O R I G I N A L

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Rey-Osterrieth complex figure: normative values in an Italian population sample

Abstract The Rey-Osterrieth complex figure test (ROCF) is a neuropsychological test extensively used in clinical practice to investigate visuospatial constructional functions, visuographic memory and some aspects of planning and executive function. The aim of the present study was to collect normative values in an Italian normal population sample (n=280) for the direct copying and delayed (10 min) reproduction of the ROCF. Multiple regression analysis revealed significant effects of age and education on performance of both copying tasks, whereas sex appeared to affect only performance on the delayed copying task. Inferential cut-offs have been determined and equivalent scores computed. The availability of equivalent scores for the ROCF will prove useful in clinical assessment since it allows the comparison of a subject's performance on the ROCF with that on other neuropsychological tests for which normative values collected with similar methods are already available for the Italian population.

Key words Rey figure · Normative data

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Introduction

The Rey-Osterrieth complex figure test (ROCF) [1, 2] is widely used in clinical and research settings to assess a variety of cognitive abilities. ROCF consists of the direct copying of a complex bidimensional figure and of its recollection from memory after a given delay. The test was first developed by Rey in 1941 and has proved to be a useful tool to analyse the integrity of non-verbal memory, visuospatial abilities, planning, organisational and problem-solving strategies, and perceptual, motor and visuoconstructional functions. One study used ROCF to determine visuoperceptual and visual memory deficits in a variety of clinical populations [3]. ROCF has also found application in the study of hemispheric differences and distinctive patterns of execution resulting from left or right brain damage. Preserved recall of the overall structure of the figures with simplification and loss of details is observed after left brain lesions, whereas qualitative errors in the copying and in the delayed reproduction from memory of the figures are produced by right-brain-damaged patients due to faulty visuospatial processing [3–5].

Patients with posterior brain lesions (i.e. parietal-occipital) also have difficulties in the spatial organisation of the drawing, probably because of visual disorientation, while patients with anterior brain lesions (mainly in the frontal lobe) show impairment in their strategic approach to reproduction; this latter deficit has been justified with the loss of programming abilities usually observed after frontal damage [6, 7]. ROCF has also been useful to detect deficits in object orientation knowledge [8, 9]. ROCF is widely used as part of extended neuropsychological batteries administered to patients with dementia, especially patients with Alzheimer's disease (AD). AD patients in the early stage of the disease do poorly on this test [10–12].

Although ROCF is commonly included in standard neuropsychological batteries [7, 13–16] and although several publications reported data from relatively large samples (within several age ranges and cultural backgrounds [2, 17–20]) no cut-off values have been established to deter-

mine when performance, either in the copying or in the delayed recall, can be considered abnormal. Age and education have a strong effect on performance [18, 21–24]. Most of the available normative studies provided either percentile scores or means and standard deviations for defined age classes relying, therefore, on z scores for establishing whether performance was within normal limits. The only exception is the study by Bertolani et al. [17], which provided internal and external tolerance limits, but these limits were derived from a relatively small sample (104 participants). Percentile scores and z scores, however, both have psychometric shortcomings since they either represent the score distribution in the tested population (i.e. percentile score) or compare an individual's performance to the mean of the reference sample (i.e. z score). Neither method is based on evaluating performance against inferential cut-offs established by calculating tolerance limits based on the tested sample; therefore, normality judgements cannot be made with a controlled inferential risk [25]. The psychometric technique of establishing inferential cut-offs based on large population samples has been widely adopted for standardising most of the neuropsychological measures used in Italian laboratories [26, 27] and has been more recently adopted for standardising some measures in the British population [28].

The aim of this study was to collect normative data for ROCF in a large Italian population sample with an age ranging from 20 to 89 years, to evaluate the effects of age, education and sex on performance and to calculate inferential cut-off scores for both copying and delayed recall scores. Furthermore, following a technique which has been frequently adopted for the standardisation of most neuropsychological tests used to test the Italian population, a transformation of row scores into equivalent scores [29] was performed. The availability of equivalent scores will be useful to compare scores achieved on ROCF with those obtained on other neuropsychological tests. This will allow a better identification of selective deficits on this test. In addition, since ROCF is often included in neuropsychological batteries used to evaluate the overall cognitive profile in dementia, having equivalent scores for this test as well will allow a better characterisation of impaired and spared abilities, independently of task difficulties, improving, therefore, clinical diagnosis.

Materials and methods

Two hundred eighty healthy Italian volunteers equally distributed for age classes (age range, 20–89 years), sex (140 women and 140 men) and education (from primary to university) took part in this study (Table 1). The mean age was 53.98 years (SD, 19.80) and the mean years of education was 11.10 years (SD, 4.81). All subjects were in good health; individuals were excluded if they had: a current or past history of alcohol or/and drug abuse; depression and/or other psychiatric diseases; history of brain injury, stroke or dementia as defined by DSM IV criteria; memory impairment or any other neurological illness. They were also excluded if their minimental state examination (MMSE) score was lower than 24 out of 30. Individuals with mild hypertension and well-compensated type II diabetes were not excluded.

The original ROCF was used [1]. Scoring followed the procedure described in the original manual [30]. ROCF includes 18 units and the maximum score for each of the two tasks (direct and delayed copying) is 36. Two points are given when the element is correctly reproduced, 1 point when the reproduction is distorted, incomplete but placed properly, or complete but placed poorly; 0.5 point is credited when the element is distorted or incomplete and placed poorly. A zero score is given when the unit is absent or not recognisable.

To perform the ROCF, a figure was placed in front of the subject, who was requested to copy the figure as accurately as possible. Different coloured pencils were made available. We followed the procedure described by Meyers and Meyers [31], which involves changing the colour of the pencil when an element in the figure is completed. This procedure is useful in appraising a subject's strategic approach to copying. When copying the figure was completed, the stimulus was removed from sight. After a 10-minute delay, subjects were asked to reproduce the figure from memory without forewarning. The delay interval was filled with a distracting verbal task. Several delay intervals have been used in previous studies [13, 32–35]; we adopted the procedure used in Bertolani et al.'s [17] study, in which a 10-minute delay was used.

Table 1 Demographic distribution of the sample. Values are numbers of subjects

Schooling, years	Age, years							Total
	20-29	30-39	40-49	50-59	60-69	70-79	80-89	
≤5	–	–	10	10	10	10	10	50
6-8	12	12	10	10	10	10	10	74
9-13	14	14	10	10	10	10	10	78
≥14	14	14	10	10	10	10	10	78

This delay is also commonly used in the assessment of delayed recall in the Italian version of the prose memory test [36].

Results

Multiple regression analyses were performed to assess the influence of sex, age and educational level on the participants' performance on the direct copying ($F_{(3,276)}$=46.441, p<0.0001) and delayed recall ($F_{(3,276)}$=69.340, p<0.0001) of ROCF. Sex did not influence performance in the direct copying task (t=-0.291, n.s.) while it had a significant effect in the delayed recall task (t=4.596, p<0.0001). Age had a significant effect on both direct copying (t=-9.769, p<0.0001) and delayed recall (t=-12.397, p<0.0001) scores. Similarly, education significantly affected performance on both the direct copying task (t=4.638, p<0.0001) and the delayed recall one (t=3.189, p=0.0016). Correction grids (Tables 2 and 3) were derived to adjust, when appropriate, the performance of each individual for age, education and sex.

Because of the skewness towards the top score, tolerance limits were computed by means of a non-parametric procedure [37]. A score is considered normal if it lies within the highest 95% of the population and abnormal if it falls within the lowest 5%. Inferential cut-off 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 cut-off score were considered abnormal. Corrected scores were then transformed into a five-point interval scale, from 0 to 4 equivalent scores [29]. Tables 4 and 5 show the equivalent scores for the direct copying and delayed recall of the ROCF, respectively.

Direct copying and delayed recall performance were scored by two independent raters. The inter-rater reliability for direct copying scores was r=0.96 (p<0.0001), whereas for delayed recall scores it was r=0.99 (p<0.0001).

Table 2 Correction grid for the direct copy of ROCF

Schooling, years	Age, years														
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
≤5	-2.00	-1.50	-1.00	-0.50	-0.25	0.25	0.75	1.25	1.50	2.00	2.50	2.75	3.25	3.75	4.25
6–8	-2.50	-2.00	-1.50	-1.00	-0.75	-0.25	0.25	0.50	1.00	1.50	2.00	2.25	2.75	3.25	3.75
9–13	-3.50	-2.75	-2.50	-2.00	-1.50	-1.00	-0.75	-0.25	0.25	0.75	1.00	1.50	2.00	2.25	2.75
14–17	-4.00	-3.50	-3.00	-2.75	-2.25	-1.75	-1.25	-1.00	-0.50	0	0.50	0.75	1.25	1.75	2.25

Adjusted score = raw score - [(age - 53.98) x - .087] - [(education - 11.10) x .171]

Table 3 Correction grid for delayed recall of ROCF

Schooling	Age, years														
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
≤5 years															
Men	7.50	-6.50	-5.50	-4.25	-3.25	-2.0	-1.00	0	1.25	2.25	3.25	4.50	5.50	6.75	7.75
Women	-4.50	-3.25	-2.25	-1.25	0	1.00	2.25	3.25	4.25	5.50	6.50	7.50	8.75	9.75	11.00
5–8 years															
Men	-8.25	-7.25	-6.00	-5.00	-4.00	-2.75	-1.75	-0.75	0.50	1.50	2.75	3.75	4.75	6.00	7.00
Women	-5.25	-4.00	-3.00	-1.75	-0.75	0.25	1.50	2.50	3.50	4.75	5.75	7.00	8.00	9.00	10.25
9–13 years															
Men	-9.50	-8.25	-7.25	-6.25	-5.00	-4.00	-3.00	-1.75	-0.75	0.50	1.50	2.50	3.75	4.75	5.75
Women	-6.25	-5.25	-4.00	-3.00	-2.00	-0.75	0.25	1.25	2.50	3.50	4.75	5.75	6.75	8.00	9.00
14–17 years															
Men	-10.5	-9.25	-8.25	-7.00	-6.00	-5.00	3.75	-2.75	-1.75	-0.50	0.50	1.75	2.75	3.75	5.00
Woman	-7.25	-6.25	-5.00	-4.00	-2.75	-1.75	-0.75	0.50	1.50	2.50	3.75	4.75	6.00	7.00	8.00

Adjusted score = raw - [(1 if male; 0 if female -0.5) x 3.158] - [(age - 53.98) x - .219] - [(education - 11.10)] x .233]

Discussion

The standardization of cognitive measures in the normal population may sometimes suffer from a not optimal age-class distribution. In this study, this was minimised by balancing, as much as possible, the distribution of the three variables under study. The findings show a significant effect of age on performance in both the direct copying and delayed recall of ROCF. This is in agreement with previous normative studies that have all shown a considerable decrement in performance with ageing [18, 21–24]. Education also had a significant factor in this study, and the results are in line with other studies [18, 22, 24]. More controversial is the effect that sex had on performance of ROCF. In this sample, sex had a significant effect only on those aspects of the task involving memory. This result is in line with the findings of Bertolani et al. [17] who also observed that sex influenced performance only on the delayed recall task. Other studies, although taking sex into account as a potential factor influencing performance, have found no evidence in support of this [18, 23, 24, 38]. An effect of sex, both on direct copying as well as on delayed recall, is reported only in one study [22]. The methods we used for establishing norms permits to partial out the contribution of normal ageing, educational level and sex, when appropriate, from the score. The normative data allow one to assess the individual patient's performance with reference to inferential cut-off scores, which are population-, rather than sample-based. Furthermore, equivalent scores were also calculated. Providing equivalent scores for ROCF, which is widely used in clinical assessment, allows one to compare performances on this test with other tests for which normative values collected with similar methods are already available for the Italian population. This allows direct comparison of performances across tests independently of the relative difficulty of individual tasks.

Sommario La figura complessa di Rey-Osterrieth (ROCF) è un test neuropsicologico ampiamente utilizzato nella pratica clinica per indagare le funzioni costruttive visuo-spaziali, la memoria visuo-grafica e alcuni aspetti delle funzioni esecutive. Scopo del presente studio è stato calcolare i valori normativi su un ampio campione di soggetti italiani (n=280) della copia e della rievocazione a memoria dopo 10 min della figure complessa di Rey. L'analisi dei dati mediante regressione multipla ha mostrato un significativo effetto dell'età e dell'educazione nella performance della copia e della differita, mentre il sesso sembra influenzare significativamente solo la rievocazione differita della stessa. È stato inoltre determinato il cut-off inferenziale e sono stati calcolati i punteggi equivalenti. La disponibilità di punteggi equivalenti per la ROCF dovrebbe costituire un importante strumento nella valutazione neuropsicologica, permettendo di paragonare la performance dei soggetti in questo compito con quella mostrata in altri test neuropsicologici, dei quali siano disponibili i valori normativi determinati sulla popolazione italiana e calcolati mediante la stessa metodologia.

Table 4 Equivalent scores for the direct copy of ROCF

Scale	Equivalent score
0	≤28.87
1	From 28.88 to 30.04
2	From 30.05 to 31.21
3	From 31.22 to 32.40
4	≥32.41

Table 5 Equivalent scores for the delayed copy of ROCF

Scale	Equivalent score
0	≤9.46
1	From 9.47 to 11.22
2	From 11.23 to 12.98
3	From 12.99 to 14.73
4	≥14.74

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