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Determinants of performance on the Rey-Osterricht Complex Figure Test: An analysis, and a new technique for single-case assessment

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The aim of the study was to identify factors determining performance on the Rey-Osterricht Complex Figure Test in a normal population, in terms of accuracy of initial copy and delayed recall. Both immediate copy and delayed recall were related to age, and especially to the strategy adopted at the initial copy. A regression equation was derived whereby delayed recall could be predicted from the strategy adopted at the initial copy and the subject’s age. This should prove useful in the analysis of Rey-Osterricht performance in individual cases.

The Rey-Osterricht Complex Figure Test (Rey, 1942; Osterricht, 1944) is widely used by clinical and research psychologists to assess neuropsychological function. The subject is instructed to copy the complex geometrical figure as accurately as s/he can, and must then recall it, without forewarning, after an interval. Two measures of performance are customarily derived: a copy score, which reflects the accuracy of the original copy and is a measure of visuo-constructive function; and a recall score, measuring the amount and quality of the original information retained in long-term spatial memory.

In an early major study of Rey-Osterricht performance in a normal population, Osterricht (1944) noted that subjects (children and adults) vary greatly in their approach to the construction of the figure. He delineated four qualitatively different copying strategies used by adults and six (the four, plus two more primitive strategies) used by children; he also recognized that a relationship exists between strategy used at copy, strategy at recall and quality of recall. However, he did not specify the nature of this relationship in any detail and, to date, these interesting observations do not appear to have been developed by researchers.

It is thus the aim of the present study, first, to develop a quantitative measure of copying strategy; second, to investigate its relationship to copy score and recall performance in a normal population; and third, to suggest ways in which a strategy of copy score might be advantageously applied in clinical practice to the study of the single case.

The order in which a subject copies the lines or figures within the Rey figure may represent a very direct measure of perceptual organization at input. Work during the past decade on the relationship between organizational or encoding factors at input and later recall performance (e.g. Tulving & Donaldson, 1972; Puff, 1979) leads to the prediction that copying strategy should be highly related to Rey score in a normal population. In brain-damaged patients, however, there is evidence that dissociations between visuo-constructive and memory functions may sometimes occur. Pillow (1981) has investigated the copying deficits of patients with frontal or parietal-occipital lesions, and attributed the impairments of the former group to a “loss of programming”, and of the latter group to “visual disorientation”. Pillow does not report on the recall performance of these patients. However, a single case study of a patient with a frontal lesion reported by Lhermitte et al. (1972) indicates that, following a disorganized copy, the patient’s recall of the figure was extremely impaired. Later, the authors introduced a step-by-step “programming aid” to help the patient copy the figure; under these conditions, their patient made a reasonably accurate copy and his recall performance was within normal limits. This case illustrates that the poor recall score of a brain-damaged patient does not necessarily
indicate a memory problem (in the sense of information ‘forgotten’); the information may be deficiency encoded in the first place.

In contrast, Taylor (1969) reports that patients with right temporal lobe damage show a recall deficit—in the absence of concomitant copying deficits. Patients who have undergone right temporal lobectomy recall significantly less of the Rey figure than those with left temporal lobectomy, pre-operatively, post-operatively and at one-year follow-up. Significant differences in copy score are found only at one-year follow-up.

Thus, recall deficits on the Rey figure may be of at least two identifiable kinds: a reflection of poor initial organization of the figure, or a ‘forgetting’ of adequately organized input. Traditionally, the copy score is used to decide on the quality of initial encoding, and is compared with recall performance. However, this procedure may have limitations (especially in ‘borderline’ cases), where a patient may achieve a reasonably accurate copy using a poor constructive strategy. What level of recall should we expect of this patient? This is one of the issues addressed in this paper.

Recent work on organization and memory of non-verbal information (Reed, 1974; Palmer, 1977; Cunningham, 1980) has utilized relatively simple stimuli, and offers little in the way of deriving for an organizational measure of strategy with complex figures such as the Rey–Osterrieth. However, the Gestalt psychologists and, in particular, Wertheimer (1958) delineated a set of principles of perceptual organization, which seem appropriate for the purpose. Two of these principles, symmetry and good continuation, are used here to derive strategy scores. The principle of symmetry states that symmetrical figures are ‘good’ figures. The good continuation principle suggests that where two straight lines intersect, the one half of a straight line is grouped with or continues the other half of the line. As applied to the Rey–Osterrieth figure, these principles may be quantified by noting the nature and sequence of the components copied by the patient.

In the following study, the relationships between different task (estimated IQ, strategy, copy score, copy time, recall score(s)) and subject (age, sex) variables are investigated to establish the determinants of copy and recall performance in a normal population. A technique is then elaborated for analysing functional deficits in the recall of the Rey–Osterrieth Complex Figure Test in the individual case.

Method

Subjects

One hundred and seven volunteer subjects (76 male, 31 female) were drawn from two sources. Sixty-two subjects were production line workers from a large car assembly factory; 45 subjects were recruited from a non-emergency orthopaedic hospital admissions ward, and were tested one-to-two days before their operations. All subjects were told (correctly) that they were being tested as a ‘normal’ control group for a study of the effects of closed head injury. Subjects with a previous history of head injury or epilepsy were excluded from the sample. Their mean age was 29.3 years, standard deviation 9.3 years, range 17–49 years, and their mean estimated IQ was 104.9, standard deviation 7.6.

Procedure

The Rey–Osterrieth complex figure was placed in front of the subject. S/he was given a pencil and instructed to ‘copy the figure as accurately (emphasized) as you can.’ While the subject copied the figure, the experimenter made a note of every line drawn in sequence. Additionally, the time the subject took to copy the drawing was noted for 76 subjects. When the subject indicated that s/he had finished the copy, the figure and the drawing were removed from sight; 40 minutes later, the experimenter said to the subject: ‘You remember that drawing you copied for me. I would now like you to recall as much of it as you possibly can.’ When the subject first indicated that s/he could recall no more, the experimenter said: ‘Give yourself a little more time. I always say to people to give themselves some more time’. In a number of cases, this procedure resulted in one further detail being recalled. When the subject indicated a second time that s/he had finished, this was accepted.

During the interval between copy and recall, the subject performed a number of other tests of memory and intellectual function (mostly verbal). No stimulus presented at this time resembled the Rey–Osterrieth figure in either form or content. Two of these were the Schonell Graded Word Reading Test and the New Adult Reading Test. These have been shown to correlate with the Wechsler Adult Intelligence Scale, and an estimated IQ, included in the analysis below, may be derived from the raw scores (Nelson & McKenna, 1975; Nelson & O’Connell, 1978). As an extra check on the validity of this measure, 62 subjects completed the first 20 items of the Mill Hill (senior) Synonyms Test, a measure of vocabulary. A correlation of 0.67 (P < 0.001) was obtained between this, and estimated IQ.

Scoring

The data were collected over a period of seven months. A subject number was put at the top of each copy, recall and strategy protocol. These were then assigned to separate folders. No data were scored until the study was completed. To avoid the possibility of bias, each measure was scored ‘en bloc’ and a week was left between the scoring of one measure and the next.

Copy score. The scoring system designed by Osterrieth (1944), and adapted by Taylor (1959) was used. This divides the figure into 18 units, specified below, and in Fig. 1.

Unit
1. Cross upper left corner, outside of rectangle
2. Large rectangle
3. Diagonal cross
4. Horizontal midline of 2
5. Vertical midline
6. Small rectangle, within 2 to the left
7. Small segment above 6
8. Four parallel lines within 2, upper left
9. Triangle above 2 upper right
10. Small vertical line below 2, between 9
11. Circle with three dots within 2
12. Five parallel lines within 2, crossing 3, lower right
13. Sides of triangle attached to 2 on right
14. Diamond attached to 13
15. Vertical line within triangle 13, parallel to right vertical of 2
16. Horizontal line within 13, continuing 4 to right
17. Cross attached to low centre
18. Square attached to 2, lower left

Each unit is assigned 2 points for a correct reproduction; 1 point if misplaced, incomplete or distorted; and 0 point if it is recognizable but misplaced and incomplete or distorted.

No precise criteria are given by any author to illustrate the degree of displacement that constitutes ‘misplaced’. An informal survey of users of the test revealed that these criteria may vary quite markedly between individuals and between centres. Taylor (1969), who has studied the effects of temporal lobectomy on Rey-Osterrieth performance, reports (personal communication) that he uses very stringent criteria to assess both copy and recall; these appear to assess accuracy in terms not only of presence, distortion and displacement of figure, but also draughtsmanship (e.g. the diagonal cross, the horizontal line and the vertical line of the large rectangle should intersect at the centre of the figure). It was decided to use similarly stringent and specific criteria to assess the copy for two reasons: first, a large percentage of the copies would otherwise have obtained maximum scores using less stringent criteria, thereby exposing the data to ceiling effects; second, pilot studies suggested that it is only by adopting very lax or very strict criteria that high inter- and intra-rater reliability may be obtained. Copy score as measured in this study is therefore an amalgam of the presence, completeness, placement, tidiness and preservation of spatial relationships of different units of the figure. (The scoring criteria are available from the author on request.) The scoring criteria are almost certainly more stringent than those customarily used by clinical psychologists. They yielded an
inter-rater reliability of 0.96 ($P < 0.001$) on 25 randomly selected copies, scored by the author and a psychologist with no previous experience of marking the Rey–Osterrieth.

'Strict' recall score. This was scored according to the same criteria as the copy.

'Lax' recall score. (The scoring criteria are available from the author on request.) A second recall measure, 'lax' recall score, was introduced for the following reasons: first, subjects did not seem to perceive the instruction 'to recall as much of the figure as you can', as implying that they should show the same degree of care and accuracy in the reproduction from memory as they had in the copy. Typically, they would draw their first few items at great speed, and only adopt the 'copying' style for the last few items recalled. Second, it seems most unlikely that, for instance, those subjects whose drawing of the diagonal cross failed to meet (or extended a small distance past) the corners of the large rectangle had 'forgotten' that the cross extended to the corners (only) of the large rectangle. Third, a number of research and clinical psychologists apply less strict criteria to the recall than to the copy, for the above two reasons. Thus, the lax recall score measures the presence, completeness, distortions and misplacements of the units; criteria for the first two remain the same as for the copy and strict recall. However, distortions and misplacements were scored less strictly; only obvious changes of shape and misplacements had points deducted. To give an example, consider the small square (bottom left) and the adjoining cross – the strict recall criteria were that (1) no one side of the small square should be less than 80 per cent of the length of any other side; (2) the cross, which meets the small square half way up its right side, should not deviate by more than 20 per cent from this 50 per cent position (misplacement). The equivalent lax recall criteria are that (1) one side of the small square should be less than 66.6 per cent of the length of any other side; (2) the cross should meet the square at some position between the bottom of its right side and the top; it should not be a continuation of the bottom side of the square. Tidiness of the reproduction was deemed unimportant for the lax recall score.

Figure 1. The Rey–Osterrieth figure. Numbers indicate the units specified by the Taylor scoring system; arrows, the points of good continuation; and the crossed arrow, a point of poor continuation (see text for further details). Good continuation points are scored if lines are continued either in the direction of the arrows, or in the reverse direction.

An inter-rater reliability of 0.98 ($P < 0.001$) was obtained on 25 randomly selected recall protocols using these criteria.

Good continuation. Good continuation was said to have been demonstrated when a straight line was drawn as one piece and continued until its final intersect with another line. Seventeen points of good continuation for the Rey–Osterrieth figure are illustrated by arrows in Fig. 1; there are, of course, a number of other possible good continuation points (e.g. the diagonal cross has 14 or 15 potential good continuation points). However, lines were not 'poorly' continued by our subjects at any point other than those shown in Fig. 1. Additionally, one point of 'poor' continuation is illustrated by the crossed arrow at the intersection of the two triangles. Subjects were awarded a point if they did not continue the line at this intersection; others, who copied the line in one piece from the top of the upper right triangle to the apex of the right-hand triangle as if it were a straight line, lost one point. The maximum good continuation score is 18 points, consisting of the 17 points shown in Fig. 1, plus the point of 'poor' continuation.

Symmetry. The scoring of the principle of symmetry was predicated on the assumption that the order in which a subject draws the components of the Rey figure should accurately reflect the structure and symmetry that the subject perceives within the figure. Points were therefore awarded for the successive construction of symmetrical units, and their symmetrical components. Cunningham (1980) also has argued that the output order of subjects' drawings may mirror the internal representation of visual stimuli.

The symmetry scoring system is illustrated in Fig. 2. Symmetry points were gained when the following rules were observed:

(1) The component parts of symmetrical figures were drawn successively (e.g. Unit 2 rectangle outline; Unit 3 diagonals; Unit 13 vertices; Unit 18 outline). Two points were awarded for the successive construction of components of the three figures which are symmetrical about two explicit (i.e. present in the figure) axes of symmetry (Units 2, 3 and 4 + 5) (see Fig. 2A). One point was awarded for the figures which are symmetrical about just one explicit axis of symmetry (e.g. the left 5

Figure 2. Examples of copying strategies and symmetry points. Dotted lines indicate previously constructed elements of the figure; solid lines, the current element. See text for further details.
and right halves of the large rectangle (Fig. 2C); the small rectangle (Unit 6); the diagonal cross (Unit 6; Unit 13; Unit 18).

(2) One point was awarded when a symmetrical figure or a symmetrical unit or an axis of symmetry within a symmetrical figure was drawn immediately after a symmetrical figure (e.g. Unit 3, 4 or 5 after 2; 13 after 13), or a symmetrical component (e.g. 3 after 5; 4 after 5; 16 after 15) or an axis of symmetry (e.g. 3 after 4; 13 after 16) or a completion line of a symmetrical figure whose components had not been drawn successively (e.g. Fig. 2F (ii)).

(3) One extra point was awarded for drawing the large rectangle first; the justification for this was that it is the `best' figure, being symmetrical about two explicit axes and being `closed'; further if it was drawn before any other figure, it would not gain a point on rule 2.

These principles are illustrated in Fig. 2. To take just one example, 2A: the rectangle gets 1 point on rule 3 and 2 points on rule 1; the diagonals 1 point for success (rule 2) and 2 points for being constructed together (rule 1); the vertical axis 1 point for success (rule 2); the horizontal axis 1 point for success (rule 2); and the composite horizontal/vertical cross, without extensions (otherwise it ceases to be a symmetrical figure about two axes), 2 points on rule 1. Note however, that while 2 symmetry points are gained by this configuration, 3 good continuation points are lost.

Figure 2 illustrates several other interesting features of the scoring system. Three exceptions to rule 1 are shown in Figs 2D, 2E and 2F (ii); rule 1 is formally contravened since not every side of these figures is drawn successively when the large rectangle has previously been constructed. However, it seems parsimonious to assume that these units are perceived as symmetrical figures when the remaining components are drawn successively. 2C illustrates a symmetrical arrangement achieved by a piecemeal approach to the construction of the large rectangle; 2E (ii) illustrates this for the small internal rectangle. Again, note that both these configurations will lose good continuation points. 2D shows two alternative 3 point arrangements for the right-hand triangle; the axis of symmetry is worth 1 point in 2D (i), but not 2D (ii), because of rule 2; in 2D (ii), rules 1 and 2 combine to give 2 points for the triangle vertices. 2F (ii) shows a case where rule 1 is contravened, since only two sides of the square are drawn successively. No points are awarded for this configuration.

There are, of course, other symmetrical units in the figure such as the diamond and the two crosses. These have been omitted from the scoring system because almost all subjects construct the component parts consecutively.

The maximum symmetry score a subject can achieve is 18 points. This follows from a combination of 2A, 2D (i), 2E (ii), and 2F (ii).

Strategy total. The strategy total is the sum of the good continuation and symmetry scores. There is a theoretical maximum of 36 points, which no subject can achieve because at three points in the construction of the figure, good continuation and symmetry strategies are in direct conflict.

Results

The mean scores and standard deviations on all the measures are given in Table 1. Comparison of scores for males and females reveals significant differences on the following measures: symmetry (F = 5.66, P < 0.05), a good continuation (F = 5.49, P < 0.05), strategy total (F = 8.88, P < 0.01), strict recall (F = 5.53, P < 0.05) and lax recall (F = 6.67, P < 0.01). The mean copy score difference almost reaches significance at the 5 per cent level (F = 3.77, P < 0.10). In contrast, comparison of performance on the reading-based IQ measure reveals an almost significant sex difference in the reverse direction (F = 3.31, P < 0.10), with females doing rather better than males. The data support other findings of sex differences in spatial skills (Harris, 1978), and the near-double dissociation between Rey–Osterrhieth and reading performance is suggestive of female superiority in this area of verbal skills (see Harris, 1977, for further examples). There was no evidence of sex differences in ‘forgetting’ from memory -- when the strategy effect is partialled out from recall scores, males and females show equivalent levels of ‘forgetting’.

The correlation matrix of the Rey performance measures, plus age, sex and IQ, is presented in Table 2. The results indicate that all the performance measures, with the exception of copy time, are significantly intercorrelated. Copy time is significantly correlated only with copy score. Taking time over the drawing may produce a more accurate copy, perhaps because greater ‘care’ is taken, but does not apparently result in better recall of the figure.

Multiple regression analyses were carried out to investigate these relationships in greater detail. The regression of age, sex, estimated IQ, strategy total and copy time on copy score (F = 16.4, P < 0.001) accounts for 52.8 per cent of the variance, and shows that age (t = −2.6, P < 0.02), strategy total (t = 4.6, P < 0.001) and copy time (t = 3.9, P < 0.001) make independent contributions to the copy score in contrast to estimated IQ (t = 1.7, P < 0.1) and sex (t = −1.0, P < 0.1). When symmetry (Sym) and good continuation (GC) scores are entered separately in the analysis in place of strategy total, their contribution is also found to be independent (Sym: t = 2.9, P < 0.01; GC: t = 2.9, P < 0.01).

Another analysis examined the relationship between the two recall measures and five independent variables viz. age, sex, estimated IQ, copy score and strategy total. Copy time was omitted since it was not significantly correlated with the dependent variables. For both ‘lax’ recall (F = 26.4, P < 0.001) and ‘strict’ recall (F = 31.9, P < 0.001), the regressions are highly significant, accounting for 54.5 per cent and 59.3 per cent of the variance respectively. Age, strategy total and to a lesser extent copy score (CS) make independent contributions to the ‘lax’ recall score (Age: t = −3.2, P < 0.005; ST: t = 6.1, P < 0.001; CS: t = 2.1, P < 0.05), and after removing shared variance account for 4 per cent (Age), 20 per cent (ST) and 2 per cent (CS) of the remainder. The same variables account for 6 per cent (Age), 9 per cent (ST) and 7 per cent (CS) of the remaining variance on the strict recall score (Age: t = −4.1, P < 0.001; ST: t = 4.9, P < 0.001; CS: t = 4.4, P < 0.001). Neither sex nor estimated IQ make any independent contribution to the recall scores (Sex: t = −1.4, −0.7; IQ: t = 0.3, 0.0). When symmetry and good continuation are entered separately, their contribution is again found to be independent: ‘lax’ recall (Sym: t = 4.2, P < 0.001; GC: t = 3.8, P < 0.001), ‘strict’ recall (Sym: t = 4.2, P < 0.001; GC: t = 2.6, P < 0.05).

The results therefore show that strategy of copy, copy time and age are the major determinants of copy score, while strategy, copy score and age are the best predictors of later recall. Though both estimated IQ and sex of the subject are related to copy and recall performance, neither make an independent contribution after other variables have been taken into account.

The amount of recall variance accounted for by copying strategy and age of subject is
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Impressively high, and suggests the utility of the regression technique to allow for prediction of the recall score from the strategy score and age of the subject. Regression procedures are a powerful way of demonstrating dissociations of function within an individual, and are well adapted for clinical use in single-case investigations of cognitive impairment (Rutter & Yule, 1975; Nelson & McKenna, 1975). The regression equation given here predicts ‘lax recall’ score (not ‘strict recall’) since most clinical psychologists score the recall of the figure according to ‘lax’ criteria.

Predicted lax recall = (0.75 × Strategy total) – (0.16 × Age) + 8.01

Standard error of estimate = 4.01

Copy score (which accounts for 2% per cent of the independent variance) is omitted from the equation, since it is felt that the added complexity of scoring and calculation necessitated by its inclusion more than offsets the marginal increase in predictive accuracy from its presence. The potential utility of this regression procedure for the single-case assessment of Rey–Osterrieth performance is discussed below.

Discussion

The results of the study unequivocally demonstrate that the copying strategy measures derived from the Gestalt principles of symmetry and good continuation are individually and in combination predictive of accuracy of copy and later recall from memory on the Rey–Osterrieth Complex Figure Test. Osterrieth’s (1944) observations concerning the possible relationship between organization of the copy and recall performance have thus been confirmed and extended.

Estimated IQ (reading ability) was significantly correlated with copy and recall performance, as would be expected, but the strategy effects were shown to be wholly independent of estimated IQ. It is possible that a non-verbal measure of IQ would have been more highly correlated with Rey–Osterrieth performance than the reading-based IQ measure since the Rey–Osterrieth is predominantly a non-verbal task. However, the magnitude of the strategy effect suggests that it is doubtful whether any general measure of intelligence – verbal or non-verbal – would be as predictive of performance as this task-specific measure.

Copy score was found to make a small independent contribution to recall performance. The effect was rather stronger for the ‘strict’ recall score than for ‘lax’ recall where it accounted for only 2% per cent of the remaining variance. Since the same scoring criteria were used for ‘strict’ recall as for the copy score the stronger effects on this measure are scarcely surprising; careless copiers tend to be careless recallers, and meticulous copiers, meticulous recallers. Copy score probably reflects the ‘care’ or ‘cognitive style’ of the subject; this may be reflected in recall performance by focusing the subject’s attention more fully on the figure. If greater ‘effort’ is made, better recall should result.

However, unlike the copy score, copy time, which has also been interpreted as reflecting ‘care’, was not related to recall performance. Analysis of individual protocols suggests that one reason for this apparent paradox is that copy time is a contaminated measure of ‘effort’. Some subjects using poor strategies tend to ‘lose their way’ while copying the figure and take their time completing it; others continue on regardless. The strategy effects tend to swamp the independent contribution of ‘effort’ measured by copy time, but those subjects who ‘lose their way’ may nevertheless produce reasonable copies, albeit poor recalls, by application of corrective ‘effort’. Accuracy of copy is probably a rather less contaminated index of ‘effort’ for these reasons.

Age also made an independent contribution to both copy and recall performance. This was a surprising result since age differences in perceptuo-motor function and memory have rarely been reported in early and middle adulthood (e.g. Craik, 1976). There have, though,
been relatively few comparative studies of memory in these age groups, and, in particular, studies of non-verbal memory. Howell (1972) has argued that lack of familiarity and complexity of to-be-remembered materials may potentiate age differences in memory. Both these factors are important components of the Rey figure, and may account for the age effects.

The experimental investigation of the determinants of Rey–Osterrieth recall performance has led to the development of a technique to assess functional deficits in the individual case. It is hoped that this technique will allow clinicians to distinguish more precisely between recall deficits due to a failure of organization at input, and recall deficits due to forgetting, thus avoiding mislabelling or misclassification of patients. In his experience, the author has found that, in a normal population, a more or less disorganized piecemeal approach to the copy of the figure is not uncommon. The end result of the copy may be quite accurate, but typically such subjects will recall only bits and pieces of the figure. For instance, one 36-year-old normal subject had a copy score of 28, a strategy score of 17 and a recall score of 11. A recall score of 10 or 5 is predicted from the regression equation. Using normative data, such a score would indicate (wrongly) a ‘memory deficit’, rather than organizational problems.

Large discrepancies (i.e. more than two standard errors) between predicted and observed recall scores are seen only rarely in a normal population. However, they may be observed quite frequently in brain-damaged patients. Consider one 28-year-old patient who had sustained a severe head injury. He obtained a recall score of 15. His copy score was 30, and strategy score 29. From the regression equation, predicted recall was 25. His observed recall was thus over two standard errors below predicted recall, and indicative of a severe non-verbal memory deficit. Note that his ‘impaired’ recall score is 4 points above the normal subject without impaired memory.

Future research will investigate the use of this technique with brain-damaged patients, and assess the extent to which different deficits (organizational vs. forgetting) are associated with different aetiologies. The work of Pillon (1981) and Taylor (1969) suggests the promise of this approach.

In sum, the present study indicates that the analysis and interpretation of performance on the Rey–Osterrieth Complex Figure Test may be enriched by a consideration of copying strategy. Copying strategy is the prime determinant both of copying and recall performance in a normal population. A technique has been presented, based on a consideration of copying strategy, which allows for a functional differentiation of two kinds of recall deficit. The author has found this technique to be of considerable value in the assessment of patients referred for neuropsychological assessment, but its full evaluation awaits further empirical investigation.

References


