05	87.93	53.50	46.60	20.61	12.1***	1&>3
DS forward	5.80	1.71	5.83	1.05	6.57	1.31	4.2*	3>1&2
DS backward	3.20	1.44	3.71	1.54	4.53	1.34	6.5**	3>1&2
Semantic spherical	1.86	1.51	3.93	2.22	6.11	2.65	18.4***	3>2>1
Lexical fluency	3.78	3.21	4.37	1.91	8.60	3.25	28.7***	3>1&2
CN total	8.50	2.25	10.79	0.35	11.93	.35	12.5***	3>2>1
CN correct	6.20	5.23	10.10	2.15	11.25	1.28	22.2***	3&2>1
CN stimulus cue	2.88	3.32	0.69	0.90	0.68	1.27	11.7***	1>2&3
CNphonemic cue	0.75	1.69	0.79	1.41	0.08	0.35	4.3*	2>3
Abstraction	1.14	0.36	1.16	0.37	1.00	0.00	3.6*	2>3
Judgment	1.14	0.36	1.05	0.22	1.00	0.00	2.7	–

VL verbal learning, *DI* distractor interval, *DR* delayed recall, *WRNP* word recognition novel prototype, *BG* Bender Gestalt, *DS* digit span, *CN* confrontation naming
1 = Dementia; 2 = mild cognitive impairment; 3 = normal < 0.05 (*), < 0.01 (**), < 0.001 (***)
Level of significance among subgroups (normal, MCI and dementia) by *F* value
Post hoc test to measure the variations between the subgroups in each battery test

current study. The 20 participants took the battery and were invited to take the battery 28 days after the first administration by the same clinician. Test-retest reliability of the current battery was calculated with Pearson correlations and 95% CIs and Spearman's rho for each subtest.

The analytic test-retest reliabilities of the current battery scores ranged from adequate to high (i.e., r = .7 and higher) in most of the battery subsets. The values of some tests (distractor interval easy, visuospatial copy and recall, digit span length, spherical and letter fluencies) were lower

Table 5 Significant *F* test between Groups as regards education

ANOVA						
		Sum of squares	df	Mean square	*F*	Sig.
Semantic fluency	Between groups	79.688	2	39.844	1.062	.348
	Within groups	5926.262	158	37.508		
	Total	6005.950	160			
VL total	Between groups	46.969	2	23.484	.646	.526
	Within groups	5565.358	153	36.375		
	Total	5612.327	155			
VL total easy	Between groups	9.388	2	4.694	.337	.715
	Within groups	2133.920	153	13.947		
	Total	2143.308	155			
VL total hard	Between groups	28.357	2	14.179	1.490	.229
	Within groups	1455.970	153	9.516		
	Total	1484.327	155			
VL 1st trial total	Between groups	8.567	2	4.283	1.041	.356
	Within groups	629.792	153	4.116		
	Total	638.359	155			
VL 1st trial easy	Between groups	1.527	2	.763	.343	.710
	Within groups	340.954	153	2.228		
	Total	342.481	155			
VL 1st trial hard	Between groups	8.572	2	4.286	5.939	.003
	Within groups	110.421	153	.722		
	Total	118.994	155			
VL 2nd trial total	Between groups	8.118	2	4.059	.843	.432
	Within groups	736.722	153	4.815		
	Total	744.840	155			
VL 2nd trial easy	Between groups	2.197	2	1.099	.588	.557
	Within groups	286.027	153	1.869		
	Total	288.224	155			
VL 2nd trial hard	Between groups	1.889	2	.944	.723	.487
	Within groups	199.881	153	1.306		
	Total	201.769	155			
VL 3rd trial total	Between groups	1.867	2	.933	.176	.839
	Within groups	813.108	153	5.314		
	Total	814.974	155			
VL 3rd trial easy	Between groups	.907	2	.454	.262	.770
	Within groups	264.990	153	1.732		
	Total	265.897	155			
VL 3rd trial hard	Between groups	1.619	2	.810	.456	.635
	Within groups	271.817	153	1.777		
	Total	273.436	155			
DI total	Between groups	9.992	2	4.996	.951	.389
	Within groups	803.566	153	5.252		
	Total	813.558	155			
DI easy	Between groups	1.301	2	.650	.342	.711

Table 5 Significant *F* test between Groups as regards education *(Continued)*

ANOVA

		Sum of squares	df	Mean square	*F*	Sig.
	Within groups	290.616	153	1.899		
	Total	291.917	155			
DI hard	Between groups	5.575	2	2.787	1.587	.208
	Within groups	268.656	153	1.756		
	Total	274.231	155			
DR total	Between groups	28.234	2	14.117	1.979	.142
	Within groups	1062.865	149	7.133		
	Total	1091.099	151			
DR easy	Between groups	7.486	2	3.743	1.385	.254
	Within groups	402.724	149	2.703		
	Total	410.211	151			
DR hard	Between groups	9.382	2	4.691	2.288	.105
	Within groups	305.558	149	2.051		
	Total	314.941	151			
Word recognition	Between groups	3.007	2	1.503	.998	.371
	Within groups	218.419	145	1.506		
	Total	221.426	147			
WRNP	Between groups	31.474	2	15.737	4.982	.008
	Within groups	464.319	147	3.159		
	Total	495.793	149			
BG copy	Between groups	7.196	2	3.598	2.146	.120
	Within groups	251.445	150	1.676		
	Total	258.641	152			
BG recall	Between groups	11.098	2	5.549	1.710	.184
	Within groups	483.580	149	3.246		
	Total	494.678	151			
Set shifting lines	Between groups	10.046	2	5.023	.653	.522
	Within groups	1145.474	149	7.688		
	Total	1155.520	151			
Set shifting time	Between groups	6249.819	2	3124.909	1.639	.198
	Within groups	272670.099	143	1906.784		
	Total	278919.918	145			
DS forward	Between groups	3.730	2	1.865	1.133	.325
	Within groups	255.112	155	1.646		
	Total	258.842	157			
DS backward	Between groups	53.748	2	26.874	12.982	.000
	Within groups	316.732	153	2.070		
	Total	370.481	155			
Semantic spherical	Between groups	6.368	2	3.184	.512	.601
	Within groups	802.443	129	6.220		
	Total	808.811	131			
Lexical fluency	Between groups	251.672	2	125.836	13.032	.000
	Within groups	1361.488	141	9.656		

Table 5 Significant *F* test between Groups as regards education *(Continued)*

ANOVA						
		Sum of squares	df	Mean square	*F*	Sig.
	Total	1613.160	143			
CN total	Between groups	29.225	2	14.613	2.722	.069
	Within groups	859.033	160	5.369		
	Total	888.258	162			
CN correct	Between groups	24.805	2	12.402	1.608	.204
	Within groups	1234.042	160	7.713		
	Total	1258.847	162			
CN stimulus cue	Between groups	.044	2	.022	.010	.990
	Within groups	353.956	156	2.269		
	Total	354.000	158			
CN phonemic cue	Between groups	5.600	2	2.800	2.915	.057
	Within groups	147.916	154	.960		
	Total	153.516	156			
Abstraction	Between groups	.089	2	.044	.448	.640
	Within groups	14.158	143	.099		
	Total	14.247	145			
Judgment	Between groups	.104	2	.052	2.014	.137
	Within groups	3.789	147	.026		
	Total	3.893	149			

VL verbal learning, *DI* distractor interval, *DR* delayed recall, *WRNP* word recognition novel prototype, *BG* Bender Gestalt, *DS* digit span, *CN* confrontation naming

($r < 0.7$). These results match the validation results of Calamia and colleges in 2013 [43] which revealed reliability in most of their results except for some memory and executive functioning scores which in both studies could be contributed to practice effects.

Calamia and collegues in 2012 [44] reported in their meta-analysis that practice effects tend to be more evident on certain tests (e.g., memory, processing speed, which can affect recall, spherical, and letter fluencies respectively) than others (e.g., visuospatial abilities, verbal knowledge), with considerable variability within different cognitive domains and some variation with different methods of assessment. They also reported that age, retest interval whether long or short could influence the amount and direction of practice effects.

For validation purpose of the current study, significance between battery tests in normal and dementia patients diagnosed according to and DSM-IV criteria for dementia were measured; results showed significant difference in most of the battery tests; verbal learning, distractor interval, delayed recall, word recognition, figure copying and recall, modified trails, confrontation naming, and abstraction. However, there was no significance between normal and dementia patients regarding digit span, stimulus cueing of confrontation naming, and judgment (judgment almost reached a statistical significance).

Upon classifying the battery tests according to three quadrants of MMSE into normal, MCI, and dementia, among the group with > 9 years education, most battery tests showed highly significant difference between 3 subgroups (e.g., verbal learning, word recognition, figure copy and recall, delayed recall, distractor interval, set shifting time, confrontation naming, digit span backward, lexical and semantic fluency) with less extent of significance for digit span forward, phonemic cueing of confrontation naming, and abstraction.

In illiterate and low-educated people, there was statistically significant difference between the 3 groups regarding semantic fluency, verbal learning, figure copy and recall, distractor interval, set shifting time, and confrontation naming. However, digit span forward and backward, phonemic cuing of confrontation naming, abstraction, and judgment showed no difference.

Overall, the battery showed good ability to differentiate between normal, MCI, and dementia people and the study showed that the battery is valid and reliable to diagnose MCI and dementia.

Regarding education, the current study showed no statistically significant association between levels of education and the following tests; verbal learning, distractor interval, delayed recall, word recognition, visuospatial figure copying and recall, set shifting abilities, forward digit span, animals and spherical fluencies, confrontation

naming, stimulus and phonemic cuing, abstraction, and judgment. This denotes the ability of the battery to be applied on illiterate subjects. However, there was highly statistically significant difference regarding backward digit span and letter fluency.

These results are concordant with Kwon et al.'s [45] results which showed insignificance in forward digit span, verbal word recognition, and animals' fluency regarding education. However, their study stated that the performance of the illiterate subjects was worse than that of literate subjects in visuospatial functions and verbal learning test.

The difference between their study and the current study in visuospatial functions could be attributed to the more complexity of Rey-Osterrrieth figure used in their study in comparison to the simple Bender copy in the current study and to the more time delay (20 min) in comparison to 10 min in the current study. Kwon et al. 2015 [45] applied the Seoul Verbal Learning Test (SVLT) which is formed of three learning-free recall trials of 12 words which is more difficult than the paired associate of Wechsler applied in the current study which compresses three learning associate recall trials of 10 words.

A study done in Turkey by Akdag and colleagues in 2013 [46] using Hodkinson Abbreviated Mental Test (which assessed working, short and long-term memory, attention, orientation, and general fund of information) to screen for dementia in elderly people also found no effect of education on cognitive function.

The new battery of current study will be under the name of Ain Shams Cognitive Assessment (ASCA) scale.

Conclusions

New valid and reliable neurocognitive diagnostic evaluation battery that can differentiate between normal, MCI, and dementia in both educated and illiterate subjects in Egyptian population under the name of Ain Shams Cognitive Assessment (ASCA) scale is now available.

Limitation of the study

Larger studies are needed for correlation between various types of dementia and test results. Imaging were lacking in most of the participants; so localization of damaged brain areas and correlation with test scores could not be done.

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Authors' contributions

All authors designed the study. EN managed collection of data from study subjects and THM managed analysis of data in preparation for statistical analysis. EN and THM wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

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Availability of data and materials

Not applicable.

Ethics approval and consent to participate

The study was approved by Faculty of Medicine Ain-Shams University (FMASU) Research Ethics Committee (REC) on 26/6/2016 with reference number 156/2016. The FMASU REC operated according to guidelines of the International Council on Harmonization and the Islamic Organization for Medical Sciences, the United States Office for Human Research Protections and the United States Code of Federal Regulations and operates under Federal Wide Assurance No., FWA 000017585.

Consent for publication

A written consent was obtained from all participants; described below in details.

Competing interests

The authors declare that they have no competing interest.

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