ORGANIZATION & RECALL: A STUDY OF THE
REY COMPLEX FIGURE TEST

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I hereby certify that, except where otherwise acknowledged, this thesis describes original research carried out by the author. It has not been submitted previously to any university or other institution.

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Abstract

Patients with frontal damage show deficits in the copy and recall of the Rey Complex Figure. Lhermitte, Derouesne & Signoret (1972) have reported improvement in the copy and recall performances of such patients following a structured copying procedure. However, their study suffers from methodological deficiencies. This thesis reports a single experiment which examined Lhermitte et al.'s claims using a modified design, incorporating several methodological improvements. In addition, generalization of improvement following training was investigated.

A sample of brain-damaged subjects with likely frontal involvement recalled and copied the Rey Figure following either a structured or an unstructured copying procedure. The structured procedure segmented the figure in accordance with normal perceptual principles. The unstructured procedure presented a segmentation which violated those principles. A reference group of normal subjects also received the unstructured copying procedure. Generalization was tested for each group using the Taylor Complex Figure. Following the structured copy, recall of the Rey Figure improved relative to baseline whereas there was no improvement following the unstructured copy in either the brain-damaged or normal subjects. Both brain-damaged groups showed an improvement in copying strategy but no special advantage was conferred by the structured training. No evidence of generalization was obtained. The possible reasons for the differential effect of training are discussed. Although the present results broadly confirm Lhermitte et al.'s claims that recall of the Rey Figure can be affected by a training procedure, the present data do not distinguish between the positive effects of the structured copying procedure and the negative effects of the unstructured procedure.

The study is the first to test Lhermitte et al.'s (1972) findings using an improved experimental design and it comprises the first application of a relatively comprehensive scoring system to the strategy of copy drawings by a brain damaged sample. It also provides the first data on the baseline memorability of the various units of the Rey Figure.
The Rey Figure Test: Introductory Comments

The Rey Figure is a widely used neuropsychological test sensitive to deficits in visuo-spatial perception, graphomotor co-ordination and visual memory. Although not originally designed as a test of 'planning', deficient performances on the test have also been frequently observed to include a problem with this process.

The figure is comprised of a range of geometric shapes, lines of axis and some additional details which amount to a complex figure, nearly free of representational content and relatively culturally unbiased (see Figure 1). Because of its complexity, it is difficult to encode verbally and is therefore particularly useful in testing visual memory. The figure also challenges the subject in several domains. In addition to quantitative information about copying accuracy and recall performance, the clinician is able to gain qualitative information through observing the nature of patients' errors and the manner in which they perform the task. The figure is therefore a potentially rich source of interpretive material.

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1 The figure is also referred to as the Rey-Osterrieth Complex Figure Test. It was initially devised by A. Rey (1941). Osterrieth's (1944) contribution was considerable, involving the creation of a scoring system for the figure which has been in widespread use ever since. Osterrieth divided the figure into elements for scoring purposes and applied the criteria of presence, accuracy, completeness and distortion to the assessment of copy productions. The use of the same scoring system for assessing memory performances was also his development. In addition, Osterrieth was responsible for obtaining norms for the figure and for categorizing the copying procedures of different subjects.
Figure 1. The Rey Complex Figure.

Figure 2. Example of the copy of the Rey Figure by a patient with a right parietal lesion.
The test has both a copying and a memory component. The copy performance is primarily used to assess visual perception, grapho-motor functioning and 'planning' ability. The memory component involves free recall of the figure after a time delay. Subjects are required to reproduce the figure from memory. While gross visual perceptual deficits are obvious from a subject's copying performance, problems in cognitive or executive processes are more difficult to differentiate.

The process of copying the figure requires a range of perceptual skills which a person with intact perception is usually quite unaware of using. Visuo-spatial problems in copying this figure may manifest themselves in several ways. Figure 2, taken from Pillon (1981), is an example of a copy made by a patient with a right parietal lesion. It shows a failure to include all aspects of the figure in the copy (which, in this example, might be interpreted as resulting from unilateral neglect), partial rotation of the figure, difficulty in reproducing the spatial and directional relationships of components of the figure and difficulty in integrating the components of the figure into a whole.

Copying errors can occur in the absence of perceptual deficits. For example, in the case of a grapho-motor problem, the patient may misdraw a line and make attempts at correction (see Figure 3). Such errors may be evident not only from the final product but also from the copying process. Patients may comment about the difficulties in drawing that they are having and the tester may observe problems in fine motor control. These may take the form of tremors or problems in grasping the pencil.

Deficits in copying the figure are also often attributed to higher level cognitive problems, for example, to a disruption of the 'planning' process. The copy performance of a subject with intact perception but cognitive/executive
Figure 3. Example of the copy of the Rey Figure by a patient with grapho-motor problems.

Figure 4. Example of the copy of the Rey Figure by a patient with 'planning' problems.
difficulties is usually relatively complete and the orientation of the figure is usually correct. However, some detail may be missing or the figure may appear carelessly drawn. The omission of a detail in such a case is thought to be due to an unsystematic approach rather than to a perceptual problem. Figure 4 is an example of a so-called planning deficit. In fact, such a deficit tends to be more evident from recording the copying order than from observing the finished copy. For example, sequencing may be inefficient. Problems of the sort illustrated in the figure may reflect a failure to analyse the figure. Whether this deficit actually concerns planning processes is not entirely clear.

Studies using the Rey Figure to differentiate frontal pathology

Since the Rey Figure is sensitive to a range of neuropsychological deficits, impaired performance on the test can occur as a result of damage to any one of several areas in the brain. Nevertheless, the test has provided a useful research tool in studies exploring localisation of function. It has been used particularly in studies attempting to differentiate the roles of the frontal lobes from other cerebral areas. One notable technique has been the use of training programs (involving compensation for the supposed defect) with subjects of different cerebral etiologies. Not only has this research contributed to the understanding of the roles of different cerebral structures, it also raises the possibility of cognitive re-training in people with cerebral damage.

In the literature of the Rey Figure, the studies of Lhermitte, Derouesne & Signoret (1972) and Pillon (1981) have been widely cited for their interesting findings in the areas of organization and recall in patients with frontal pathology.
Pillon (1981) presented subjects with frontal or parieto-occipital lesions either a programmed copying guide or a spatial reference guide to assist them in copying the figure. The programmed copying guide consisted of a cumulative three-stage presentation of the figure. Subjects copied the figure at each stage on separate pages. The spatial copying guide was presented in just one stage. On this guide, crucial spatial points were indicated but the figure was incomplete, leaving subjects to complete the lines in their own copies. Pillon found that the programmed approach, as opposed to the spatial reference guide, led to a greater improvement in copying by frontal subjects. The reverse was true for parieto-occipital subjects. The effects of the two strategies on recall were not examined.

In their study of the 'frontal syndrome', Lhermitte et al. (1972) also suggested that frontal and posterior patients could be differentiated by their performances on the Rey Figure. They observed that frontal patients showed a lack of structure in their copies of the figure, even in the absence of perceptual-motor problems, and that their recall was impoverished. They attributed the copying difficulties of the frontal patients to an inability to analyse the composition of the figure and an inability to establish a copying plan. To explore the hypothesis that frontal and posterior subjects perform poorly on the test for different reasons, they provided a copying program to both the frontal and posterior subjects. Subjects were required to copy the figure over six stages. Elements of the figure were introduced cumulatively. At each stage, subjects copied the elements delineated by the experimenter in addition to the elements which had been outlined in previous stages. It was found that at each stage the frontal patients preserved the demonstrated copying order of the previous stage and added the new elements last. They also included all the elements at each stage and their complete copies at stage six were well structured. In contrast, subjects with posterior lesions did not maintain a
structured approach, although they were able to benefit in the early stages from being shown the major elements of the figure. In fact, the final copies of the posterior group included as many errors as their first unaided copies.

Lhermitte et al.'s training program also had a particularly beneficial effect on recall for one frontal patient. Tested following the structured program, the frontal patient in question improved markedly, attaining a score in the normal range. In comparison with his performance prior to training, this patient showed fewer perseverative elements in his post-training recall performance. Lhermitte et al. associated the improvement in copying and recall performance with the peculiarly frontal nature of the patient's deficits. However, the effect of training on recall was less marked for the other three frontal subjects, although they showed a slight post-training recall improvement. Furthermore, the post-training recall performance of the posterior subjects was not reported. In view of the fact that only one of the four frontal subjects showed a marked improvement, it must be queried whether indeed the result was not due to chance.

Several important issues are raised by the studies of Pillon and Lhermitte et al. First, the finding that subjects were reported to benefit from a structured copying approach is potentially significant in considering re-training of individuals with frontal damage. Second, the findings raise questions about the nature of the impaired processes in the frontal group for which the provision of a copying program was a substitute or an enhancement. Third, Lhermitte et al.'s study has been interpreted as providing evidence in favour of the view that at least some frontal memory deficits are related to a breakdown in processes specifically affected by frontal damage and are not 'pure' memory deficits. Finally, some methodological issues arise from Lhermitte et al.'s study
which need to be addressed if its conclusions are to be convincing. Some of these issues will be addressed below.

**Copying performances of frontal subjects: conceptual issues**

Lhermitte *et al.* attributed the copying problems of frontal subjects with the Rey Figure to an inability to analyse the composition of the figure and an inability to form a plan for the execution of the copy. Pillon (1981) referred to a "loss of programing" and an "inability to regulate sequential behavior" (after Luria & Tsvetkova, 1964). Others have noted a disorganized copying approach in frontal patients (e.g. Messerli, 1979, cited in Lezak, 1983). Most commonly, frontal patients' copying deficits on the Rey Figure have been seen as a planning problem.

Exactly what Lhermitte *et al.* meant by an "inability to form a plan" for the execution of the copy is not clear. It would seem that this phrase was applied loosely without consideration of what it meant in relation to the task. Planning deficits are quite often invoked in the neuropsychological literature. However, the concept of planning has received little explicit attention. In the context of the Rey Figure, planning may refer to several processes. One interpretation of a planning problem might be the failure to imagine the course of copying the figure (or at least the early stages thereof), bearing in mind copying contingencies. The term 'planning' has elsewhere been interpreted in this manner, for example, Porteus (1959) saw the essence of planning as a process of "prehearsal". However, it is not clear that a normal person copying the Rey Figure engages in explicit and exhaustive planning of this kind. For example, a normal person may simply carry out a scant preliminary analysis into gross units and select a starting sequence. In a normal subject, this does
not preclude responding to copying contingencies as they arise. Thus, at any point in the copying process, a normal subject may decide which element it would be most efficient to copy next. Such a decision would seem to involve the consideration of immediate spatial demands but does not involve exhaustive advance planning. Whatever name is applied to it, this process is a flexible one, subject to constant mutation as the task proceeds.

Lhermitte et al. also referred to an inability by the frontal patient to analyse the composition of the figure. However, the authors implied that the frontal patient did not have difficulties actually perceiving the different elements of the figure as compared with the posterior group. It is not clear whether the authors meant by an "inability" to analyse the components of the figure, an actual inability (to analyse the figure's components) or a failure to think to analyse the figure. The second alternative would seem to denote a metacognitive or executive dysfunction. In normal subjects metacognitive processes cue them to analyse the figure, either before and/or during the copying process.

It is not clear that the analysis of components and forming a plan for execution are separate processes. Both may be subordinate to the metacognitive process of thinking to analyse and sequence the copying procedure.

The use of a term such as 'planning' to describe copying deficits on the Rey Figure (excluding those associated with perceptual or graphomotor problems) can conceal the difficulty in interpreting exactly what processes are impaired. This problem with the use of the term 'planning' is not confined to the Rey Figure but is also seen in the wider neuropsychological literature.

Planning deficits have seldom been defined in the literature and the notion has tended to be used in a self-explanatory way. As a result, references to
planning in the neuropsychological literature have not contributed to the fine grained analysis of frontal lobe deficits.

One ambiguity arising from the use of the term 'planning' concerns the level at which the deficit has been seen to be operating. Lezak (1982) clearly located planning deficits within the executive domain and defined executive functions as those relating to the organization and execution of goal directed activity. She considered cognitive dysfunctions to be essentially synonymous with intellectual impairments. Walsh (1978), on the other hand, did not make an executive/cognitive distinction in discussing frontal lobe problems. He did not differentiate planning from problem solving but included deficits in these together in the category 'intellectual changes'. Elsewhere the term 'planning' has also been used synonymously with problem solving processes, for example, in relation to tower puzzles (Shallice, 1982).

In the absence of clear definitions of planning, there has been an assumption that test selection has defined the underlying construct. Planning deficits have tended to be implicitly defined in a circular way as those deficits which particular tests elicit. Tests commonly seen to target planning functions are: maze tests (e.g. Porteus, 1959; Walsh, 1978), trailmaking tests (e.g. Gilandas, 1984), tower puzzles (e.g. Shallice, 1982), the Rey Figure (e.g. Lezak, 1983), and Block Design (while not primarily targeting planning, Lezak, 1983, suggested this puzzle could be used to observe planning skills; and Luria & Tsvetkova, 1964, used it to directly explore 'programming' skills in a single case study). Concern about ecological validity has led some authors to develop tests of everyday planning skills; for example, Lezak's (1982) Tinker Toy Test and Stoltze & von Cramon's Planning Test (referred to in Cramon & Matthes-von Cramon, 1990). The latter implicitly defines planning in terms of the ability to develop a daily schedule. In summary, it would appear that
planning has been operationalized to mean different things, ranging from the more concrete organization of a program of action or a schedule to the abstract analysis of contingencies, consequential thinking and the selection of action based on this. While these are not mutually exclusive, the nature of the tasks would seem to draw on slightly different processes. Furthermore, the tests mentioned are varied in their requirements and clearly involve several skills, making their use in assessing 'pure' planning skills problematic.

While planning may be the proper term to describe the requirements for copying the Rey Figure, it is unclear whether such a skill exists in its own right or whether it is a composite of abilities or a by-product of breakdown in some other more basic function. Impairments in certain processes have been implicated in frontal deficits generally, and, by extension, in planning deficits. For example, Fuster (1987) subsumed many frontal functions under the "mediation of cross-temporal contingencies". Grafman (1989) implied that planning deficits may result from an inability to form and shift concepts. Employing a broad definition of attention, Stuss & Benson (1984), suggested that many frontal deficits could be considered as essentially disorders of attention. Gray (1990) also acknowledged a relationship between attentional and executive processes. In addition to the pivotal role of attention, Stuss & Benson, (1984) also referred to a loss of self-awareness occurring with frontal damage. To what extent planning and other frontal deficits may stem from an absence of self-awareness is also unclear.

On the basis of the foregoing discussion, it is clear that the term 'planning', both in discussions of task performance such as with the Rey Figure, and in reviews of cerebral dysfunction, should be applied with caution. The previous discussion also demonstrates the complexity involved in identifying precisely
the impaired processes in task performance and in ascertaining the causal relationships between functions associated with the frontal region.

Copying and recall: the relationship of organization and memory in frontal memory deficits

Lhermitte et al.'s report that a frontal subject's recall improved as a result of receiving a structured copying approach is interesting and significant for its contribution to the understanding of memory deficits, and for its implications for cognitive training, in cases of frontal lobe involvement.

It is well-established that frontal lobe damage produces impaired performance on a range of memory tests. One question of interest has been whether this reflects a true memory impairment or a breakdown in other processes. Some authors have argued that frontal memory impairments are secondary to information processing deficits. For example, Stuss & Benson (1987) claimed that frontally damaged patients rarely show problems on 'pure memory' tests. Although specific tests were not mentioned, the authors implied that pure memory tests do not require the learning of successive lists of words, for example. This is because such tests allow for the possibility of interference which, by implication, they would see as arising from information processing problems. They also excluded tests in which temporal ordering or visual search might contaminate the results, as such processes were also assumed to arise from a breakdown in functions other than those relating to memory. Hecaen & Albert (1978) expressed a similar view to that of Stuss & Benson, indicating that frontal memory problems are unlikely to arise from a disruption to "specific memory processes". Wilson, (1989) stated that the memory failures
of frontal patients are due to problems of the "central executive" rather than to "poor memory per se". Barbizet (1970) also suggested that frontal damage often leads to particular memory difficulties. However, he implied that these difficulties should be viewed both as a disorder of intellectual output and as a specific kind of memory disorder.

Understanding the basis of impaired memory performance in patients with frontal lobe damage has been complicated by inconsistent findings in the research literature. Studies have targeted different kinds of memory process and have used subjects with different etiologies. Even where similar memory tests have been used, conflicting results have often been obtained. For example, it might be argued that only patients with 'pure' memory deficits would show impaired performance on single tests of recognition. If frontal subjects do not have 'pure' memory deficits, they might be expected to perform normally on such tests. In keeping with this view, Ghent, Mishkin & Teuber (1962) observed normal performance on immediate and delayed recognition tasks in frontal subjects. Prisko (described in Milner, 1964), on the other hand, found significantly higher mean errors in frontal subjects as compared with a temporal lobe group on tests of recognition. There has also been a lack of agreement as to whether subjects with frontal lesions show deficits on tests of learning. Several authors have reported that frontal patients have difficulty with these (e.g. Delis, 1989; Barbizet, 1970; Wood, Ebert & Kinsbourne, 1982). However, other authors (e.g. Shimamura, 1989) have noted normal performance on tests of new learning in frontal patients. The reason for this inconsistency is unclear. It is possible that the variability in results is due to the variability in etiologies studied and in a consequent variability in extent and locus of the frontal lesion.
In reviewing the frontal lobes and memory, Petrides (1989) pointed to evidence that there are "marked functional differences between the various parts of the frontal lobe". In addition, he noted that there are neural connections between some parts of the frontal cortex and the amygdalo-hippocampal region in the mesial part of the temporal lobe, an area specifically associated with memory. On the basis of this he suggested that frontal memory disturbances may involve both an element of 'pure' memory loss and a breakdown in other processes. The contribution of each of these to memory performance would depend on the areas of the frontal cortex affected.

A second question of interest has been precisely which secondary processes have been thought to affect memory performance in patients with frontal involvement.

One implication of Lhermitte et al.'s (1972) study is that failure to organize material to be remembered is a cause of poor recall in patients with frontal lobe involvement. Bennett-Levy (1984) suggested that posterior lesions cause 'forgetting' of adequately organized input whereas frontal lesions produce poor initial organization which, in turn, disrupts memory processes. Barbizet (1970), reviewing frontal memory impairments, claimed that the underlying problem is in the learning of new material. He suggested that the primary difficulty is an organizational one and that if the examiner substitutes for the patient's frontal lobes by organizing the material, the patient can then learn the material moderately well. Wood, Ebert & Kinsbourne (1982), commenting on the impaired performance in rote learning a word list of an ostensibly frontal patient with a closed head injury, claimed that his deficit was due to a failure to impose structure on the material to be recalled. They reported that the patient showed virtually no improvement in recall over the five trials and there was gross interference between the new and old list. The
patient also recalled words randomly from anywhere in the list, thereby not utilizing primacy and recency (temporal) structure. Rocchetta (1986) found that frontal patients were deficient in categorization skills and reported diminished immediate recall in these patients. Frontal patients failed to utilize categories as cues for the purposes of recall, in contrast to left temporal patients. Moscovitch (1982), reported that subjects with frontal lobectomy showed poor release from proactive interference (PI) whereas subjects with left temporal hippocampal involvement showed normal release.2 (A failure to show release from PI in frontal patients has been reported elsewhere, e.g. Freedman & Cermak, 1986, cited in Grafman, 1989). The failure to show normal release from PI in this study might be interpreted as resulting from a failure to categorize or organize the material to be learned. Alternatively, as the authors suggested, such an effect might be the result of a perseverative tendency.

A breakdown in other, higher order, processes has been suggested to underlie the impaired memory performance of frontal patients. How these relate to organizational processes is unclear. Organizational processes may be viewed as operating at two levels. First, organization comprises specific cognitive skills, such as categorization. Second, some processes at the metacognitive or executive level are presumably organizational in nature. Barbizet (1970) suggested that frontal patients forget how to learn. Hecaen & Albert, (1978) pointed to the possibility that frontal subjects forget to remember and further added that this may be due more to an alteration of selective attention than to a defect of memory. Stuss & Benson (1987), reviewing frontal

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2 The authors used a test involving the presentation of four successive lists of 12 words from the same lexical category. Memory of each list of 12 words was tested following each list presentation. The fifth list contained 12 words from a different lexical category. In normal subjects there is a release from proactive interference, with List 5 when the words are from a novel category.
memory deficits, also suggested that the frontal memory problem appears to arise from "an inability to maintain consistent directed attention over time based on an inability to control interfering stimuli". In their view, the prefrontal cortex has a "directive, organizational controlling role in the process of memory". Other processes implicated in frontal memory deficits are a failure to use knowledge to direct behaviour (Stuss & Benson, 1987), lack of temporal discrimination of items in memory (Stuss & Benson, 1987), "impaired integration of behaviour over a period of time" (Walsh, 1978, p.117) and the inability to "create stable motives of recall (Luria, 1973, p.211). Luria also suggested that in different frontal lesion sites, a "lowering of cortical tone" leads to a loss of "the selectivity of mnestic processes" (Luria, 1973, p.302).

In summary, a variety of different processes have been implicated in the impaired memory performance of frontal patients. However, there has been little systematic analysis of this issue. Whatever the underlying processes involved, one frequently mentioned and immediate cause would seem to be failure to organize (e.g. Barbizet, 1970; Wood et al., 1982; Bennett-Levy, 1984). Organizational processes have been central to the understanding of memory in normal subjects (e.g. Wingfield & Byrnes, 1981) and, as Lhermitte et al.'s study suggests, the manipulation of organizational factors may be significant in the remediation of memory impairments in brain damaged patients. The nature of organizational processes and their relationship to memory impairments in subjects with cerebral damage is therefore a useful and important issue for exploration.

Other than Lhermitte et al.'s study, there are few studies which have explored the relationship of organization and recall in the Rey Figure in brain damaged subjects. Binder (1982) (cited in Lezak, 1983) scored the number of configural, fragmented and missing units in the copy drawings of patients with
left and right sided lesions. Previously, patients' organizational input has only been qualitatively\(^3\) assessed. Left-sided patients were reported to show more configural wholes in their recall performances as compared with their copy performances, suggesting that slow processing was at the basis of poor copy performance. Ability to organize the figure was presumably intact in these patients. Frontal patients were not included in this study and copy performance was its central focus.

Another important study has specifically examined the relationship of organization and recall in normal subjects. Bennett-Levy (1984) developed an operational definition of organization and examined the relationship of organization to recall in a large sample of normal subjects. Using regression techniques, Bennett-Levy developed an equation which enabled the prediction of recall from organization score and age. Organization was operationalized in terms of a copying strategy score which was the sum of separate scores for symmetry and good continuation. Copying strategy was scored in a large sample of normal subjects and the relationship between strategy scores and recall computed. A correlation between copying strategy and recall (r = 0.56, p < .0001) was found. Thus, copying strategy accounted for a high proportion of recall variance. Much of the remaining variance was accounted for by age and copy score. IQ did not make an independent contribution. (It should be noted that the choice of symmetry and good continuation criteria on which to base the strategy score was directly derived from selected principles of organization developed by Wertheimer. While

\(^3\) While a 'planning' or organizational component in the analysis of subjects' copies of the Figure was not originally intended by Rey (1941), it has been common practice to make qualitative observations based on the approximate order and structure of copies. This has been done by requesting the subject to use different coloured pencils for each stage of the drawing or by the clinician/researcher noting the subject's order of copying in one of several ways.
some criticism could be aimed at the choice of principles and aspects of the scoring procedure, the benefits of the study far outweigh these issues.

Bennett-Levy's study was significant for several reasons. First, the development of a prediction equation is a potentially useful tool for distinguishing 'pure' memory deficits from those with an organizational basis in a brain damaged population. Second, the strong relationship found between copying strategy and recall performance, obtained with a relatively large sample (n=107), was a substantial confirmation of the importance of organizational factors in recall of the Rey Figure. Third, the study operationalized organization quantitatively, in a more comprehensive way than had been previously attempted (e.g. as compared with Binder, 1982).

Methodological issues arising from Lhermitte et al.'s study

Lhermitte et al.'s (1972) study was significant for its use of a training procedure with brain damaged subjects and suggested differences between the nature of memory impairment in a frontally damaged patient and that of patients with posterior cerebral involvement. However, it is questionable whether, on the basis of a significant improvement in one subject out of four in a frontal group, any claims concerning the reported training effect can be upheld. Lhermitte et al. tested patients on the copy and memory components of the Rey Figure. This was followed by a structured training procedure consisting of six stages. In Stage 1, only the central rectangle was presented for copying. In Stage 2, the diagonals and the medians, in addition to the central rectangle, were presented for copying. In Stage 3, the right-hand triangle and its details were added to the elements from the previous two stages. This procedure continued until Stage 6, when the complete Figure was presented to the
patient. At each stage, new elements were presented in red while previously seen elements were outlined in black. Lhermitte et al. found that in Stages 3 to 6 the frontal patients proceeded by copying the large rectangle and medians first, followed by other details of the figure, thus producing well-organized copies. Furthermore, one subject's recall improved to within normal range following the training.

As a result of their training, different elements of the figure were given variable exposure time. These elements were also copied an unequal number of times; for example, the central rectangle was seen over six exposures and copied six times, whereas the left-hand cross was seen only once and copied once. Overall, the figure was seen several times in its various stages of completion. The authors claimed that the frontal patients were using an organized approach to copying. The procedure, however, allows for an alternative interpretation of the results, which is that the patient's recall improved as a result of repeated exposure to parts of the figure.

The authors claimed that the patient was actively using structure in his copy, on the basis that even though the new elements introduced at each stage of the training were outlined in red, the patient ignored these at the start of each copy and still adhered to the 'historic' order of presentation, namely, large rectangle first, the medians second, followed by each of the remaining elements. However, the reported improvement in copying approach could have resulted from a rigid adherence to the order which had been presented and not necessarily to active attention to the structure of the figure.

The authors further implied, on the basis of the significant improvement in recall performance by one subject, that in frontal patients there was a relationship between organization and recall. However, the finding that one of
four frontal patients showed a significant recall improvement following training is slender evidence on which to base an assertion about the nature of frontal memory deficits. In addition to the foregoing, the authors did not include any control group. One option would have been to expose a second group to the figure for the same duration as the first subject but not to provide any copying guide. A second option would have been to give an unstructured presentation to a second group.

Other problems arise from the report of this study; for example, the results for the posterior group were not reported but were merely alluded to. Also, the procedure was not described in detail. For example, it was not indicated whether initial testing and training all occurred in one session or were separated in time.

Finally, in spite of the fact that a training procedure was used in their study, Lhermitte et al. did not seek to test whether their patients would show generalization to another related task. Clearly such a test of generalization would be important in estimating the likely practical benefits of their training procedure. The issue of generalization of learning has been of considerable interest in the literature on cognitive retraining and rehabilitation following brain injury (Volpe & McDowell, 1990). Studies vary in their findings as to whether generalization of training is possible. There is some evidence that cognitive retraining programs can lead to generalized benefits. These benefits have not only been shown with respect to performance on similar tasks, but have also manifest themselves in other areas of functioning, such as social behaviour (e.g. Cramon & Cramon, 1990). However, elsewhere only specific gains following training have been reported. In one study, (Glisky, Schacter & Tulving, 1986) subjects only improved in the task trained and furthermore, in order for the effects of training to manifest themselves, it was necessary to
replicate the precise conditions of the training task. The inconsistency across studies may be due to the fact that training procedures have varied considerably and the evaluation of generalization effects has been approached in different ways. It is therefore difficult to draw any firm conclusions about the generalizability of formal cognitive training programs (Diller & Gordon, 1981).

The present study

Lhermitte et al.'s study was an important contribution to the research literature on training of patients with frontal damage. However, it does not provide conclusive evidence either for the effectiveness of the training or for the nature of the apparent training effect. The study was limited because the evidence was based on the improved recall performance of only one frontal subject, appropriate controls were absent, generalization was not explored and no formal measure of organization was employed.

The present study had two aims. The first was to verify whether, indeed, a structured training procedure leads to improved recall and copy organization of the Rey Complex Figure in a brain damaged group with probable frontal deficits. The second was to establish whether any improvement would generalize to a different but similar task.

A modified version of Lhermitte et al.'s design was used to explore the relationship between a structured copying approach to the Rey Figure and the level of organization in subsequent copies, as well as recall performance. In order to test whether Lhermitte et al.'s findings were more broadly applicable to a group with frontal involvement, more subjects were used and a range of
subjects with frontal etiologies included. While the present study incorporated the same six-stage structured presentation used by Lhermitte et al., subjects were only requested to copy the elements of the figure once. This was intended to reduce exposure time to the figure and to minimize the likelihood that recall improvements would ensue from exposure and copying practice alone. A second experimental group was included in order to examine more precisely the role of organization on subjects' subsequent copying behaviour. This group was given a training procedure employing a relatively disorganized copying approach. This approach was based on copying performance by a head-injured patient.

In contrast to the study of Lhermitte et al., the present study employed a formal scoring system for the organization of copy performance. This constitutes the first application of Bennett-Levy's scoring criteria to the performance of a clinical group.

Finally, a standard administration of the Taylor Figure, a commonly used parallel form of the Rey Figure, was used to assess the extent to which transfer of learning would occur for subjects receiving the structured training. In addition, Bennett-Levy's organizational criteria were also adapted for the first time in this study to the scoring of the copy of the Taylor Figure.
Method

Two groups of subjects were included: a clinical group who had sustained cerebral damage of varying etiology but with likely frontal involvement\(^1\), and a reference group consisting of normal subjects. Each subject was given a standard administration of the Rey Complex Figure Test (Stage 1) and a training and generalization session one week later (Stages 2, 3 and 4).

The training session consisted of a six-stage copying procedure in which the elements of the Rey Figure were presented cumulatively. Subjects were allocated to one of two training groups. The structured group received a copying procedure in which the elements of the figure were presented in a structured way. The unstructured group, by contrast, followed a relatively unstructured copying procedure. All subjects were tested for their recall of the figure after a delay. A generalization test was then administered to all subjects.

Subjects

The reference group comprised nine normal adult subjects. Four were females and five were males. The age range of this group was 30 to 60 years. Five of these subjects had completed secondary level training and four had completed tertiary level. Mean number of years spent in formal education was 13.6 (standard deviation = 2.37 years). Potential subjects with a history of central nervous system disorder, loss of consciousness, mental retardation or psychiatric illness were excluded.

\(^1\) as assessed by the referral source.
There were nineteen subjects in the clinical group. Fourteen were males and five were females. Seventeen subjects had been referred for neuropsychological assessment at Royal Canberra Hospital, Woden Valley Hospital, Canberra and Royal Talbot Hospital, Melbourne. Two were referred directly by neurologists. All but two subjects completed the training procedure.

The clinical group subjects ranged in age from 18 to 66 years. Of the sample, five subjects had either commenced or completed tertiary training. The remaining fourteen subjects had received secondary schooling to varying levels. Mean number of years in education was 11.79 (standard deviation = 1.84 years).

Thirteen of the nineteen clinical subjects had suffered diffuse damage. Twelve of these had incurred closed head injuries. Seven of these had been involved in motor vehicle accidents while the other five had either fallen (for example, through horseriding) or received static injuries. The mean time since accident was 3.9 years (standard deviation = 5.5) and ranged between 8 months and 21 years. All individuals in the head-injured group were at least 3 months out of post-traumatic amnesia (PTA) at the time of testing. Length of PTA ranged from several days to twelve weeks. Of the remaining subjects in the clinical group, four had suffered from cerebrovascular accidents (two haemorrhagic and two obstructive strokes) with frontal involvement. Two subjects had developed tumours (one, an astrocytoma in the left frontal region and the other, a right frontal meningioma. Both had been surgically removed prior to testing).
Potential subjects who had obvious perceptual or motor deficits which could have affected test performance were not included. Individuals with a pre-morbid history of psychiatric disturbance were also excluded.

Significance tests revealed no difference in age between normal and clinical subjects ($t(26) = -1.08, p > .05$) and no significant difference was found in age between the structured and unstructured groups ($t(17) = -0.17, p > .05$). Similarly, years of education did not differ significantly between normal and clinical subjects ($t(26) = -0.30, p > .05$); nor did they differ between the structured and unstructured groups ($t(17) = 0.49, p > .05$).

Subjects with closed head injuries comprised the largest group within the brain damaged sample. These subjects were included because of the likely frontal involvement caused by their injuries. Although closed head injury produces diffuse damage (e.g. from diffuse axonal injury, anoxia/hypoxia and increased intra-cranial pressure), the relationship between closed head injury and frontal pathology is a well established one. Frontal and temporal damage is frequently pronounced in these cases (Lezak, 1983; Teasdale & Mendelow, 1984) as a result of the rotation of the brain within the skull following impact injuries. Shearing injuries in these areas are caused by the constraint of the under-surfaces of the frontal lobes and the pole of the temporal lobes between specific bony structures on the inner surface of the skull, as the brain rotates back and forth (Adams, 1975). The shearing of fibres in these regions leads to the formation of haemorrhagic contusions which have been found to occur in far greater density in the frontal and temporal regions.
**Procedure**

**Stage 1: Baseline testing**

Subjects received a standard administration of the Rey Complex Figure Test. In this test, subjects are first required to copy the figure as accurately as possible. An intervening verbal task follows, after which subjects are required to reproduce the figure from memory.²

In the present case, the Controlled Word Association Test (Benton, 1973) was used as an intervening task. This is a standard verbal fluency test of three and a half minutes' duration. A verbal task was used to minimise both mental rehearsal of the figure and interference by the task with the visual representation of the figure in memory.

Time taken to copy the figure was recorded using a hand-held stop watch. The experimenter also recorded the subject's copying order by drawing the figure as the subject drew it and noting the temporal order and direction of lines. This method has been used elsewhere for research purposes with the Rey Figure (see Lezak, 1983; Bennett-Levy, 1984).

**Stage 2: Training**

The training session took place one week after baseline testing. Subjects were randomly allocated to one of two groups. Each group was given a

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² The delay interval used in the administration of this test has varied across studies. Intervals used have included 3-4 minutes (e.g., Osterrieth, 1944; Gilandas, 1984), 20, 30, & 40 minutes and 1 hour (see Lezak, 1983). Ebert (1982) reported that recall did not change significantly in subjects regardless of delay, providing the delay was no longer than one hour.
modified administration of the Rey Complex Figure Test. The first (structured) group received an organized presentation of the figure (Figure 1). The second (unstructured) group received a relatively disorganized presentation (Figure 2), taken from the initial copy performance of a brain-damaged subject who did not undertake the training phase of the study. Subjects were required to copy the figure only once but to do so in the manner designated by the experimenter. Both structured and unstructured approaches were presented in six stages. At each stage the whole figure was exposed but only particular elements were highlighted. Subjects were required to copy only the elements which were highlighted in red at each stage. In this way, each subject copied the figure once through progressive stages and repeated copying and prolonged exposure to the figure were avoided.

Following this training procedure, subjects completed an intervening task (an alternative form of the Controlled Word Association Test) after which they were asked to recall the Figure.

A seven day interval between Stages 1 and 2 was considered to be sufficiently long to allow memory of the figure to diminish. It was also thought to be sufficiently short to minimise the possibility that cognitive recovery alone might affect recall scores.

It should be noted that while some improvement in recall of the figure was expected since subjects had seen it in the previous week, the variable of interest was relative change in scores rather than absolute scores of the experimental groups.
Figure 1. The structured copying approach for the Rey Complex Figure.

Figure 2. The unstructured copying approach for the Rey Complex Figure.
Stage 3: Generalization

Immediately following Stage 2 recall of the Rey Figure, subjects were asked to copy the Taylor Figure (Figure 3). This is an alternative form of the Rey Complex Figure Test. Copy time and copying order were noted by the tester. Subjects were required to recall the figure after a delay of three and a half minutes, during which they completed an intervening task. A verbal task involving serial subtraction was used. (It was necessary to use a different intervening task here to avoid the possibility that over-familiarity with the Controlled Word Association Test would enable subjects to rehearse the Taylor Figure in expectation of a recall test.)

This stage was included in order to ascertain whether any effect, which might have resulted from receiving a structured copying presentation on the Rey Figure at Stage 2, would generalize to performance on a second, similar task.

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3 Lezak (1983) reported that Taylor (1969, 1979) developed this figure as an alternative form to the Rey Figure, implying that it could be used as a re-test. While no normative data have been reported for the Taylor Figure, Lezak (1983) commented that scores on the figure had been found to be similar to those on the Rey Figure in a sample of patients who had had left temporal lobectomies. In addition, Berry, Allen & Schmitt (1991) found the copy and recall scores of 54 older normal subjects to be generally comparable on the two figures. They reported moderate reliability between the two figures. The Taylor Figure is frequently used in clinical neuropsychological practice. Ebert (1982) used the figure in a study, describing it as the "Taylor version of the Complex Figures of Rey".
Figure 3. The Taylor Complex Figure.
Stage 4

Following recall of the Taylor Figure, subjects were asked to re-copy the Rey Figure. The order of copy was noted by the experimenter.

This stage was included to ascertain whether any effects of training at Stage 2 would be reflected in subjects' free copy of the Rey Figure.

It would have been logical to test subjects on the final copy of the Rey Figure (Stage 4) immediately after Stage 2. However, this would have been the third time subjects were required to draw the figure in succession on the same occasion and there was a risk that they might tire of the task and show diminished co-operation. Therefore the generalizaton task was introduced prior to the final copy of the Rey Figure. It was not expected that this would have had a significant effect on the findings.

In practice, varying the procedure did prove important in maintaining co-operation.

The reference group of nine normal subjects was included in order to ascertain how the imposition of a copying procedure might affect a normal population. It was expected that normal subjects might achieve maximum recall scores purely as a result of a second exposure to the figure. If these subjects were given the structured copying procedure, it would not be possible to separate the effects of receiving a structured copying approach from the effects of a second exposure alone. In view of this, it was decided to give this group only the unstructured copying procedure at Stage 2. If the reference group nevertheless were to show an improvement in recall following this approach, it would suggest that in normal subjects internalized organization of the figure can override an imposed copying format. If they
did not improve, or even showed decreased recall, this would suggest that the imposed format interfered with their internalized representation of the figure. This would be an indication that externally imposed cues can be powerful tools in either aiding or impeding performance. It might also provide an analogue of the internal disorganization of some frontally damaged subjects. It would also confirm Bennett-Levy's findings that copying strategy of the complex figure is strongly correlated with recall in normal subjects.

Finally, the inclusion of a normal reference group was considered useful insofar as it would provide an opportunity to obtain some data on the comparability of the Taylor and the Rey Figures. However, because of the nature of the training procedure formal normative data would not be provided (see footnote 3).

Scoring

Copy performances were scored using the standard system designed by Osterrieth (1944) and adapted by Taylor (1959) (see Appendix A). This system divides the figure into eighteen components. Each is allocated a maximum score of two points, which are awarded according to presence, completeness and accuracy of the component. The overall score for the figure represents the cumulative total for all units. Thus, the maximum score for the figure is 36. To more precisely interpret placement, completeness and distortion, Bennett-Levy's strict criteria were also applied (see Appendix A). These strict criteria were developed by Bennett-Levy (1984) to reduce the likelihood of ceiling effects on copy scores. They were also found to produce higher inter- and intra-rater reliability.
In addition to scoring copying accuracy, copying strategy was scored using Bennett-Levy's (1984) system. The copying strategy score comprised 18 points for symmetry and 18 points for good continuation (see Appendix A). Symmetry scores were awarded for the sequential copying of major symmetrical units within the figure (that is, for completion of one of these units before starting on another component of the figure) and for the copying of one of these units immediately following another. Good continuation points were awarded for drawing a line within the figure to its terminal point. By definition, it is not possible to gain full marks for both of these, since in order to produce good continuation, it is necessary to neglect the uninterrupted production of a symmetrical unit at different points in the copying process.

In scoring recall performances, Bennett-Levy's (1984) lax recall criteria were used (see Appendix A.). This was because the application of the copy criteria to recall performance seemed unrealistic since most subjects are observed to treat the recall component purely as a test of memory. Subjects tend to regard care and accuracy in drawing as secondary to ensuring that as much as possible of the material remembered is shown. If a subject does not draw a line exactly to its completion point, it cannot be concluded that s/he has forgotten that part of the figure. Using these criteria, therefore, points were deducted only in the case of very obvious distortions and misplacements.

The Taylor Figure was scored in the same way as the Rey Figure. So that performance could be compared between the two figures, it was necessary to adapt Bennett-Levy's strict copy and lax recall criteria to the Taylor Figure. These adaptations are set out in Appendix B. In addition, copying strategy criteria were also adapted to this figure. It was only possible, however, to
derive a total score of 16 and 17 for symmetry and good continuation respectively for the Taylor Figure, making a maximum strategy score of 33. Therefore, in subsequent analysis of data where strategy scores for the Taylor Figure were included, these scores were transformed.
Results and Discussion

The two questions addressed by this study were, first, whether brain-damaged subjects would benefit from structured training in performance on the Rey Figure Test and, second, whether any improvement in performance would generalize to a novel figure. The primary index of the effect of training was provided by differences in recall of the Rey Figure before and after training. Additional measures were provided by changes in copying strategy and copying accuracy. Generalization was tested by comparing initial performance on the Rey Figure with performance on the Taylor Figure following training.

Recall of the Rey Figure

Baseline recall (Stage 1)

It was a prerequisite for this study that the brain-damaged group should manifest memory problems. Given the expected presence of frontal lobe involvement in the brain-damaged group, such problems were likely. In order to establish that this was the case, a comparison was made between the recall scores on the first trial of the Rey Figure for the brain-damaged subjects and the reference group.

Table 1 shows mean recall scores prior to training for the three groups. Mean recall for the reference group was significantly higher than that for the brain damaged subjects ($t(26) = 2.09, \ p < .05$). The reference group mean represented performance at the 60th percentile of the Rey Figure norms (Osterrieth, 1944), while the brain-damaged subjects were performing at the 35th percentile. This confirms the existence of memory deficits in the clinical
group and suggests that there was potential for improvement through training in the brain-damaged group.

Mean recall for the structured and unstructured training groups did not differ significantly ($t_{(16)} = -1.47, p > .05$), suggesting that prior to training the two groups were broadly comparable in terms of the severity of their memory problems.

Table 1

**Baseline recall of the Rey Figure**

<table>
<thead>
<tr>
<th></th>
<th>Structured Group</th>
<th>Unstructured Group</th>
<th>Reference Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>18.75</td>
<td>21.71</td>
<td>24.06</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>3.95</td>
<td>6.30</td>
<td>6.02</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>14 - 25</td>
<td>10.5 - 31.5</td>
<td>14 - 35</td>
</tr>
</tbody>
</table>

Although the brain-damaged group showed a mean deficit in recall, there was considerable overlap in recall performance between normal and clinical subjects. Scores also ranged widely within the two groups. The fact that some brain-damaged subjects scored higher than some normal subjects, however, cannot be taken as evidence that their recall was unimpaired following brain damage. It is possible that brain-damaged subjects' scores decreased in comparison with pre-morbid levels, regardless of the absolute value of scores received.
The effect of training on recall

The primary question asked in this study was whether the brain-damaged subjects would improve in their recall of the Rey Figure as a result of training with a structured copying procedure. Structure was imposed both through the delineation of identifiable units comprising the figure and through the presentation of those units in a particular copying order. The pattern of results suggests that a structured training procedure can enhance recall in brain-damaged subjects.

Recall scores of the Rey Figure for the structured and unstructured group were compared before and after training. Means and standard deviations of scores at Stage 1 and Stage 2 are presented in Table 2.

A 2 x 2 ANOVA (Group x Stage), with repeated measures on Stage, using the unweighted means solution for unequal n was conducted on the recall data. No main effects were obtained for Group or Stage (F(1, 34) = .23, p > .05; and F(1,34) = .24, p > .05 respectively). However, there was a significant Group x Stage interaction (F(1, 34) = 10.83, p < .01) (see Appendix C).

A simple effects analysis of the interaction showed that the structured group significantly improved in its recall across trials (F(1, 34) = 7.13, p < .05). By contrast, the unstructured group showed a tendency to decrease in recall between trials, although this was not significant (F(1, 34) = 3.93, p > .05).

The reference group (who also received the unstructured presentation) showed no improvement between Stages 1 and 2 (t(8) = 2.1, p > .05).
Table 2

Recall of the Rey Figure before and after training
(Stage 1 and Stage 2)

<table>
<thead>
<tr>
<th></th>
<th>Stage 1</th>
<th>Stage 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structured</strong></td>
<td>18.75</td>
<td>21.95</td>
</tr>
<tr>
<td>Group s.d.</td>
<td>3.95</td>
<td>7.58</td>
</tr>
<tr>
<td><strong>Reference</strong></td>
<td>24.00</td>
<td>21.22</td>
</tr>
<tr>
<td>Group s.d.</td>
<td>6.02</td>
<td>5.88</td>
</tr>
</tbody>
</table>

In summary, only the structured training procedure enhanced recall performance. The present study therefore supports Lhermitte et al.'s findings, but using a method that avoids contamination by practice effects unrelated to the training procedure. It confirms Lhermitte et al.'s conclusion that the provision of a structured copying strategy can lead to improved recall in subjects with brain damage and constitutes the first group study demonstrating such an effect. In view of the likely frontal involvement in the etiologies of the sample, the present results are consistent with Lhermitte et al.'s suggestion that frontal subjects can improve their recall as a result of some organizational input. However, the results do not provide definitive evidence that frontal lobe functions were implicated in the improvement, since many of the subjects would also have suffered diffuse damage.
The nature of the training effect

The question arises as to the precise cause of the improvement in recall following the structured presentation. It was considered that an examination of the memorability of the various units of the figure might provide information relevant to this question. Recall by all groups of the various units of the figure at Stage 1 and Stage 2 was compared. An assessment was made of the intrinsic memorability of the various units, and of the kinds of units which were remembered by the structured group following training.

Figure 1 shows the Rey Figure articulated into its various units. A recall score was calculated for each unit. This comprised the sum of the scores on that unit for all subjects in a given group, expressed as a proportion of the maximum possible sum for that group (this measure corrected for variations in group size). Table 3 shows the recall scores for each unit obtained by the three groups. To assess the degree to which groups were in agreement as to the memorability of individual units, correlations were computed between the scores for the various pairs of groups for Stage 1.

All correlations were significant ($r_{ref,u/s} = 0.6441$; $r_{ref,s} = 0.6762$; and $r_s, u/s = 0.8583$, $p < .01$ respectively). In general, these correlations confirm the existence of intrinsic differences in the memorability of the various units. The correlations between the reference group and the brain-damaged groups indicate that these differences survive brain damage to a degree. However, the correlations are only moderate and it appears that there was a higher correlation between the two brain-damaged groups than either showed with the reference group. This might suggest that the recall of particular units was differentially affected by brain damage.
Figure 1. The numbered scoring units of the Rey Complex Figure.
Table 3

Recall scores obtained for each unit of the Rey Complex Figure at Stage 1 and Stage 2, expressed as proportions

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Structured group</th>
<th>Unstructured group</th>
<th>Reference group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage 1</td>
<td>Stage 2</td>
<td>Shift</td>
</tr>
<tr>
<td>1</td>
<td>.53</td>
<td>.58</td>
<td>.05</td>
</tr>
<tr>
<td>2</td>
<td>.83</td>
<td>1.00</td>
<td>.17</td>
</tr>
<tr>
<td>3</td>
<td>.70</td>
<td>.95</td>
<td>.25</td>
</tr>
<tr>
<td>4</td>
<td>.85</td>
<td>.80</td>
<td>-.05</td>
</tr>
<tr>
<td>5</td>
<td>.95</td>
<td>.80</td>
<td>-.15</td>
</tr>
<tr>
<td>6</td>
<td>.15</td>
<td>.50</td>
<td>.35</td>
</tr>
<tr>
<td>7</td>
<td>.10</td>
<td>.33</td>
<td>.23</td>
</tr>
<tr>
<td>8</td>
<td>.53</td>
<td>.78</td>
<td>.25</td>
</tr>
<tr>
<td>9</td>
<td>.28</td>
<td>.33</td>
<td>.05</td>
</tr>
<tr>
<td>10</td>
<td>.13</td>
<td>.10</td>
<td>-.03</td>
</tr>
<tr>
<td>11</td>
<td>.78</td>
<td>.85</td>
<td>.08</td>
</tr>
<tr>
<td>12</td>
<td>.35</td>
<td>.50</td>
<td>.15</td>
</tr>
<tr>
<td>13</td>
<td>.85</td>
<td>.90</td>
<td>.05</td>
</tr>
<tr>
<td>14</td>
<td>.58</td>
<td>.65</td>
<td>.07</td>
</tr>
<tr>
<td>15</td>
<td>.45</td>
<td>.60</td>
<td>.15</td>
</tr>
<tr>
<td>16</td>
<td>.56</td>
<td>.48</td>
<td>-.10</td>
</tr>
<tr>
<td>17</td>
<td>.48</td>
<td>.53</td>
<td>.05</td>
</tr>
<tr>
<td>18</td>
<td>.30</td>
<td>.48</td>
<td>.18</td>
</tr>
</tbody>
</table>

Some units were more memorable than others. The reason for this is open to conjecture. At Stage 1, Unit 5 received scores of .9 or above in all groups. Units 2 and 4 received scores of .8 or above in all groups. Unit 11 received scores of .7 or above in all groups and Units 3 and 13 received scores of .6 or above in all groups. Units 5, 2, 4, 3 and 13 are all major symmetrical units or axes within the figure according to the Bennett-Levy scoring system. However, symmetry alone does not explain the relatively high recall of Unit 11. This unit was unusual in that many subjects termed it a face. It is possible that because of this association, the unit was particularly salient. It may also have stood out for other reasons, such as being the only circular shape in the figure. There was less agreement between groups as to which units were recalled least.
well. Only Unit 10 was consistently poorly recalled by all groups, receiving scores of .13 or less in each group.

It is noteworthy that brain-damaged subjects recalled Units 9 and 7 considerably less well than normal subjects. The result for Unit 9 is of particular interest, since it is a relatively large feature in the overall figure. The disparity for Unit 7 is less surprising since this unit is smaller and less obvious in the figure than other units. Why the brain-damaged subjects found it difficult to recall Unit 9 is not clear. It is possible that the absence of details attaching to it and the lack of internal detail made it less noticeable. Other features outside the central rectangle either had internal details or external attachments, or both, (e.g. Units 13 and Units 18). While this may explain why brain-damaged subjects recalled this unit poorly, it does not explain the extent of the disparity in recall of this unit between the brain-damaged and normal subjects.

Differences in the memorability of units following training were examined to determine whether there had been differential effects of training on individual units. It might have been expected that the largest increases in recall following training would be for the less intrinsically memorable units, since there would probably be a ceiling effect for the more memorable units following training. The correlation between baseline recall of units by the structured group and change scores following training was \( r = -0.427 \). This value approaches but does not reach significance (\( p = 0.08 \)). Consequently, no clear conclusion can be reached on this point.\(^1\)

\(^1\) Confirmation of this negative correlation between initial performance and the shift following training would raise the question of whether this relationship is a statistical artefact. In general, if \( X \) and \( Y \) are imperfectly correlated, regression to the mean alone will generate a correlation between \( X \) and \( (X-Y) \). A suggestion that this is not the explanation in this case is provided by the observation that there was no indication in these data of a correlation...
In fact, some units showed a decrease in recall following structured training. In particular, this was the case for certain units with high initial memorability (e.g. Units 4 and 5). However, it is noteworthy that recall for Unit 2, the central rectangle, was perfect following the structured training. This represents a shift of .17 over initial recall for this unit. It is possible that this unit is the most important of the highly memorable units in facilitating recall of other units in the figure. It may provide an organizational 'anchor' on which to 'hang' other units.

The preceding discussion has emphasized the possible beneficial effects of the structured training, and the significant interaction provided a prima facie case for the conclusion that the structured presentation did, indeed, improve recall. However, there are at least two alternative possible explanations for these results. The first is that the interaction resulted from interference by the unstructured procedure rather than facilitation by the structured procedure. The second possibility is that the structured procedure conferred an advantage which was not due to structuring per se.

Interference by the unstructured copying procedure may have occurred in two ways. The first is that it may have imposed an abnormal, and difficult-to-remember perceptual structure on the figure.

Alternatively, it is possible that the unstructured copying procedure made greater demands, occupied more processing time, and hence did not allow subjects to work on encoding the figure. In the unstructured procedure, subjects were required to interrupt lines and lift their pencils to continue between the post-training scores and change scores. Such a relationship would have been expected if regression to the mean, alone, was operating.
copying at another part of the figure. This may have reduced the opportunity to encode the figure, thus preventing subjects from using their own strategies to organize the figure. On the other hand, the simpler, more continuous copying procedure involved in the structured presentation may have reduced the information-processing demands for the structured group, enabling subjects to devote time to encoding the figure.

Evidence from other sources supports the suggestion that the mere activity of copying can affect recall. The processes of copying and perceiving the Rey Figure were distinguished in a study of Waber, Bernstein & Merola (1989). While that study employed a sample of children, its results may be nevertheless relevant to the present study. The recall performances of normal children, who had been asked either to study the Rey Figure visually or to copy it, were examined. Younger children who had studied the figure visually without copying it produced more organized memory performances than those who had copied the figure. They also remembered as much of the figure as did older children. However, no difference in organization of the figure was found in the older children in either condition. It was concluded that motor input had interfered with the process of visual encoding in the younger group.

It is possible that in the present brain-damaged sample, the copying process interacted with memory for the figure, just as it did in Waber et al.'s (1989) younger sample. A suggestion that the training procedure was affecting the unstructured group is provided by an examination of the shift scores for individual units. Although there was no significant decrease in recall scores for the unstructured group following training, there was a negative correlation between unit memorability and change scores for this group, which approached but did not reach significance (r = -0.447, p < .06). Thus, the
results of this analysis for the unstructured group are almost identical to those obtained for the structured group. However, for both groups the result is statistically inconclusive, and further evidence is required. Since mean performance in the post-test did not change for the unstructured group, this correlation would imply that the training effected a decrement in performance with the more memorable units. Indeed, in this group, all of the most memorable units (the eight units with greater than .6 baseline recall scores) showed a fall in recall following training. In contrast, only 40% of the remaining units showed a decrement following training.

The foregoing discussion raises the possibility that the significant result reported was in fact due to the negative effects of the training given to the unstructured group rather than to the positive effects of the structured training. Weak support for this suggestion is provided by the fact that neither group receiving the unstructured training procedure was able to benefit from the second exposure to the figure. Normally a second exposure would be expected to improve recall, and improvement should have been seen after both training procedures. The present data does not permit the resolution of this issue. It could have been resolved by the inclusion of an additional brain-damaged control group which simply copied the Rey Figure at Stage 2, without any training procedure. Anecdotal evidence that the structured training procedure conferred an advantage is provided by the spontaneous comment by one subject at Stage 4 that "it gives you how to go about it".

**Copying Strategy**

An analysis was made of the copying strategies used by the various groups at each stage of the experiment. The baseline copying strategies were
considered of interest as an index of the effects of the brain damage, while changes in strategy following training might provide evidence relating to the nature of the training effect.

**Baseline copying strategy (Stage 1)**

It was noted earlier that organizational factors have been thought to affect the memory performance of frontal subjects on the Rey Figure Test (e.g. Bennett-Levy, 1984; Lhermitte et al., 1972). If this is so, it might be expected that subjects in the present study would show a poor copying strategy in their initial copies of the figure, when compared with normal subjects.

As described earlier, copying strategy was measured in terms of a combination of the scores for symmetry and good continuation.

Mean copying strategy scores for all groups for Stage 1 and Stage 4 are set out in Table 4. Brain damaged subjects obtained significantly lower baseline copying strategy scores than normal subjects ($t$(24) = -2.47, $p < .05$). This difference might reflect abnormalities of perceptual organization per se. Alternatively, it might reflect abnormalities specifically relating to the copying task, for example, in organizing the figure for purposes of copying, or in organizing the copying performance itself.
Table 4

Copying strategy scores of all groups for initial free copy of Rey Figure (Stage 1) and final (free) copy of the figure.

<table>
<thead>
<tr>
<th>Group</th>
<th>Stage 1</th>
<th>Stage 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structured</td>
<td>22.50</td>
<td>25.80</td>
</tr>
<tr>
<td>Group s.d.</td>
<td>4.35</td>
<td>3.79</td>
</tr>
<tr>
<td>Unstructured</td>
<td>25.14</td>
<td>27.14</td>
</tr>
<tr>
<td>Group s.d.</td>
<td>4.34</td>
<td>3.44</td>
</tr>
<tr>
<td>Reference</td>
<td>27.89</td>
<td>28.33</td>
</tr>
<tr>
<td>Group s.d.</td>
<td>3.26</td>
<td>2.45</td>
</tr>
</tbody>
</table>

The effect of training on copying strategy

As has been shown, recall improved following a structured presentation of the Rey Figure. It might therefore be expected that copying strategy scores would also have increased for the structured group.

To examine the question of whether the structured group would show such an improvement, copying strategy scores for the structured and unstructured groups were compared at Stage 1 and Stage 4 (corresponding to the initial copy of the Rey Figure and the second (free) copy of the Rey Figure, respectively). A 2 x 2 ANOVA (Group x Stage), with repeated measures on Stage, using the unweighted means solution for unequal n was conducted on copying strategy scores at Stages 1 and 4. No main effect for Group was
found \( F(1,32) = 2.01, p >.05 \) but there was a main effect for Stage \( F(1,32) = 5.40, p <.05 \). There was no significant interaction between the two groups \( F(1,32) = 0.30, p >.05 \); that is, type of training had no differential effect on copying strategy scores at Stage 4. The reference group's copying strategy scores did not change across the two copying trials \( t(8) = -0.35, p >.05 \).

These results indicate that neither the structured nor the unstructured copying procedure conferred a specific effect on copying strategy at Stage 4 in the clinical group, although both groups showed an improvement in score. It is therefore likely that copying practice alone was responsible for the increase in copying strategy scores across trials in the clinical groups. This result is surprising in view of the effect on recall performance of the structured training procedure at Stage 2. It is also inconsistent with both Lhermitte et al.'s and Pillon's conclusions that organization of copy improved following training using a programmed copying approach in frontally damaged subjects. However, the results of both these studies might be queried, first, on the grounds that neither used a control group which was simply re-tested on the figure without being given any copying instructions; and second, on the basis that neither study employed a quantitative measure of copying strategy but relied on qualitative observations of the organization of copy.

There is additional evidence of a dissociation between copying strategy and recall in the brain-damaged subjects. First, initial copying strategy was not related to recall of the Rey Figure in the brain-damaged subjects \( r=0.3353, p >.10 \). This was still the case if age was taken into account using the multiple regression equation developed by Bennett-Levy (1984) for normal subjects \( \text{Predicted lax recall} = (0.75 \times \text{Copy Strategy score}) - (0.16 \times \text{Age}) + 8.01 \). In the present study, this equation yielded errors of prediction in excess of one standard error of estimate for 12 of the 18 brain-damaged subjects who...
participated in Stage 1 of the study. In contrast, recall was accurately predicted for 7 of the 9 normal subjects.

The question arises as to why the structured presentation facilitated recall of the Rey Figure but did not generate a specific improvement in copying strategy.

One possibility is that the structured copying experience affected the subjects' utilization of structure (for purposes of recall) rather than their perception of structure per se. In favour of this view is the fact that some brain-damaged subjects obtained satisfactory copying strategy scores at Stage 1. Since some of these subjects were able to improve their recall significantly following training, this might suggest that the structured procedure served to remind these subjects to utilize the basic organizational information which they already possessed for the purposes of recall. In support of this suggestion, other studies have reported poor utilization of intact cognitive abilities (e.g. Eslinger & Damasio, 1985).

Irrespective of the question of the relationship between copying strategy and recall, the question arises as to why there was an improvement in copying strategy between Stages 1 and 4 for all groups. It is not clear why this occurred. However, the fact that the unstructured group also showed an increase in copying strategy score is of interest since it indicates that the structured training experience was not a prerequisite for improvement.

Several authors (e.g. Delis, 1989; Lezak, 1982) have noted (through informal clinical observation) spontaneous improvements in the organization of recall drawings following a poorly organized copy of the Rey Figure in brain-damaged subjects. It is possible that these subjects possessed some inherent
organizational skills but that they needed time to either consolidate these or to become aware of their utility. Likewise, in the present study, the brain-damaged subjects may have required time to think to analyse the figure. Their primary problem may have been slowness in processing information rather than the absence of a basic skill.

**Copying Accuracy**

**Baseline Copying Accuracy**

Mean (strict) copy scores are set out in Table 5. Brain-damaged subjects obtained significantly lower copying strategy scores than normal subjects prior to training ($t_{(24)} = -2.6114$, $p < .05$). The initial drawings of the brain-damaged subjects were complete, overall, and approximately proportionate. However, their finished drawings differed from those of the normal subjects largely in terms of precision. This diminished precision appeared to result from impulsiveness. In a few instances, imprecision was due to slight motor problems.

**The effect of training on copying accuracy**

Strict copy scores did not improve between Stage 1 and Stage 4 for either group. Strict copy scores at Stage 1 (initial free copy of Rey Figure) and Stage 4 (second free copy of Rey Figure) were compared in brain-damaged subjects using a 2 x 2 (Group x Stage) ANOVA. No main effects for Group or Stage were found ($F_{(1,32)} = .04$, $p > .05$ and $F_{(1,32)} = 1.72$, $p > .05$ respectively) and there was no significant interaction ($F_{(1,32)} = 0.80$, $p > .05$). Similarly, the
reference group showed no significant improvement in copy scores between Stage 1 and Stage 4 ($t(8) = 0.93, p >.05$).

The fact that normal subjects' copying accuracy scores did not increase with practice, might be attributed to a ceiling effect. However, this does not apply to the clinical groups, which showed lower baseline performance.

Since copying strategy improved equally for both clinical groups, it might have been expected that copying accuracy would also have improved for both groups. However, it appears that the improvement in copying strategy for these subjects did not confer any advantage on accuracy. This is perhaps not surprising, given that the brain-damaged subjects' lower accuracy scores more often resulted from problems with precision rather than omission or distortion. As indicated, in some instances precision errors might be explained by mild problems with motor co-ordination. In these circumstances, subjects could not be expected to improve, at least over short periods. In conclusion, at a group level, the way a copy is organized would not appear to be related to accuracy of copy. This is also true at the individual level (a small non-significant correlation between copying strategy and copying accuracy was found for the brain-damaged subjects: $r = 0.1844$).
Table 5

Strict copy scores for the first (Stage 1) and final (Stage 4) copies of the Rey Figure

<table>
<thead>
<tr>
<th></th>
<th>Stage 1</th>
<th>Stage 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structured</td>
<td>29.50</td>
<td>29.75</td>
</tr>
<tr>
<td>Group s.d.</td>
<td>3.96</td>
<td>4.64</td>
</tr>
<tr>
<td>Unstructured</td>
<td>29.29</td>
<td>30.71</td>
</tr>
<tr>
<td>Group s.d.</td>
<td>3.96</td>
<td>3.16</td>
</tr>
<tr>
<td>Reference</td>
<td>33.17</td>
<td>32.22</td>
</tr>
<tr>
<td>Group s.d.</td>
<td>2.17</td>
<td>2.43</td>
</tr>
</tbody>
</table>

Copy time at Stage 1: Relationship with recall in clinical and normal subjects

The question arises as to whether the recall deficiencies of the clinical group were simply due to hasty responding in the copying task, with consequent reductions in encoding time. In order to examine this question, an analysis was made of copying times at Stage 1.

Mean copy time of the Rey Figure (at Stage 1) for the clinical and normal group is set out in Table 6. Copy times did not differ significantly between the brain-damaged and normal groups ($t(25) = -1.29, p > .05$). Therefore, the recall
deficit was not due to reduced exposure time. Indeed, the tendency was for the brain-damaged subjects to take longer.

Table 6

Mean copy time (in minutes) for the initial copy of the Rey Figure

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain-damaged</td>
<td>4.27</td>
<td>3.13</td>
</tr>
<tr>
<td>Reference</td>
<td>2.84</td>
<td>0.85</td>
</tr>
</tbody>
</table>

This tendency towards longer copying time in the clinical groups was accompanied by deficient recall. This might imply that any additional time taken was not utilized for efficient encoding. A negative relationship between study time and recall was evident at an individual level within the clinical group. Thus, there was a significant negative relationship between copy time and recall in this group ($r = -0.5705$, $p < .02$). No significant relationship was found between copy time and initial recall in the normal group ($r = 0.1692$, $p > .05$). The explanation of these data is unclear. Within the clinical group, the correlation might simply reflect variations in the severity of brain damage. At a group or individual level, the association of longer copying time with poor recall might reflect inefficient encoding strategies, or time spent in activities other than encoding, such as copying itself.
Generalization

The second question explored in this study was whether learning gained at Stage 2 would generalize to a comparable task. Generalization was assessed by comparing performance on the Taylor Figure with performance on the Rey Figure. It was seen in the previous section that the recall of subjects given a structured presentation of the figure improved whereas that of the unstructured group did not. If the effect of the structured training generalized, better scores could be expected on the Taylor Figure for the structured group as compared with the unstructured group. Generalization could manifest itself in two aspects of the structured group's performance: recall and copying strategy. In each case, generalization could be assessed by comparing performance on the Taylor Figure with the initial performance on the Rey Figure.

Mean recall scores for the Rey Figure at Stage 1 and for the Taylor Figure are set out in Table 7.

Before considering the issue of generalization, it is relevant to consider whether the two figures are of equivalent difficulty. Evidence on this question is provided by a comparison of the reference group's performance on the Rey and the Taylor Figures. No significant effect was found ($t(8) = 1.85, p > .05$). Normal subjects performed equally on the recall of the Rey and the Taylor Figures. This is consistent with the conclusion that the two figures
Table 7

<table>
<thead>
<tr>
<th></th>
<th>Stage 1</th>
<th>Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structured</td>
<td>( \bar{x} ) = 18.75</td>
<td>( \bar{x} ) = 15.80</td>
</tr>
<tr>
<td>Group s.d.</td>
<td>3.95</td>
<td>5.94</td>
</tr>
<tr>
<td>Unstructured</td>
<td>( \bar{x} ) = 21.71</td>
<td>( \bar{x} ) = 17.57</td>
</tr>
<tr>
<td>Group s.d.</td>
<td>6.30</td>
<td>7.63</td>
</tr>
<tr>
<td>Reference</td>
<td>( \bar{x} ) = 24.06</td>
<td>( \bar{x} ) = 26.00</td>
</tr>
<tr>
<td>Group s.d.</td>
<td>6.02</td>
<td>5.14</td>
</tr>
</tbody>
</table>

are of comparable difficulty. This might be queried on the grounds that the Taylor Figure Test was presented to all subjects after the Rey Figure Test in the present study and thus order effects were not controlled\(^2\). Nevertheless, the study of Berry et al. (1991), on an older normal sample, lends support to the view that the two figures are comparable.

Recall scores of the two clinical groups were compared in a 2 x 2 ANOVA (Group x Stage), with repeated measures on Stage, using the unweighted means solution for unequal n. A main effect for Stage was found (\( F(1,32) = \)

\(^2\) In particular, it is possible that receiving the Taylor Figure Test directly after the Rey Figure led to an expectation in normal subjects during their copy of the Taylor Figure that a recall test would follow, enabling them to rehearse prior to the recall test. However, if this occurred, recall scores should have been better for the Taylor Figure. Since the recall of this figure was only equal to that for the Rey Figure, this might imply that the Taylor Figure was more difficult to recall than the Rey Figure. In view of such considerations, the comparability of the figures can be only tentatively assumed.
20.80, \( p < .001 \) but there was no significant effect for Group \( (F(1,32) = 1.50, \ p > .05) \) and no significant Group x Stage interaction \( (F(1,32) = 0.59, \ p > .05) \). It can be concluded that recall scores were lower for the Taylor Figure in both groups.

These results provide no evidence of generalization of the recall advantage conferred by the structured training on the Rey Figure.

A corresponding analysis was carried out on the copying strategy scores. Table 8 shows mean copying strategy scores for all groups for the initial copy of the Rey Figure and for the Taylor Figure. Since no special advantage was conferred by the structured training on copying performance (accuracy or strategy), generalization would not be expected. This was confirmed by a 2 x 2 ANOVA (Group x Stage), with repeated measures on Stage,
Table 8

Copying strategy scores for first copy of Rey Figure (Stage 1) and copy of the Taylor Figure (Stage 3)

<table>
<thead>
<tr>
<th></th>
<th>Stage 1</th>
<th>Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structured</td>
<td>X 22.50</td>
<td>27.50</td>
</tr>
<tr>
<td>Group</td>
<td>s.d. 4.35</td>
<td>2.84</td>
</tr>
<tr>
<td>Unstructured</td>
<td>X 25.14</td>
<td>26.86</td>
</tr>
<tr>
<td>Group</td>
<td>s.d. 4.34</td>
<td>3.89</td>
</tr>
<tr>
<td>Reference</td>
<td>X 27.89</td>
<td>28.00</td>
</tr>
<tr>
<td>Group</td>
<td>s.d. 3.26</td>
<td>2.62</td>
</tr>
</tbody>
</table>

using the unweighted means solution for unequal n. This yielded no significant main effects (F(1,32) = 0.11; F(1,32) = 2.60, p >.05). While the slight improvement shown by the structured group was not evident in the unstructured group, the interaction was not significant (F (1,32) = 3.13, p >.05).

The normal reference group showed no significant change in copying strategy scores between initial copy of the Rey Figure and the Taylor Figure (t(8) = 1.30, p >.05).
Interference

Perusal of the recall drawings of the Taylor Figure suggested that one reason for the significant decrease in recall scores in the brain-damaged group may have been proactive interference from the Rey Figure. This occurred in all groups but appeared to be more frequent amongst brain-damaged subjects.

To assess interference, elements of the Rey Figure appearing in the recall drawings for the Taylor Figure were scored as if they were drawings of the Rey Figure. The greater a subject's Rey recall score in his/her Taylor recall performance, the more the interference. Table 9 sets out mean interference scores for both groups. A single-factor ANOVA, using the unweighted means solution for unequal n, on the interference scores of the reference, structured and unstructured groups, showed a significant difference between the group means (F(2,75) =5.66, p < .01). Follow-up pairwise comparisons of the three means showed significantly higher interference in the brain-damaged groups in comparison with the normal group but no difference between the structured and unstructured groups (t(17) = -2.43, p < .05; t(15) = -3.67, p < .05; t(15) = -1.54, p > .05, respectively)

It would therefore appear that while exposure to two figures on the one occasion may not have adversely affected the normal group, it was a disadvantage to the clinical group.
Table 9

Mean interference scores for the Taylor Figure recall drawings

<table>
<thead>
<tr>
<th>Structure</th>
<th>M</th>
<th>s.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structured</td>
<td>3.80</td>
<td>3.05</td>
</tr>
<tr>
<td>Unstructured</td>
<td>5.32</td>
<td>5.63</td>
</tr>
<tr>
<td>Reference</td>
<td>1.56</td>
<td>1.67</td>
</tr>
</tbody>
</table>

The demonstration of interference effects in the present brain-damaged group is consistent with interference effects commonly reported in the memory performances of frontal lobe subjects (e.g. Konorski & Lawicka, 1964; Luria, 1973; Hecaen & Albert, 1978; Stuss, 1987; Grafman, 1989). While the interference occurring in the present study was proactive in nature other authors have also observed retroactive interference in frontal subjects. Luria (1973), for example, referred to the "pathological inertia of recently established traces", suggesting the blocking of retrieval processes for earlier material by recent learning.

The occurrence of interference effects might throw light on the nature of the recall impairment in the brain-damaged subjects. It has been suggested that the occurrence of proactive interference (also referred to as associative interference and proactive inhibition) indicates an encoding, rather than a
retrieval problem (Crowder, 1982; Postman & Underwood, 1973). According to this view, proactive interference does not arise from retrieval competition but because, in acquisition, subjects exhaust mediating resources leaving fewer encoding resources for subsequent learning. If this were so, the interference noted in the brain-damaged group in the present study may have indicated encoding rather than retrieval deficits. Encoding deficits have also been attributed to proactive inhibition in the recall performance of other subjects with presumed frontal involvement, namely, that of Korsakoff patients (Crowder, 1982).

Concluding remarks

In summary, the primary result of the present study was that brain-damaged subjects recalled the Rey Figure better following a structured training procedure than following an unstructured procedure. In contrast, the type of training procedure did not affect copying strategy. Finally, there was no generalization of the training effect to recall of a similar, but novel figure.

The effect of training on recall

The present study was predicated on the assumption that any change in recall scores would result from the positive effects of structured training and not from the negative effect of the unstructured training procedure. However, while the recall scores of the brain-damaged subjects were indeed affected by the training procedures used in the present study, it is unclear which procedure was primarily responsible for this effect. It is possible that both kinds of training affected the performance of the respective groups.
If the effect was largely due to the unstructured training, an implication of this is that the structured training passively facilitated subjects' utilization of exposure time to encode the figure. The unstructured training, on the other hand, may have served to prevent encoding. This may have occurred through direct interference with subjects' perception of the figure. Alternatively, the unstructured copying procedure may have demanded more concentration, thus limiting subjects' free encoding time.

If the effect was largely due to the structured training, there are several possible ways in which this may have occurred. The first and most obvious is that the structuring of the figure may have served to remediate an organizational deficit. From the structured procedure, subjects may have perceived the figure as comprised of identifiable units or as a system of part-whole relationships, or both. Secondly, the structured procedure may have demonstrated an efficient copying sequence. If this were so, the information recalled would have been the memory of a series of motor acts, rather than of spatial content. Thirdly, the training procedure may be seen as having provided subjects with a structured rehearsal sequence in which the whole training episode, rather than just the figure, was the unit of memory. If this were the case, subjects' recall would have been comprised of moments in the copying sequence. These moments would have contained both action and spatial information linked to each other. While subjects in the unstructured group would also have been involved in a rehearsal process, the fragments recalled would not have involved perceptual units which could cue the recall of other related units. A fourth explanation is that subjects actually learnt to use structure to cue recall. However, in view of subjects' failure to generalize, it is unlikely that there was learning of a metacognitive skill of this sort.
The effect of training on copying strategy

It was suggested that copying practice alone might account for the improvement in copying strategy for the Rey Figure by both brain-damaged groups. Copying practice may have led to an increase in copying efficiency which was independent of any structural content in the training procedures. That the structured training procedure conferred no differential advantage on copying strategy is surprising, both in view of the improvement in recall by the structured group and particularly given that the training was in copying strategy and not in memory techniques. The possibility that brain-damaged subjects encoded episodic information at Stage 2 rather than specific spatial content might explain this result. Since the free copy of the Rey Figure at Stage 4 did not specifically require the recall of information, subjects may not have used the memory of their training experience whilst engaged in free copying.

Generalization

Generalization did not occur in this experiment. If this failure represents a broader failure of generalization of learning in brain-damaged patients, the implications for the cognitive remediation of this group are significant. One implication might be that cognitive retraining would need to focus on the re-learning of specific real-life tasks. However, while generalization did not occur under the particular conditions of the present study, it is still possible that generalization might have occurred under other conditions. For example, interference would be expected to decrease with increasing delay. To the extent that interference explains the failure to generalize, generalization might have occurred if the two tests had been separated by a longer interval. Also,
generalization might have been facilitated if the training had comprised more than one trial. In addition, for generalization to occur, it may have been necessary for training to take a more explicit form. Training took the form of instruction in a particular copying procedure, and learning was incidental. It has been suggested elsewhere that generalization requires explicit training and the opportunity to practice skills in the context in which they are required (e.g. Mateer, Sohlberg & Youngman, 1990; Mateer, 1991).

The nature of the training effect

A number of reasons were suggested in the earlier discussion for attributing the recall deficits in the brain-damaged sample to organizational problems, rather than to pure memory problems. However, it is possible that the training effect primarily remediated a memory deficit rather than a problem of organization. As noted earlier, it is likely that the lesions of many of the subjects involved the temporal lobe, and problems of pure forgetting are frequently reported in patients with damage in this area (e.g. Walsh, 1978; Bennett-Levy, 1984). The possibility that the memory deficits were due to retention problems cannot therefore be ruled out, and the question cannot be settled on the basis of the present data.

If the brain-damaged sample did, indeed, have a problem of pure forgetting, the third explanation for the positive effect of structured training may best account for the results. As mentioned, this explanation suggests that subjects did not encode spatial information independently of the copying process. Rather, they recalled the copying process itself. In this view, it would not be surprising that subjects receiving the structured copying training should recall more than those in the unstructured condition, since the structured copying procedure provided more effective retrieval cues than the unstructured
procedure. The structured approach emphasised perceptual organization. As already noted (from subjects' initial drawings and subsequent copying strategy scores), subjects possessed some basic elements of normal perceptual organization. Since the structured approach conformed to pre-existing perceptual structures, each fragment recalled would provide a hook for the next. The unstructured procedure, on the other hand, violated perceptual organization. If perceptual structure is violated, any fragments retrieved would have nothing to attach to, leading to poorer recall. Interestingly, this explanation might suggest that the differential training effect on recall owed more to the disruption due to the unstructured training than to the assistance provided by the structured training.

The foregoing explanation would also account for the failure to generalize. The memory generated by the two training procedures would be specific to the Rey Figure and irrelevant to any other figure.

In summary, while speculative, this explanation does account for the training effect on recall, the lack of a differential training effect on copying strategy, and the absence of generalization. It also explains the lack of a differential effect of structured training on copying strategy. If this account were correct, the effect of the training exercise undertaken in the present study would be quite different from that originally intended. The structured training exercise might be seen as remediating a memory deficit rather than remediating a problem with organization, and as such, would conform to the body of practice in memory retraining which encourages subjects to engage in elaborative rehearsal.
Limitations of the present study and future directions

The present study employed both a structured and unstructured training condition. The question of which type of training was responsible for the change in recall scores might have been determined with the inclusion of a third brain-damaged group required to copy the figure a second time without training instructions. Including such a group might help to ascertain the amount of improvement occurring purely as a result of a second exposure to the figure.

A second limitation of the present study was that the relationship between effect of training and frontal locus of lesion was not well-established. A future study might incorporate a more homogeneous sample of focal frontal subjects. In addition, such a study could include a separate group of subjects with established focal temporal/hippocampal involvement. This might help to ascertain the effectiveness of type of training with different types of memory impairment. An additional study is needed in which the training procedure is modified so that spatial content is more clearly differentiated from the sequential procedure in which it is embedded.

Contribution of present study

Despite the limitations of this study, it represents an advance over Lhermitte et al.'s study in several ways.

While that study has been widely cited, the claimed positive effect for structured training on recall was based on the improvement of only one out of four subjects. The present study has confirmed a training effect using a group
design with a larger sample of brain-damaged subjects. While the procedure was closely related to that used by Lhermitte et al., it was modified and improved to reduce the effects of copying practice and exposure. A second brain-damaged group, which received an unstructured training procedure, was included to provide a control for improvement arising from a mere second exposure to the figure.

The methodology used in this study was original in several other respects. It is the first application of comprehensive scoring criteria to the copying strategy used by a brain-damaged sample. As a result, the study constitutes the first attempt to ascertain the relationship between copying strategy and recall in a brain-damaged sample. Secondly, this is the first study (of normal or clinical subjects) to document copying strategies for the Taylor Complex Figure, a frequently used alternative form of the Rey Figure. Finally, the analysis of baseline and post-training recall scores for specific units of the Rey Figure is unique to this study.

As already indicated, there were limitations associated with the use of a head-injured group. This is because the diffuse nature of their injuries restricted the inferences which could be drawn about organization and its relationship to memory in specifically frontal subjects. Nevertheless, the inclusion of patients with closed head injury is of significant practical relevance. These patients represent a high proportion of individuals presenting for cognitive rehabilitation. An understanding of the factors which improve their recall is essential. It is also important to establish the conditions under which generalization does and does not occur for this group so that appropriate remediation techniques can be developed. The failure of generalization in this study is important because it indicates factors, such as interference, which impede learning in brain-damaged subjects.
Finally, the present study raises several important theoretical and methodological issues which could usefully form the basis of future research in the area discussed.
References


Rey, A. (1941). L'examen psychologique dans les cas d'encephalopathie traumatique. *Archives de Psychologie*, 28(112), 112-164.


Appendix A

Standard Scoring System for the Rey Complex Figure: copy and recall drawings

Units
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 within 2, below 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 5 below 2
18. Square attached to 2, lower left

Scoring

Consider each of the 18 units separately. Appraise accuracy of each unit and relative position within the whole of the design. For each unit count as follows:

Correct  )placed properly  2 points
         )placed poorly  1 point

Distorted or incomplete but recognizable  )placed properly  1 point
                                         )placed poorly  1/2 point

Absent or not recognizable  0 points

Maximum score  36 points
SCORING SYSTEM FOR THE COPY OF THE REY FIGURE

General points:

1) The instructions I give the testee are: "Now I would like you to copy this figure as accurately (emphasized) as you can." "Taking care not to forget anything" may be added.

2) 2 points are awarded for a correct figure. One point is always awarded if all the components of the Unit are present even though more than one detail may be inaccurately drawn according to the criteria below. Only if there is severe distortion of the Unit or it is incomplete may half a point be awarded.

3) 1 point should be deducted if:
   i) lines are not approximately straight.
   ii) lines do not reach, or extend beyond, their intersection point.
   iii) lines are broken, redrawn or crossed out.

Unit 1: Cross upper left corner outside of triangle.
Description: The cross should extend to the central horizontal line rectangle and upwards extends to almost the top of the triangle. The line adjoining the cross to the rectangle cuts the rectangle between the top of the rectangle and Unit 7. The extension of the cross above this cut and below this cut are of equal length.

Points are deducted if:
1) The cross is extended above the top triangle.
2) The cross does not extend downwards to the central horizontal line or very close to the central horizontal line.
3) The top of the cross above the cut, or the bottom half below the cut is more than twice the length of the other.
4) The line joining the cross to the rectangle is not placed between Unit 7 and the top of the rectangle.

Unit 2: Large rectangle.
Description: The vertical sides of the rectangle are 70% of the length of the horizontal sides.

Points are deducted if:
1) The vertical side is greater than 90% or less than 50% of the length of the horizontal side.
2) There are disconnections within any of the sides of rectangle.
3) The rectangle sides extend beyond the rectangle and are untidy, or fail to meet.
4) The rectangle is malformed such that it ceases to be rectangular or square-like. In this case, 1½ points are deducted.

Unit 3: Diagonal cross.
Description: The cross meets the rectangle at the angles of the rectangle.
Points are deducted if:
1) Any of the ends of the cross fail to intersect with the corners of the rectangle; this is scored very strictly.
2) There are disconnections within the cross; these usually occur at the centre of the figure.
3) This disconnection is extreme. In this case, 1½ points are deducted.
4) If the diagonal cross and the horizontal midline and the vertical midline of the large rectangle fail by much to intersect at the centre, and two points are awarded for each of Units 3, 4 and 5, then 1 point should be deducted from the diagonal cross Unit 3.

Unit 4: Horizontal midline of the large rectangle.
Description: The horizontal bisects the large rectangle at the centre of its vertical sides.

Points are deducted if:
1) The horizontal does not bisect the large rectangle at between 40 and 60% of the length of the vertical line (Unit 5).
2) There is disconnection within the horizontal line at the centre of the figure.
3) This disconnection is extreme. In this case, 1½ points are deducted.

Unit 5: Vertical midline of the large rectangle.
Description: The vertical midline of the large rectangle bisects the large rectangle at the midpoint of its horizontal sides.

Points are deducted if:
1) The vertical line does not bisect the horizontal line at between 40 and 60% of the length of the horizontal line (Unit 4).
2) The upper and the lower parts of the vertical line are disconnected at the centre.
3) This disconnection is extreme. In this case, 1½ points are deducted.

Unit 6: Small rectangle within the large rectangle to the left.
Description: The angles of the small rectangle meet with the sides of the diagonal cross Unit 3. The horizontal sides of the small rectangle are approximately 74% of the length of the vertical side.

Points are deducted if:
1) The horizontal line is more than 94% or less than 54% of the length of the vertical line.
2) The angles of the small rectangle fail to intersect with the diagonal cross Unit 3.
3) There is clear disconnection between one side of the diagonals within the small rectangle and the other sides.
4) There is clear disconnection between the top of the rectangle and the bottom of the rectangle.
Unit 7: Small segment above the small rectangle Unit 6.  
**Description:** The segment cuts the diagonal between the second line down and the third line down of the four parallel lines Unit 8.

**Points are deducted if:**
1) Unit 7 fails to intersect with the diagonal between the second line down and the third line down of Unit 8.
2) Unit 7 extends beyond the diagonal.

Unit 8: Four parallel lines within the rectangle upper left.  
**Description:** The parallel lines are equally spaced between the top of the rectangle and the central horizontal line.

**Points are deducted if:**
1) The distance between any two parallel lines - including the top of the rectangle and the central horizontal line - is twice as much as the distance between any other two of the parallel lines.

Unit 9: Triangle above the large rectangle upper right.  
**Description:** The length of vertical line of this triangle is less than the length of the top half of the vertical midline, Unit 5. The length of the vertical line of the triangle is approximately 46.5% of the length of the sloped line of this triangle.

**Points are deducted if:**
1) The vertical line of this triangle is longer than the distance between the top of the vertical midline of the large rectangle and the centre point of the large rectangle.
2) The vertical line of this triangle is more than 56.5% or less than 36.5% of the length of the sloped line of this triangle.

Unit 10: Small vertical line within the large rectangle below the Unit 9 triangle.  
**Description:** This line is towards the left side of the quadrant.

**Points are deducted if:**
1) The line is not to the left of the quadrant.
2) The line extends beyond the diagonal or beyond the top of the rectangle.

Unit 11: Circle with three dots within the large rectangle.  
**Description:** The circle does not touch either the diagonal cross or the large rectangle or the horizontal midline of the large rectangle. The dots within the circle are face-like and are filled in.

**Points are deducted if:**
1) The circle is not well-joined.
2) The dots within the circle are left open.
3) The dots within the circle are skewed or not face-like.
4) Any of the edges of the circle touch the diagonal or the large rectangle or the horizontal midline of the large rectangle.
Unit 12: Five parallel lines within the large rectangle crossing the diagonal cross lower right.
Description: These lines are equidistant and do not touch the sides of the large rectangle or the vertical midline or the horizontal midline. They bisect the diagonal cross at 90°.
Points are deducted if:
1) The spacing between any two of these lines is twice as much as any other two of these lines.
2) The lengths of these lines are very unequal.
3) These lines touch the sides of the large rectangle or the vertical midline or the horizontal midline.
4) Their intersection with the diagonal cross is a long way from 90°.

Unit 13: Sides of triangle attached to large rectangle on the right.
Description: The distance from the apex of the triangle to the right vertical side of the large rectangle is approximately 38.33% of the length of the horizontal midline of the large rectangle. The triangle is an isosceles triangle.
Points are deducted if:
1) The distance from the apex of the triangle to the right vertical side of the large rectangle is less than 28.33% or more than 48.33% of the length of the horizontal midline of the large rectangle.
2) The triangle is skewed and not isosceles.
3) The triangle sides extend beyond the corners of the large rectangle.

Unit 14: Diamond attached to the triangle Unit 13.
Description: The diamond does not extend below the bottom of the large rectangle. It is attached to Unit 13.
Points are deducted if:
1) The diamond is severely misshapen.
2) The diamond extends beyond the bottom of the large rectangle.
3) The width of the diamond is greater than half the distance between the apex of the triangle Unit 13 and the right vertical side of the large rectangle.
4) The diamond is not attached to the apex of the triangle Unit 13.

Unit 15: The vertical line within the triangle Unit 13 parallel to the right vertical of the large rectangle.
Description: The line is left of centre within the triangle Unit 13. It is parallel to the right vertical of the large rectangle.
Points are deducted if:
1) The line is not to the left of the triangle Unit 13.
2) The line is not approximately parallel to the right vertical of the large rectangle.
3) The line extends outside the triangle Unit 13.
Unit 16: Horizontal line within the triangle Unit 13 continuing the horizontal midline to the right.
Description: This line runs from the end of the horizontal midline of the large rectangle to the apex of the right triangle Unit 13.

Points are deducted if:
1) The line is severely off horizontal.
2) It fails to intersect with the apex of the right triangle; this is scored very severely.

Unit 17: Cross attached to the lower centre extension of the vertical midline in the large rectangle.
Description: The cross intersects with the right vertical side of the square Unit 18 at its mid-point. The cross is attached to the lower extension of the centre vertical line of the large rectangle and terminates beyond the beginning of the five parallel lines Unit 12, and before the imaginary extension of the right vertical line of the large rectangle.

Points are deducted if:
1) The cross is not between the 30% and 70% points of the length of the right vertical line of the bottom square Unit 18.
2) The cross extends beyond the right vertical line of the large rectangle.
3) The cross does not extend as far as the beginning of the five parallel lines Unit 12.
4) The crossing line of the cross is very uneven, that is if one side of the crossing line is more than twice the size of the other side.

Unit 18: Square attached to the large rectangle lower left.
Description: The sides are of course equal. A diagonal runs from upper left to lower right. The length of the top of the square is equal to the length from the right side of the square to the vertical midline.

Points are deducted if:
1) One side of the square is less than 80% of the length of any other side of the square.
2) The top side of the square is not between 30% and 70% of the length of the bottom side of the rectangle to the vertical midline.
In the above, (manufactured) example, each unit is worth 1 point, for a total Copy Score of 18. This example should be studied in association with the Copy Score instructions. N.B. that although many units contain more than one error according to the criteria, only one point is deducted as all units are present and complete, and in none is there severe distortion (see General Points No. 2).

Below are listed the unit numbers, and the rules which have been transgressed:

<table>
<thead>
<tr>
<th>Score</th>
<th>Unit</th>
<th>Transgressed Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cross upper left corner, outside of rectangle</td>
<td>1, 2, 4</td>
</tr>
<tr>
<td>2.</td>
<td>Large rectangle</td>
<td>3, General Point 3</td>
</tr>
<tr>
<td>3.</td>
<td>Diagonal cross</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>Horizontal midline of 2</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>Vertical midline</td>
<td>1, 3</td>
</tr>
<tr>
<td>6.</td>
<td>Small rectangle, within 2 to the left</td>
<td>1, 2</td>
</tr>
<tr>
<td>7.</td>
<td>Small segment above 6</td>
<td>1</td>
</tr>
<tr>
<td>8.</td>
<td>Four parallel lines within 2, upper left</td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>Triangle above 2 upper right</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>Small vertical line within 2, below 9</td>
<td>2</td>
</tr>
<tr>
<td>11.</td>
<td>Circle with three dots within 2</td>
<td>1, 2</td>
</tr>
<tr>
<td>12.</td>
<td>Five parallel lines within 2, crossing 3, lower right</td>
<td>1, 2, 3</td>
</tr>
<tr>
<td>13.</td>
<td>Sides of triangle attached to 2 on right</td>
<td>1, 3</td>
</tr>
<tr>
<td>14.</td>
<td>Diamond attached to 13</td>
<td>1, 4</td>
</tr>
<tr>
<td>15.</td>
<td>Vertical line within triangle 13</td>
<td>1, 3</td>
</tr>
<tr>
<td>16.</td>
<td>Horizontal line within 13, continuing 4 to right</td>
<td>2</td>
</tr>
<tr>
<td>17.</td>
<td>Cross attached to low center</td>
<td>1, 2, 4</td>
</tr>
<tr>
<td>18.</td>
<td>Square attached to 2, lower left</td>
<td>1, 2</td>
</tr>
</tbody>
</table>

Score: 18
**GOOD CONTINUATION**

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.

*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 component parts of the Rey figure should accurately reflect the structure and symmetry that the subject perceives within the figure. Points were therefore awarded for the successful 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 constructed elements of the figure; solid lines, the current element. See text for further details.

2. If after 1: if after 15, the output order of subjects' drawings may mirror the internal representation of visual stimuli. 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.

3. The maximum symmetry score a subject can achieve is 18 points. This follows from a combination of 2A, 2D (ii), 2E (iii), and 2F (i).
SCORING SYSTEM FOR THE RECALL OF THE REY FIGURE

General points:

1) The focus of the recall score is that it should be a measure of an S's ability to remember details of the figure, rather than a measure of copying ability. Thus, the strict copying criteria relating to accuracy of drawing are omitted; points are not deducted for wobbly lines, broken lines, crossings out and minor failures to intersect with other lines.

2) 1 point is deducted for incomplete or misplaced units.

3) 1½ points are deducted for units which are both incomplete and misplaced, but recognizable; and for units where two component parts are omitted.

4) The instructions below are addressed only to the more apparent cases where scorers may differ in their judgements of "misplacement, incompleteness or accuracy". Thus, there is relatively little comment made about some units.

Unit 1: Cross upper left corner outside the rectangle.

Points are deducted if:
1) The cross does not extend downwards past Unit 7.
2) The cross extends farther than the bottom of Unit 6.
3) The line joining the cross to the rectangle does not cut the rectangle at some point above the top of Unit 6.

Unit 2: Large rectangle.

Points are deducted if:
1) The vertical side is greater than 90% or less than 50% of the length of the horizontal side.
2) The rectangle is malformed such that it ceases to be rectangular or square-like. Here, deduct 1½ points.

Unit 3: Diagonal cross.

Points are deducted if:
1) 1 or 2 quarters are misorientated or omitted, the other quarters are present and correct; deduct 1 point.
2) 3 or 4 quarters are misorientated; or 1 or 2 quarters are omitted and 1 or 2 quarters misorientated; or 1 correctly orientated quarter is present, the rest omitted; deduct 1½ points.
3) 1 misorientated quarter present, all other quarters omitted; deduct 2 points.

Unit 4: Horizontal midline of the large rectangle.

Points are deducted if:
1) The horizontal does not bisect the large rectangle at between 35% and 65% of the length of the vertical line Unit 5.
Unit 5: Vertical midline of the large rectangle.
Points are deducted if:
1) The vertical line does not bisect the horizontal line at between 35% and 65% of the length of the horizontal line Unit 4.

Unit 6: Small rectangle within the large rectangle to the left.
NB: No points are deducted for "failure to intersect with the diagonal cross Unit 3", as long as the Unit is not misplaced.

Unit 7: Small segment above the small rectangle Unit 6.
Points are deducted if:
1) The unit is not placed in the correct segment (1/8th) of the rectangle, or if it is misorientated. 1 1/2 points are deducted if it is both misplaced and misorientated.

Unit 8: Four parallel lines within the rectangle upper left.
Points are deducted if:
1) The wrong number of lines are drawn, or the unit is misplaced. 1 1/2 points are deducted for both wrong number of lines and misplacement.

Unit 9: Triangle above large rectangle upper right.
Points are deducted if:
1) The vertical line of the triangle is more than 70% or less than 20% of the length of the sloped line of the triangle.

Unit 10: Small vertical line within the large rectangle below the Unit 9 triangle.
Points are deducted if:
1) The line is not to the left of the quadrant.
2) It is both misplaced and wrongly orientated. Here, 1 1/2 points are deducted.

Unit 11: Circle with 3 dots within the large rectangle.
NB: Points are not deducted if the "eyes" are left 'open'.

Unit 12: Five parallel lines within the large rectangle, lower right.
Points are deducted if:
1) The wrong number of lines are drawn or the unit is misplaced. 1 1/2 points are deducted for both wrong number of lines and misplacement.
Unit 13: Sides of triangle attached to large rectangle on the right.

Points are deducted if:
1) The distance from the apex of the triangle to the right vertical side of the large rectangle is more than 80% of the length of the horizontal midline of the large rectangle.
2) One of the sides of the triangle is an extension of one of the horizontal sides of the large rectangle.

Unit 14: Diamond attached to the triangle Unit 13.

Points are deducted if:
1) The unit is misshapen or misplaced. 1½ points are deducted for both misplacement and misshapenness.

Unit 15: The vertical line within the triangle Unit 13.

Points are deducted if:
1) The line is not to the left of the triangle.

Unit 16: Horizontal line within the triangle Unit 13.

Unit 17: Cross attached to the lower centre extension of the vertical midline in the large rectangle.

Points are deducted if:
1) The cross does not meet the square at some position between the bottom of its right side and the top. 1 point is deducted if it is merely a continuation of the bottom side of the square.

Unit 18: Square attached to the large rectangle, lower left.

Points are deducted if:
1) One side of the square is less than 66.6% of the length of any other side of the square.
2) An extra diagonal is added, or the diagonal is misorientated.
In the above (manufactured) example, some of the criteria for scoring the Recall of the Rey-Osterrieth Figure are elucidated. This example should be studied in association with the Recall Score instructions ("Lax" Recall, as referred to in the British Journal of Clinical Psychology, 1954, paper).

Below are listed the unit numbers, and the rules which have been transgressed:

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<tr>
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<th>Unit</th>
<th>Transgressed Rules</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1. Cross upper left corner, outside of rectangle</td>
<td>General Point 2</td>
</tr>
<tr>
<td>2</td>
<td>2. Large rectangle</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3. Diagonal cross</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>4. Horizontal midline of 2</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>5. Vertical midline</td>
<td>General Point 2</td>
</tr>
<tr>
<td>6</td>
<td>6. Small rectangle, within 2 to the left</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>7. Small segment above 6</td>
<td>1</td>
</tr>
<tr>
<td>(\frac{5}{2})</td>
<td>8. Four parallel lines within 2, upper left</td>
<td>1</td>
</tr>
<tr>
<td>(\frac{5}{2})</td>
<td>9. Triangle above 2 upper right</td>
<td>2</td>
</tr>
<tr>
<td>(\frac{5}{2})</td>
<td>10. Small vertical line within 2, below 9</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>11. Circle with three dots within 2</td>
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</tr>
<tr>
<td>(\frac{5}{2})</td>
<td>12. Five parallel lines within 2, crossing 3, lower right</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>13. Sides of triangle attached to 2 on right</td>
<td>1</td>
</tr>
<tr>
<td>(\frac{5}{2})</td>
<td>14. Diamond attached to 13</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>15. Vertical line within triangle 13</td>
<td>(\frac{5}{2})</td>
</tr>
<tr>
<td>2</td>
<td>16. Horizontal line within 13, continuing 4 to right</td>
<td>1</td>
</tr>
<tr>
<td>(\frac{5}{2})</td>
<td>17. Cross attached to low center</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>18. Square attached to 2, lower left</td>
<td>General Point 2</td>
</tr>
</tbody>
</table>

\(19\frac{1}{2}\)
Appendix B

Standard Scoring System for the Taylor Complex Figure: copy and recall drawings

Units
1. Arrow at left of figure
2. Triangle to left of large square
3. Square, which is the base of figure
4. Horizontal midline of large square, which extends to 1
5. Vertical midline of large square
6. Horizontal line in top half of large square
7. Diagonals in top left quadrant of large square
8. Small square in top left quadrant
9. Circle in top left quadrant
10. Rectangle above top left quadrant
11. Arrow through and extending out of top right quadrant
12. Semicircle to right of large square
13. Triangle with enclosed line in right half of large square
14. Row of 7 dots in lower right quadrant
15. Horizontal line between 6th and 7th dots
16. Triangle at bottom right corner of lower right quadrant
17. Curved line with 3 cross-bars in lower left quadrant
18. Star in lower left quadrant

Scoring

Consider each of the 18 units separately. Appraise accuracy of each unit and relative position within the whole of the design. For each unit count as follows:

Correct
> placed properly 2 points
> placed poorly 1 point

Distorted or incomplete but recognizable
> placed properly 1 point
> placed poorly 1/2 point

Absent or not recognizable 0 points

Maximum score 36 points
SCORING SYSTEM FOR THE COPY OF THE TAYLOR FIGURE (adapted from Bennett-Levy's scoring system for the copy of the Rey-Osterrieth Complex Figure)

General points

1. 2 points are awarded for a correct figure.
   1 point is always awarded if all the components of a unit are present even though more than one detail may be inaccurately drawn according to criteria below.
2. Severe distortion of a unit gains only 1/2 point.
3. 1 point should be deducted if:
   i) lines are not approximately straight.
   ii) lines do not reach, or extend beyond, their intersection point.
   iii) lines are broken, redrawn or crossed out.
4. 0 point is awarded if component is omitted.

Unit 1: Arrow at left of figure

Points are deducted if:

1. The arrow is extended above an imaginary horizontal line extending out from the top edge of the small square in the top left quadrant.
2. The arrow is not extended downwards an approximately equal distance from the main horizontal line bisecting the figure as it extends above that line.

Unit 2: Triangle to left of large square

Points are deducted if:

1. The distance from the apex of the triangle to the left vertical side of the large square is less than half the distance from the left side of the square to the vertical mid-line or more than 3/4 of that distance.
2. The triangle is skewed and not isosceles.
3. The triangle sides extend beyond the corners of the large rectangle.

Unit 3: Large square which is the base of figure

Points are deducted if:

1. Any parallel sides of the figure are 20% longer than the other parallel sides.
2. There are disconnections within any of the sides of the square.

3. The square is malformed such that it ceases to be square-like. In this case 1 1/2 points are deducted.

Unit 4: Horizontal midline of large square, which extends to 1.

Points are deducted if:

1. The horizontal does not bisect the large square at between 40% and 60% of the length of the vertical line (Unit 5).

2. There is disconnection within the horizontal line at the centre of the figure.

3. This disconnection is extreme. In this case, 1 1/2 points are deducted.

Unit 5: Vertical midline of large square.

Points are deducted if:

1. The vertical line does not bisect the horizontal line at between 40% and 60% of the length of the horizontal line (Unit 4).

2. The upper and lower parts of the vertical line are disconnected at the centre.

3. This disconnection is extreme. In this case, 1 1/2 points are deducted.

Unit 6: Horizontal line in top half of large square.

Points are deducted if:

1. This line does not bisect the upper half of large square between 30% and 60% of the vertical midline above the centre.

2. This line is not approximately parallel to the top edge of the large square and central horizontal midline.
Unit 7: Diagonals in top left quadrant of large square.

Points are deducted if:

1. There is clear disconnection between diagonal lines on either side of the horizontal bisecting line.

Unit 8: Small square in top left quadrant.

Points are deducted if:

1. The horizontal sides are more than 30% longer or shorter than the length of the vertical sides.
2. The angles of the small square fail to intersect with the diagonal cross (Unit 7).
3. There is clear disconnection between the top of the square and the bottom of the square.
4. The square occupies more than 50% or less than 20% of upper left quadrant

Unit 9: Circle in top left quadrant

Points are deducted if:

1. The centre of the circle is not approximately at the bisection point of the diagonals and the horizontal line.
2. The circle is not well-joined.
3. Any of the edges of the circle touch the small square within the top left quadrant.
4. The circle occupies more than 2/3 the area of the small square or less than 1/2 that area.

Unit 10: Rectangle above top left quadrant.

Points are deducted if:

1. The short ends of the rectangle are longer than the distance between the horizontal bisecting line of the upper two quadrants and the top of the large square or less than half that distance.
Unit 11: Arrow through and extending out of top right quadrant.

Points are deducted if:

1. The arrow extends beyond an imaginary line drawn from the top of the rectangle above the upper left quadrant.

2. The angle of the arrow is less than 30° or more than 60° off the right vertical side of the large square and/or does not leave the large square exactly at the corner.

Unit 12: Semicircle to right of large square.

Points are deducted if:

1. The distance between the highest point of the arc and the right vertical side of the large square is greater than two-thirds the distance between the right vertical side of the large square and the apex of the triangle within the right two quadrants of the large square.

2. The semi-circle extends over more than 60% or less than 40% of the right vertical side of the large square.

Unit 13: Triangle with enclosed line in right half of large square.

Points are deducted if:

1. The distance between the base and the apex of the triangle is greater than two thirds or less than one third the distance between the right vertical side of the large square and the vertical mid-line.

2. The base of the triangle extends more than 60% or less than 40% the distance of the right vertical side of the large square.

Unit 14: Row of 7 dots in lower right quadrant.

Points are deducted if:

1. The spacing between any two of these dots is twice as much as any other two of these dots.

2. The dots are left open rather than filled in.

3. The dots diverge markedly from the diagonal at any point.

4. Incorrect number of dots.
Unit 15: Horizontal line between 6th and 7th dots.

Points are deducted if:

1. The line does not transect the lower right quadrant between the fifth and seventh dot.

2. The line transects the lower right quadrant more than one third the distance between the lower horizontal edge of the large square and the mid-line or less than one tenth that distance.

Unit 16: Triangle at bottom right corner of lower right quadrant.

Points are deducted if:

1. The triangle is severely misshapen.

2. The distance from the base of the triangle to the apex is greater than 41% or less than 20% the distance between the lower right corner of the large square and the horizontal midline of the large square.

3. The triangle is not attached to the right lower corner of the large square.

Unit 17: Curved line with 3 cross-bars in lower left quadrant.

Points are deducted if:

1. Cross-bars are not approximately equidistant apart.

2. There are more than two sinusoidal curves.

3. Curved line does not converge with other diagonals at centre of large square nor meet at lower left corner of large square.

Unit 18: Star in lower left quadrant

Points are deducted if:

1. Star has greater or fewer than eight points.

2. Any point of the star touches the right vertical side or lower edge of the lower left quadrant.
The Taylor Complex Figure. Arrows indicate the seventeen points of good continuation. Good continuation points are scored if lines are continued either in the direction of the arrows or in the reverse direction. The maximum good continuation score is 17.

**Symmetry scoring criteria**

Briefly summarised, symmetry scores were awarded for completeness and succession in relation to certain figures and axes within the larger figure. Completeness refers to the construction of the component parts of a single symmetrical figure without interruption. 1 point is awarded for the completion of a figure which is symmetrical about one explicit axis of symmetry (e.g. the triangle to the left of the large square) and 2 points are awarded for the completion of a figure which is symmetrical about two explicit axes of symmetry (e.g. the large square and the vertical and horizontal midlines forming one figure when drawn successively). Succession refers to the drawing of a symmetrical axis within a symmetrical unit, immediately following the drawing of that unit.

See overleaf for an example of the application of the scoring criteria for copying strategy to the Taylor Figure. For a more detailed description of the application of the symmetry scoring criteria, see Bennett-Levy's scoring criteria for the Rey Figure in this Appendix.
Example of a copying strategy for the Taylor Complex Figure earning the maximum score of 16 symmetry points. Dotted lines indicate previously drawn elements of the figure; solid lines, the current element.

Note: because all subjects draw the small square and circle within the top left quadrant without breaking off to complete another aspect of the figure, no points for completion were awarded to these units. 1 point was awarded to each of them, for succession only.
LAX RECALL CRITERIA

SCORING SYSTEM FOR THE RECALL OF THE TAYLOR FIGURE (adapted from J. Bennett-Levy's scoring system for the recall of the Rey Complex Figure).

General points

1) The focus of the recall score is that it should be a measure of an S's ability to remember details of the figure, rather than a measure of copying ability. Thus, the strict copying criteria relating to accuracy of drawing are omitted; points are not deducted for wobbly lines, broken lines, crossings out and minor failures to intersect with other lines.

2) 1 point is deducted for incomplete or misplaced units.

3) 1 1/2 points are deducted for units which are both incomplete and misplaced, but recognizable; and for units where two component parts are omitted.

4) The instructions below are addressed only to the more apparent cases where scorers may differ in their judgements of "misplacement, incompleteness or accuracy". Thus, there is relatively little comment made about some units.

Unit 1: Arrow at left of figure

Points are deducted if:

1) The arrow is not extended downwards an approximately equal distance from the main horizontal line bisecting the figure as it extends above that line.

Unit 2: Triangle to left of large square

Points are deducted if:

1) Distance from apex of triangle to left vertical side of large square is more than 50% length of horizontal midline of large square.

2) One of the sides of the triangle is an extension of one of the horizontal sides of the large square.

Unit 3: Large square

Points are deducted if:

1) One of the sides of the square is more than 30% longer than the side at right angles to it.
2) The square is malformed such that it ceases to be square-like. Here deduct 1 1/2 points.

**Unit 4:** Horizontal midline of large square, which extends to i.

Points are deducted if:

1) The horizontal line does not bisect the large square at between 35% and 65% the length of the vertical line, unit 5.

**Unit 5:** Vertical midline of large square.

Points are deducted if:

1) The vertical line does not bisect the large square at between 35% and 65% of the horizontal line, unit 4.

**Unit 6:** Horizontal line in top half of large square

Points are deducted if:

1) This line does not bisect the upper half of the large square between 35% and 65% of the vertical midline above the centre.

**Unit 7:** Diagonals in top left quadrant.

1) 1 or 2 quarters are misorientated or omitted, the other quarters are present and correct. Deduct 1 point.

2) 3 or 4 quarters are misorientated; or 1 or 2 quarters are omitted, and 1 or 2 misorientated; or 1 correctly orientated quarter is present, the rest omitted; deduct 1 1/2 points.

3) 1 misorientated quarter present, all other quarters omitted. Deduct 2 points.

**Unit 8:** Small square top left quadrant.

No points are deducted for failure to intersect with diagonal cross, unit 7, as long as unit is not misplaced.

**Unit 9:** Circle in top left quadrant.

No points are deducted if circle is not well-joined.
Unit 10: Rectangle above left quadrant.
Points are deducted if:

1) The rectangle is larger than any one of the four rectangles comprising the half of the square above the horizontal midline.

Unit 11: Arrow through and extending out of top right quadrant.
Points are deducted if:

1) Any part of diagonal shaft of arrow is missing - deduct 1/2 point.
2) Arrow extension is severely misplaced.

Unit 12: Semicircle to right of large square.
Points are deducted if:

1) Semicircle extends over more than 75% or less than 30% length of right side of square.
2) Distance from highest point of arc to right side of square is more than half the distance between the right side of square and centre of square along the horizontal midline or less than 1/8th that distance.

Unit 13: Triangle with enclosed line in right half of large square.
Points are deducted if:

1) The distance between the base and the apex of the triangle is greater than two thirds or less than one third the distance between the right vertical side of the large square and the vertical midline.
2) Base of triangle extends over more than 75% or less than 30% the length of the right side of the large square.

Unit 14: Row of 7 dots in lower right quadrant.
Points are deducted if:

1) Wrong number of dots drawn or the set is severely misplaced. If both, deduct 1 1/2 points.

Unit 15: Horizontal line between the 6th and 7th dot.
Points are deducted if:
1) Line is not in lower half of lower right hand quadrant.

2) Line is both misplaced and misorientated. Here deduct 1 1/2 points.

**Unit 16**: Triangle at bottom right corner of large square.

Points are deducted if:

1) The unit is misshapen or misplaced. 1 1/2 points are deducted for both misplacement and misshapeness.

**Unit 17**: Curved line in lower left quadrant.

Points are deducted if:

1) There are more than 5 or fewer than 2 sinusoidal curves.

2) The line is severely misplaced.

3) Wrong number of cross bars drawn.

**Unit 18**: Star in lower left quadrant.

No points are deducted for the wrong number of arms or points in star. Only deduct points if star is severely misplaced or misshapen.
### Summary of Analysis of Variance on recall data at Stage 1 and Stage 2

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### Summary of Analysis of Variance on copying strategy data at Stage 1 and Stage 4

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Summary of Analysis of Variance on copying accuracy (strict copy) data at Stage 1 and Stage 4

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Summary of Analysis of Variance on recall data at Stage 1 and Stage 3

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Summary of Analysis of Variance on copying strategy data at Stage 1 and Stage 3

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Summary of Analysis of Variance on interference scores in recall drawings of the Taylor Figure

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