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ORIGINAL ARTICLE

Early detection of memory impairments in older adults: standardization of a short version of the verbal and nonverbal Recognition Memory Test

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Abstract

In several neurological conditions, in elderly and cognitively impaired subjects, memory functioning must be evaluated to early detect the cognitive deterioration processes. In particular, recognition memory assessment is an essential step in the clinical and neuropsychological evaluation of early memory impairments. The Recognition Memory Test (RMT) developed by Smirni et al. (G Ital Psicol XXXVII(1):325–343, 2010) is an effective instrument to assess verbal and nonverbal recognition memory in the Italian population. The current study provides a new, brief, and reliable RMT format to evaluate recognition memory on elderly subjects and it reports normative data in an older adult Italian population sample (including 100 participants well distributed across sex, education, and age categories). The shortened version of RMT keeps the administration procedures and materials of the original Italian RMT constant, i.e., words, faces, and buildings. Multiple regression analysis revealed significant effects of age and educational level on performance but no effect of sex. Inferential cutoffs have been determined and equivalent scores computed. The availability of equivalent scores for the Recognition Memory Test will prove useful in the clinical evaluation of patients' memory profiles.

Keywords Memory assessment · Recognition memory · Shorter form · Elderly evaluation

Introduction

Differentiating early neurodegenerative disorders from normal aging is currently one of the main requests for neuropsychological evaluation. Screening will become increasingly important as the elderly population grows, because dementia prevalence dramatically increases with age, and most dementia detection will occur at the primary rather than specialty care level [1]. The use of brief, reliable, and simple tools can make primary care screening more effective. Administration time is considered a critical determinant of the acceptability of routine dementia screening [2]. Neuropsychological measures are the main tool for early detection of memory loss. In a previous study, we developed and standardized the original battery of verbal and nonverbal Recognition Memory Tests (RMTs) to assess objective memory deficits in neurodegenerative diseases in Italian population [3, 4]. The RMT is composed of three subtests, each one evaluates different components of memory: verbal (i.e., words) and nonverbal memory (i.e., unfamiliar faces and unknown buildings).

The application of the RMT validated by our group has been repeatedly tested also in experimental studies in both healthy subjects and neurological patients [5–11].

However, in the clinical setting, we observed that older test-taker showed a cognitive overload during the administration of the three subtests of the RMT. Our instrument, even if

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adequately reliable to identify even minor memory deficits, required a cognitive burden extremely heavy in terms of attention maintenance, and memory, especially with older and/or deteriorated subjects. In fact, the administration of all three subtests of the RMT takes about 20 min, and on impaired subjects even a little more. Considering that the RMT is usually included in a larger tests battery that also investigates other cognitive skills, it would be a too demanding task for the weaker subjects (i.e., elderly and cognitively impaired subjects).

Following these clinical observations, we decided to develop a new tool that would be more appropriate for the evaluation of recognition memory on elderly subjects.

Furthermore, in literature, short forms have been often reported for neuropsychological tests. Such as, a short version of the Boston Naming Test [12] was developed for individuals with aphasia, since the administration of the full 60 items of the Boston Naming test resulted lengthy and time-consuming [13]. A short version of the California Verbal Learning Test (CVLT) [14] has been developed, reducing the list from 16 items and four categories to nine items and three categories [15]. This nine-item CVLT version was developed to prevent cognitive overload in older test-takers and has been used with stroke and dementia patients as well as frail elderly. The nine-item CVLT had good psychometric properties, and that it has become a reasonable alternative to the standard 16-word CVLT among subjects who are obviously impaired [15]. In the Italian population, short forms for neuropsychological tests have also been reported, such as the short version of the Stroop test [16–17] and the modified version of the Wisconsin Card Sorting Test [18, 19].

The aim of this study was to develop a shorter version of the RMT test that preserved the psychometric characteristics of the original 30-items RMT test and was more discriminating on a population of elderly subjects. The second aim of the current study was to provide normative data in an Italian population sample over 50. The availability of equivalent scores for the RMT provides a useful tool in neuropsychological assessment and it could prove useful in the clinical evaluation of patients' memory profiles [4]. Furthermore, RMT equivalent scores allow comparison of the recognition memory performances with those on other neuropsychological tests for which normative values collected with similar methodological criteria are already available for the Italian population.

This study provides normative data on the short form of the Italian RMT for words, unfamiliar faces, and unknown buildings. For this purpose, we administered short form of the RMT to a normative sample of 100 healthy subjects who varied in age, years of education, and sex. Normative data relative to performance scores on the three tests of the short RMT will be reported.

Materials and methods

Participants

A sample of 100 healthy volunteers (mean age 64.37 ± 8.43 years, range 50–79; mean education 12.08 ± 4.54, range 5–18), including 46 males and 54 females, participated in this study (Table 1). Inclusion criteria for participations were as follows: (1) age between 50 and 79 years and (2) at least 5 years of formal education. Exclusion criteria were as follows: (1) cognitive impairment based on Mini Mental State Examination [20] score < 26, (2) subjective complaining of memory or other cognitive impairments, and (3) psychiatric or neurological disorders. The samples were subdivided into three groups, one for each decade of age. Number of males and females was counterbalanced across the three groups (Table 1).

Materials

In order to shorten the previous version of the RMT, for each subtest, 20 items were selected from the pool of the 30 original RMT items using the *items difficulty analysis*. The performances of subjects aged between 50 and 79 to the administration of the three subtests of the original 30-item RMT of our previous study [4] were analyzed. For each item, the percentage of errors committed by the chosen sample was computed. Each item has been ranked in the order of difficulty, that is, in ascending order based on the percentage of errors committed. For each subtest, items with the same level of difficulty were selected.

The characteristics of the testing materials used were extensively described in our previous study [4]; therefore, we will only provide a brief outline.

The three subtests evaluate different components of memory for words, unfamiliar faces, and unknown buildings.

Recognition Memory Test for words

The stimuli used in the verbal Recognition Memory Test were concrete and abstract words adapted from Bertinetto et al. [21], comparable in frequency of use (mean 7.89 ± 4.29). The words had a length from four to six letters and were

Table 1 Demographic characteristics of the normative sample

Decade	Number	M/F	Age (mean years)	Education (mean years)
50–59	32	15/17	55.03	13.38
60–69	36	16/20	63.53	12.72
70–79	32	15/17	74.65	10.06
Total	100	46/54	64.37	12.08

M males, *F* females

written in capital letters in an A4 sheet. In the recognition phase, each target word has been paired with two words selected as distractors based on semantic or phonemic proximity with the target word.

Recognition Memory Test for unfamiliar faces

The stimuli were black and white photograph printed in an A4 sheet of unfamiliar faces of Caucasian young women, approximately 25 years old, with Italian physiognomy characteristics, expressive neutrality, and no special signs. In the recognition phase, each target face has been coupled to other two faces chosen as distractors with physiognomic features similar to the target, i.e., haircut and color, eye shape and color, and nose and mouth shape.

Recognition Memory Test for unknown buildings

The stimuli were black and white photos printed in an A4 sheet of unknown buildings, with typically Italian architectural features, stylistic neutrality, absence of specific connotations, and possible verbal cues (for example, civic number and street names). In the recognition phase, each target building has been paired with two buildings of the same type: the palaces were coupled with other palaces and houses with other houses.

The administration order of the three subtests (i.e., words, buildings, faces) was counterbalanced across and randomly assigned to subjects.

Methods

The three subtests had the same administration procedure. The order of administration of the three subtests was randomized. For each subtest, there were two phases, one for study and one for recognition. In the study phase, the 20 target stimuli were individually displayed with a 3-s interval per item. In the recognition phase, proposed immediately after the end of the study phase, three stimuli were presented simultaneously: the target stimulus and two distractors. The targets were distributed randomly to the top, bottom, or center of the sheet. The subject was asked to recognize, among the three items, the one previously seen in the study phase. The order of presentation of the stimuli of the recognition phase was different from that of the study phase. The number of correct answers gives the score of each subtest. Overall, the three subtests can be administered in about 10 min.

Statistical analyses

The normality of the three subtests score distribution by means of the Kolmogorov–Smirnov test was first examined. To determine whether the three subtests (i.e., words, faces, and buildings) were equivalent with each other as to the level of difficulty, correlational analyses (by means of Pearson's r) among scores obtained for the three subtests of the short RMT were performed. Then, we compared scores on the three subtests of the short RMT using one-way ANOVAs.

ANOVA analyses were performed to investigate the effects of age, sex, and education (years of schooling) on recognition memory performance. For demographic variables that significantly affect the performances, the best fitting linear regression model that could be used to adjust original scores according to the demographic variables was computed. The multiple regressions included the variables that resulted significant when considered one at a time. Taking this model as a basis, we calculated from the raw score an adjusted score, by adding or subtracting the contribution given by each significant concomitant variable in the final correction model. Following this approach, scores can be directly confronted across subjects of different demographic data. Adjusted scores were then ranked, and by means of a non-parametric procedure [22], tolerance limits were set, for the three subtests. A score was considered normal if it lies within the highest 95% of the population and abnormal if it falls within the lowest 5% of the population. Inferential cutoff scores were then derived and these defined the score at which or below which the probability that an individual belonged to the normal population was less than 0.05. Scores equal to or lower than the cutoff score were considered abnormal. Corrected scores were then transformed into a five-point interval scale, from 0 to 4 equivalent scores [23]. The equivalent scores were classified with an ordinal relationship: 0 = scores lower than the cutoff; 4 = scores higher than the median value of the sample; 1, 2, and 3 = intermediate scores between the central value and the limit cutoff on an interval scale.

Furthermore, to compare the original 30-item version to the short 20-item version of the RMT, correlational analyses between each subtest of the two versions of the RMT were carried out and as a further comparison, we also calculated the percentages of correct answers given to the two versions of the RMT. To compare similar age groups, these latter analyses were computed considering only memory performances among subjects aged between 50 and 79 in our previous study [4].

All statistical analyses were performed by SPSS statistical package.

Results

Kolmogorov–Smirnov's test for the distribution of scores showed a normal distribution for the three subtests, with a p value > .05 (RMT for words: $p = .20$; RMT for faces: $p = .22$; RMT for buildings: $p = .21$).

Analyses were computed to examine correlations within the three subtests of the short RMT. There were significant positive correlations between the three subtests (short RMT for words vs short RMT for faces $r = .88$, $p < .0001$; short RMT for words vs short RMT for buildings $r = .89$, $p < .0001$; short RMT for faces vs RMT for buildings $r = .90$, $p < .0001$). Table 2 shows these correlational analyses within each age group.

The repeated measures ANOVA (three-subtest scores as within subjects factor) did not show significant differences in the whole sample on the three subtests [F (1,99) = 2.42, $p = .12$]. Similarly, the ANOVAs did not show significant differences in the scores of the three subtests for each decade of age. Table 3 shows average scores, standard deviation, and ANOVAs of the normative sample divided by decades of age in the three subtests.

One-way ANOVAs were performed to investigate the effects of age, sex, and education on the recognition performance of the short RMT. The predictive capacity of the age and education independent variables reached a significant probability level ($p < .0001$) for all three subtests [*Age*: short RMT for words: F (2,97) = 42.8; short RMT for faces: F (2,97) = 34; short RMT for buildings: F (2,97) = 32.3; *Education*: short RMT for words: F (5,94) = 6.8; short RMT for faces: F (5,94) = 7.8; short RMT for buildings: F (5,94) = 7.5]. Instead, the independent sex variable did not reach a significant probability level [short RMT for words: F (1,98) = 1.4, $p = .24$; short RMT for faces: F (1,98) = 1.7, $p = .19$; short RMT for buildings: F (1,98) = 1.7, $p = .19$]. Males and females had similar performances in all subtests of the short RMT.

The correction scores were carried out following the statistical methodology proposed by Capitani [23]. The linear regression coefficients between individual test scores and age and education levels were calculated using the logarithmic transformation of age [Log (100-age)] and the square root of number of years of education. By developing the best fitting linear regression analysis for the different values of both significantly independent predictive variables, it was possible to calculate corrected scores to be applied to the raw scores obtained in the tests. Table 4 reports the correction grid for the most frequent combinations of age and education. The intermediate values can be obtained by interpolation or using the original linear regression analysis reported below Table 4. The equivalent scores were determined for the short RMT already corrected for age and education to allow comparison of the performance of each individual with the standardization sample.

Given our sample size and the type of test, we identified the tenth position of the distribution as the demarcation line, so we consider pathological the ten lowest performances. The lower performances represent 10% of the standardization sample (10: 100 = x: 100 from which $x = 1000/100 = 10$). Considering the cutoff of 10%, the remaining part below the median is (50–10) 40%. From the normal distribution table, we verified that an area of 40% is the one identified by a deviation slightly more than -1.28 Z points. To calculate the equivalent scores, we divided the deviation by -1.28 in three equal parts and we obtained $-1.28/3 = Z\ -0.42667$. The values delimiting the equivalent scores (ES) are reported in Table 5.

Furthermore, there were significant positive correlations between the three subtests of the original 30-item RMT and the three subtests of the short 20-item RMT (RMT for words original vs short: $r = .80$, $p < .0001$; RMT for faces original vs short: $r = .79$, $p < .0001$; RMT for buildings original vs short: $r = .79$, $p < .0001$). A further analysis to compare the original and the short versions of the RMT involved the percentage of correct answers to each subtest of both the original 30-item version and the short 20-item version. This analysis showed that the original 30-item RMT was more difficult for elderly subjects (RMT for words original 30-item 73.8% of hits; RMT for faces original 30-item 73% of hits; RMT for buildings original 30-item 72% of hits vs RMT for words short 20-item 80.8% of hits; RMT for faces short 20-item 80.4% of hits; RMT for buildings short 20-item 79.9% of hits).

Table 2 Correlation indices between the three subtests of the short RMT in the normative sample divided by decades of age

Decade	Short RMT		
	Words/faces	Words/buildings	Faces/buildings
50–59	.78	.81	.81
60–69	.78	.81	.82
70–79	.79	.81	.83
Total	.88	.89	.90

All correlations are significant $p < .0001$

Table 3 Average scores, standard deviation, and ANOVA of the normative sample divided by decades of age in the three tests

Decade	RMT $W_{(s.d.)}$	RMT $F_{(s.d.)}$	RMT $B_{(s.d.)}$	$^{(df)}F$	p
50–59	17.9 (1)	18.1 (1.5)	17.7 (1.3)	$^{(1,31)}2.71$	.11
60–69	16.7 (2)	16.6 (2.5)	16.5 (2.3)	$^{(1,35)}1.22$	.28
70–79	13.8 (2.2)	13.4 (2.7)	13.7 (2.4)	$^{(1,31)}.53$	.59
Total	16.2 (2.5)	16.1 (3)	16 (2.6)	$^{(1,99)}2.42$	.12

RMT W short Recognition Memory Test for Words, *RMT F* short Recognition Memory Test for Faces, *RMT B* short Recognition Memory Test for Buildings, *s.d.* standard deviation, *df* degrees of freedom, *F* Fisher's test, *p p* value

Table 4 Adjustments to be added to, or subtracted from, the raw scores of the short Recognition Memory Test according to age (expressed in years) and education (expressed in years)

Short Recognition Memory Test												
Age	RMT Words				RMT Faces				RMT Buildings			
	Education				Education				Education			
	5	8	13	18	5	8	13	18	5	8	13	18
50	− 0.8	− 1.5	− 2.4	− 3.1	− 0.8	− 1.7	− 2.9	− 3.8	− 0.7	− 1.4	− 2.4	− 3.2
55	− 0.2	− 0.9	− 1.7	− 2.5	− 0.1	− 1	− 2.1	− 3.1	− 0.1	− 0.8	− 1.8	− 2.6
60	+ 0.5	− 0.2	− 1.1	− 1.8	+ 0.7	− 0.2	− 1.3	− 2.2	+ 0.6	− 0.1	− 1.1	− 1.9
65	+ 1.3	+ 0.6	− 0.3	− 1	+ 1.6	+ 0.8	− 0.4	− 1.3	+ 1.4	+ 0.7	− 0.3	− 1.1
70	+ 2.1	+ 1.5	+ 0.6	− 0.1	+ 2.7	+ 1.8	+ 0.7	− 0.2	+ 2.3	+ 1.6	+ 0.6	− 0.2
75	+ 3.2	+ 2.5	+ 1.6	+ 0.9	+ 4	+ 3.1	+ 2	+ 1	+ 3.4	+ 2.7	+ 1.7	+ 0.8
80	+ 4.5	+ 3.8	+ 2.9	+ 2.2	+ 5.5	+ 4.7	+ 3.5	+ 2.6	+ 4.7	+ 4	+ 3	+ 2.2

RMT short Recognition Memory Test. Best fitting linear regression analysis: {intercept + [β coefficient age (Log $^{(100\text{-età})}$)] + β coefficient education (√education)}. RMT Words: intercept − 8.23795, β coefficient age 13.34403, β coefficient education: 1.136793. RMT Faces: intercept − 13.6314; β coefficient age 16.03762, β coefficient education 1.476727. RMT Buildings: intercept − 9.3198, β coefficient age 13.61113, β coefficient education 1.277857

Discussion

In this study, the construction and standardization of a short form of a battery of three verbal and nonverbal Recognition Memory Tests were presented. The main aim of this study was to develop a shorter version of the RMT to quickly and reliably detect early memory deficit among memory impaired patients and frail elderly subjects. We collected normative data in an Italian population sample over 50.

We computed internal consistency of the short RMT and emerged high positive correlations between the three subtests, and no significant differences between the three subtests in the overall sample and in each group of age at the ANOVA analyses. So, the three subtests (words, faces, and buildings as stimulus materials) of the short Recognition Memory Test were equivalent for difficulty.

Table 5 Equivalent scores (ES) classification of adjusted scores of the short RMT

Short Recognition Memory Test			
	RMT W Score range	RMT F Score range	RMT B Score range
ES = 0	0–12.8	0–12.2	0–12.6
ES = 1	12.9–13.9	12.3–13.4	12.7–13.6
ES = 2	14–15	13.5–14.7	13.7–14.8
ES = 3	15.1–16.1	14.8–16	14.9–15.9
ES = 4	≥ 16.2	≥ 16.1	≥ 16

ES equivalent scores, *RMT W* short Recognition Memory Test for Words, *RMT F* short Recognition Memory Test for Faces, *RMT B* short Recognition Memory Test for Buildings

The short RMT has been standardized in a sample of normal subjects of different ages (from 50 to 79) and education (from 5 to 18 years of formal education) of both sexes. The performances on the three subtests of the short RMT were significantly influenced by age and schooling level. Therefore, a correction factor for age and education was calculated. The sex factor did not contribute significantly to determining the performance level. Inferential cutoffs have been determined and equivalent scores computed.

The availability of normative data for the short RMT will be very valuable in clinical settings for testing patients with amnesias resulting from diffuse or focal lesions, and in dementia deterioration or neurodegenerative brain diseases. The use of reference norms will permit a better characterization of the patient's memory impairments. Furthermore, it is well known that the availability of equivalent scores of a test proves useful in neuropsychological assessment. It allows comparison of the scores obtained in the recognition memory with those in other tests for which normative values are available in the Italian population obtained with similar psychometrical methods.

Furthermore, correlational analyses were computed between the original 30-item RMT and the short 20-item version to compare reliability of the new version of the test. Analyses revealed high and positive correlations between the two versions of the Recognition Memory Test. Moreover, the data revealed that in the short version of the RMT the elderly subjects have a higher percentage of correct answers compared to the original 30-item RMT. This means that the short version of the RMT is more discriminating for low-level performance, therefore more suitable for elderly subjects.

In sum, these data show that the short version of the RMT maintains the psychometrical characteristics of the original 30-item RMT while being more discriminating in the detection of memory deficit in elderly subjects.

However, because of high prevalence and social costs of amnesias and neurodegenerative diseases such as dementia in late life, a growing consensus favors cognitive screening as part of routine primary care of the elderly [2]. Dementia is a major cause of impairment among the elderly; identifying dementia in primary care could minimize the impact of a late intervention [24]. In the last few years, investments to create tools to detect the early memory disorder have been made. In 2013, a workshop recruited by the Alzheimer's Foundation of America and the Alzheimer's Drug Discovery Foundation developed a report with recommendations for improving the early detection and clinical care for dementia [25]. One of the recommendations involved the implementation of cognitive screening practices in personalized healthcare. The consensus considered cognitive screening as part of the dementia care. Currently, more than ever, there is a need for fast and reliable memory assessment tools that allow a first screening to differentiate early neurodegenerative disorders from normal aging.

In conclusion, these short RMT could be considered a valid and reliable tool for identifying impairments in the recognition memory in Italian elderly subjects. Furthermore, it allows quick and reliable evaluating of different components of the anterograde memory. In particular, both verbal and nonverbal memory can be individually evaluated, both for unfamiliar faces and for topographic stimuli (buildings).

Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

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