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LEARNING OF CONSTRUCTIVE TASKS
BY BRAIN-DAMAGED ADULTS

by

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ABSTRACT

LEARNING OF CONSTRUCTIVE TASKS BY BRAIN-DAMAGED ADULTS

Frequently, hemiplegic patients present visuo-constructive dysfunctions which have a detrimental influence on their becoming independent in activities of daily living. The related literature is abundant on the subject of evaluation of those deficits, but lacks scientifically elaborated treatment procedures. Furthermore, several studies have reported quantitative and qualitative differences in learning abilities of brain-damaged adults according to the side of the brain injury.

The main hypothesis that was investigated stated that hemiplegic subjects presenting visuo-constructive deficits could learn through repetition, simple visuo-constructive tasks, whether their lesion was in the right or the left hemisphere; furthermore, that trained patients would progress farther than the hemiplegic patients who were not trained to do the same tasks.

In an effort to support this hypothesis, 16 right brain-damaged and 16 left brain-damaged subjects presenting visuo-constructive deficits were tested. One-half of each group repeated the test daily and the other half received no daily training sessions.

Analysis of variance showed that (1) no quantitative differences were found in learning of visuo-constructive tasks according to hemispheric side of lesion, and (2) subjects being trained daily had significantly higher final scores when compared to initial scores than the non-trained subjects.

From this study, it would appear that repetition of simple visuo-constructive tasks might help hemiplegic subjects suffering from deficits in this area, to improve on their performance. A number of factors may influence some patients' improvement, but the present investigation did not reach definite conclusions on this aspect. It is suggested that occupational therapists and other rehabilitation workers interested in brain damage induced visuo-constructive dysfunctions, should elaborate research in this area, in order to make the treatment of hemiplegic patients more efficient.

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Chapter 1

INTRODUCTION

Cerebro vascular disease is a major cause of disability and death. In 1971, 16,067 people died from a stroke in Canada.[1] McCullough and Sarmiento (1970) indicated that approximately 20 percent of the stroke victims die at the onset of their stroke or during the initial stages of their illness, 20 percent recover only slightly and require continuous custodial care and 60 percent are rehabilitated to some degree.

Many patients having sustained a cerebro vascular accident are left with contralateral hemiplegia. These people account for a great part of the clientele of rehabilitation centers, neurology wards of general hospitals, convalescent hospitals and nursing homes. Rehabilitating these patients presents a challenge since they suffer, more or less severely, from a variety of symptoms such as sensori-motor deficits, perceptuo-motor dysfunctions, apraxic and agnosic disturbances and impairment of certain intellectual functions.

The final aim of any rehabilitative measure for

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[1] Statistiques Canada. Division de la Santé et du Bien-Etre. Information Canada, Ottawa. Novembre 1972.

stroke patients is to help them achieve their optimal functional recovery, in order to enable them to become as independent as possible in their personal, vocational and social life (Levenson, 1965).

For many years, the emphasis of treatment has been placed on motor re-education of the paralyzed limbs. Many treatment techniques have been devised to achieve this aim. Unfortunately, while recuperation of function in the lower limb is often satisfactory, the prognosis is much poorer with respect to the recuperation of the motor function in the upper limb.

Furthermore, many recent studies have shed light on the presence of perceptuo-motor dysfunction in brain-damaged patients. It has been established by several authors that these problems, although they may be different according to the laterality of the brain lesion, may be present in subjects having suffered a lesion in either side of the brain. The presence of these dysfunctions has been equated with difficulties in achieving satisfactory performance in activities of daily living (Anderson and Choy, 1970; Halperin and Cohen, 1971; Lorenze and Cancro, 1962; Macdonald, 1960; Williams, 1967).

Among those perceptuo-motor problems, difficulties regarding spatial perception and praxis are frequently encountered in brain-damaged subjects. Visuo-spatial disorders are manifested by several symptoms. The subject may suffer from defective localization of objects in space; he may neglect people or objects situated on the side of his hemiplegia and this contra-lateral neglect may or may not be associated with hemianopsia or other visual field defects. Sometimes, there is illusory obliquity of vertical and horizontal directions, teleopsia, micropsia and/or loss of the ability to perceive depth. In some cases, there is inverted vision. These subjects may have difficulties in orienting themselves or manipulating objects in space.

Visuo-spatial disorders have been associated with visuo-constructive deficits by several authors (Benton, 1969b; Dee, 1970; De Renzi and Faglioni, 1967). Visuo-constructive deficits are usually characterized by misrepresentation of perspective among the elements of a model or of its components, mirror-image, perseveration, macro or micrographia, closing-in or other similar symptoms. These manifestations may be ignored by the patient; he may however be aware of his difficulties and be distressed or indifferent towards them.

There are many conflicting statements regarding the possibility of re-educating brain-damaged subjects in this area of dysfunction. Very few research programs have been conducted to explore scientifically the possibility of improvement of defective performance due to these deficits. The purpose of the present investigation is to explore the ability of hemiplegic patients suffering from perceptuo-motor deficits, to learn through repetition of constructive tasks. In addition, an attempt will be made to verify whether there is a difference in learning capacities with subjects who sustained a right or a left hemispheric injury.

Chapter 2

REVIEW OF THE LITERATURE

Visuo-constructive Deficits in Brain-damaged Adults

In 1934, Kleist first described a "disturbance which appears in formative activities (arranging, building, drawing) and in which the spatial part of the task is missed although there is no apraxia of single movement" (cited by Critchley, 1953:172). He named this dysfunction: constructive apraxia. As indicated by Benson and Barton (1970), constructive apraxia has been studied clinically for more than 50 years but it was still ill-defined and subject to many controversies. These authors stated that many factors were responsible for such controversies, the most important causes being: (1) most studies were clinical in nature and derived conclusions from purely empirical data, (2) the diagnosis of constructive apraxia was made on qualitative analysis instead of on quantitative controlled evaluation, (3) authors often did not discuss the basis of selection of their subjects, and (4) a wide variety of terminology was used: constructive apraxia, visuo-constructive deficits, apractognosia, planotopokinesia, visuo-spatial agnosia, etc. In the present study, the term visuo-constructive deficits will be used as it seems to be the most widely accepted by modern authors.

Constructive tasks imply combining and organizing an activity in which details must be clearly perceived and in which the relationships among the parts must be apprehended in order to achieve the desired synthesis (Benton, 1969a). Constructive tasks require a good perception of the components, retention of the material, integration of the visual stimuli and capacity to organize the sequence of actions in order to execute the task. As Frederiks (1969) pointed out, perception and motor behavior form a unity and it is difficult to assess to what extent the visuo-constructive deficits result from disorders of perception, mental deterioration, aphasia, sensory deficits or other factors. His opinion was that visuo-constructive deficits are not one disorder but a complicated syndrome having many aspects, among which are perceptual and praxical dysfunctions.

Several authors have attempted to explain the nature of visuo-constructive deficits. Many investigators postulated that in right brain damage, visuo-constructive deficits were associated with visuo-spatial disorders and were therefore caused by a perceptual dysfunction; on the other hand, in left brain damage, they were a dysfunction of the cognitive function expressed by an executive defect (De Renzi and Faglioni, 1967; Hécaen and Assal, 1970; Gainotti and Tiacci, 1970; McFie and Piercy, 1952; Piercy, Hécaen and De Ajuriaguerra, 1960; Warrington, James and Kinsbourne, 1966). Another school of thought (Dee, 1970; Domrath, 1968; Piercy and Smyth, 1962) postulated that visuo-constructive deficits were secondary to perceptual deficits, whatever the side of the lesion.

Birch, Belmont, Reilly and Belmont (1961) analyzed the perceptual dysfunctions in a group of right brain-damaged subjects and concluded that there was no evidence of impaired whole perception but clear evidence of impaired ability to analyze visual perception which they explained as a "perceptual analytic or apraxic difficulty." Whitty and Newcome (1965) considered visuo-constructive deficits as the motor expression of spatial disorganization because constructive tasks implied a coordinated manipulation of objects and body segments in space. Therefore, the difficulties would be caused by an agnostic dysfunction rather than by a pure perceptual problem. Critchley (1953) stated that the patient with visuo-constructive deficits probably had a defective orientation in space and this defect emerged when the subject attempted a motor task within the visuo-spatial sphere.

Benton (1967) hypothesized that it was impossible to establish a real distinction between visuo-constructive deficits due to an executive dysfunction and visuo-constructive deficits due to a perceptual impairment. He advocated in his studies of 1967 and 1969 that it might have proven more useful to establish two types of visuo-constructive deficits according to the types of tasks: (1) assembling tasks, e.g., sticks and blocks construction, and (2) graphic tasks, e.g., copy and free drawing. Dee (1970) agreed with Benton's theory and he classified his subjects into assembling apraxics and graphomotor apraxics although many subjects performed poorly on both types of tasks and were included in both groups.

Visuo-constructive deficits were sometimes associated with general mental impairment. Benton and Fogel (1962) explained that mental impairment should not have been considered as the sole cause of visuo-constructive deficits; they showed that several patients with severe intellectual impairment performed well on constructive tasks whereas some patients who were not severely affected intellectually showed marked visuo-constructive deficits.

Hemispheric Side of Lesion

Kleist considered visuo-constructive deficits as a symptom resulting from a lesion of the dominant hemisphere. For many years, his theory was generally accepted. However, several authors have since shown that visuo-constructive deficits could be associated with lesions of the sub-dominant hemisphere (Critchley, 1953; De Ajuriaguerra, Hécaen and Angelergues, 1960; Hécaen, De Ajuriaguerra and Massonet, 1951; Hécaen, Penfield, Bertrand and Malmo, 1956; McFie, Piercy and Zangwill, 1950; McFie et al., 1952; Paterson and Zangwill, 1944; Piercy et al., 1960). Several of these authors have demonstrated that visuo-constructive deficits were more frequent and more severe in right brain lesions. Benton and Fogel (1962), Benton (1967, 1968), Piercy et al. (1962), also concurred with this view.

De Renzi et al. (1967) made a study which did not corroborate this theory in that they did not find significantly more numerous and more severe apraxics with right brain lesions than with left brain lesions. In Dee's (1970) study, no significant differences in the severity of visuo-constructive deficits in left and right lesions were established. His study included aphasics and his subjects worked with their ipsilateral hand. This procedure would eliminate the bias in selection reported by Warrington *et al.* (1966). The latter authors considered that the view of a higher frequency and severity of visuo-constructive deficits in people who sustained a right brain damage was due to an artifact of the selection of the subjects. For example, in many investigations, subjects with aphasia and with severe sensori-motor disturbances in their preferred hand were eliminated. Benton (1962) agreed with this view as he stated that his right group might have had more extensive lesions since left brain-damaged with equally extensive lesions might have been eliminated on account of aphasia. Piercy *et al.* (1960) rejected this hypothesis by arguing that only severe dysphasics were eliminated in their study. They stated ..."on the contrary, if dysphasia tends to mask constructional disability, the milder cases in particular would tend to be obscure, thus artificially increasing the average severity of constructional deficits in left-side cases." (p. 238) They advocated the same point of view regarding the presence of sensori-motor dysfunctions and concluded that in any case, the subjects who presented these problems were tested with both hands in their study. It is the feeling of the majority of authors, however, that aphasics and subjects presenting severe sensori-motor deficits must not be excluded from a study, if a true equation of the subjects is desired.

Another possible bias reported by Warrington et al. (1966) was that patients with dominant hemisphere involvement might have consulted earlier because defects of speech and of the preferred hand were more functionally incapacitating than sensori-motor problems of the non-preferred hand. The right hemisphere damaged group would therefore have had more extensive lesions when tested. This may have been possible in progressive lesions but not in cerebro vascular accidents or trauma of the brain.

Differences in Visuo-constructive Deficits According to the Side of Lesion

It has been stated that visuo-constructive deficits could be present with lesions in either hemisphere although there were controversies as to whether these deficits were more frequently associated with lesions of the right hemisphere and whether they were caused by different dysfunctions in lesions of the right and the left hemisphere. Several authors have attempted to describe the differences between visuo-constructive deficits in right brain lesions and in left brain lesions.

Most authors agreed that the left brain-damaged patients had a tendency to oversimplify the model whereas right brain-damaged subjects' designs were disorganized but as complex as the model. Two other facts were generally accepted: the frequent association of contralateral neglect with right brain damage and the general spatial disorganization shown in the constructive tasks of the same group. Piercy et al. (1960) stated that the left brain-damaged subjects were helped by the provision of a model but the right brain-damaged patients were not. Piercy et al. (1960) and Gainotti et al. (1970) noted that right brain-damaged patients had a tendency to orient their designs diagonally. The piece-meal approach, which consists of reproducing a design line by line by constantly referring to it, as described by Paterson and Zangwill (1944), was usually associated with lesions of the right hemisphere (Gainotti et al., 1970; McFie et al., 1960; Piercy et al., 1960). For Piercy et al., (1960) closing-in was mostly found in left brain-damaged subjects although Gainotti et al. (1970) did not find significant differences between their two groups. Gainotti et al. (1970) and Warrington et al. (1966) studied more precisely the drawing of angles. They agreed that patients who had sustained a right hemispheric injury tended to produce fewer right angles than were contained in the model, whereas left brain-damaged patients produced a greater number of right angles; in both studies, the difference was significant.

Concerning acute angles, Warrington _et al_. (1966) found a significant decrease with right lesion subjects and an increase with left lesion subjects. Gainotti _et al_. (1970) found no such significant association. Perseveration and amendments were associated with right brain lesions according to Mendilaharsu _et al_. (1968) but Gainotti _et al_. (1970) did not find such a significant difference in their study.

There were also controversies regarding errors in size. Gainotti _et al_. (1970) and Warrington _et al_. (1966) found no significant difference in the two groups, but Mendilaharsu _et al_. (1968) stated that macrography was more frequently associated with right brain damage and micrography with left brain damage. They further stated that macrography was related to a maniac type of defense and micrography was related to depressive or catastrophic reactions which were more frequently encountered in left lesions. Indifference reactions were more often associated with right lesions. De Ajuriaguerra _et al_. (1960) had also observed such associations of specific psychological characteristics. It is important to note however, that some authors (Piercy _et al_., 1962) did not agree with the theory that there were some qualitative differences in visuo-constructive deficits according to the side of the hemisphere damaged.

Studies were also made regarding associated symptoms of visuo-constructive deficits with right and left brain lesions. Dysphasia is well known to be associated with left hemisphere lesions. Hemianopsia and topographical disorientation could be associated with lesions of either hemisphere (McFie *et al*., 1960; Piercy *et al*., 1960; Warrington *et al*., 1966). Spatial agnosia, hemiasomatognosia and visuo-spatial dysfunctions were more frequently associated with lesions of the right hemisphere (De Ajuriaguerra *et al*., 1960; McFie *et al*., 1960 and Piercy *et al*., 1960).

Hemispheric Dominance

It was established over a century ago that the left hemisphere is dominant for language functions in right-handed people. Since this discovery, several authors have attempted to determine hemispheric dominance for different intellectual functions including the dominance of the right hemisphere for visuo-spatial orientation. It cannot be stated that there is a definite dominance for praxis and gnosis as there is for speech. Benton (1970) studied the results of many investigators on the subject of dominance and concluded that the right hemisphere possesses at least a relative dominance in respect to perception and retention of non-verbal visual material. Bogen and Gazzanica (1965) and Whitty et al. (1965) concurred with this theory.

Piercy et al. (1960 and 1962) agreed with the hypothesis that there is bilateral but unequal representation for visuo-constructive functions and that the right hemisphere is relatively dominant for these functions. The differences found in visuo-constructive deficits between right and left hemispheric lesions were too subtle to substantiate an hypothesis of functionally different hemispheres regarding tasks of this nature, according to these authors. However, Warrington (1960) considered the hypothesis of asymmetry of cortical organization for the function of constructional praxis. The two hemispheres would make separate and different contributions and disorders of either hemisphere would result in impaired performance. Benson and Barton (1970), Critchley (1953) and Paterson and Zangwill (1944) stated that lesions in retro-rolandic regions, especially in the posterior parietal and parieto-occipital regions, were apt to be associated with the clinical manifestations of visuo-constructive deficits and this, with lesions in either hemisphere.

It was therefore evident, from the data studied, that visuo-constructive deficits were a relatively frequent manifestation of lesions in either the left or the right hemisphere. Arseni, Voinesco and Goldenberg (1958) found visuo-constructive deficits in 66.6 percent of their 9 LBD subjects and in 100 percent of their 20 RBD patients. Piercy et al. (1960) reported 16.7 percent of subjects with visuo-constructive deficits in left brain damage (N=150) and 37.8 percent in right brain damage (N=111). Hécaen and Angelergues (1961) stated that visuo-constructive deficits were diagnosed in 64 out of 162 LBD subjects and 73 out of 118 RBD subjects. In Piercy et al.'s (1962) study, 7 out of 18 LBD subjects showed visuo-constructive deficits and 13 out of 19 RBD patients had the dysfunction. Finally, Arrigoni et al. (1964) reported 28 cases of visuo-constructive deficits out of 70 LBD subjects and 35 cases out of 55 RBD subjects. These reports on the incidence of visuo-constructive deficits in brain-damaged subjects demonstrated that these deficits were encountered in 37.8 to 100 percent of the patients who had a right brain lesion and in 16.7 to 66.6 percent of the left brain-damaged subjects.

Learning in Brain-damaged Adults

Published reports dealing with the capacity for learning by brain-damaged adults provided the basis of the present study. The investigators' conclusions were controversial as shown by the following discussion.

Warrington _et al_. (1966) did a study designed to explain the differences in visuo-constructive deficits in brain-damaged subjects of the right and the left hemispheres. One of the tests used in that study consisted of the drawing of a cube, followed by the drawing of elements of the cube at increasing levels of difficulty and finally the drawing of a second complete cube. One of the hypotheses stated that the left brain-damaged patients would benefit from this form of training because their main difficulty lay in the planning of the task; on the other hand, the right brain-damaged group who showed difficulties with spatial relationships were not expected to derive benefit from copying simple lines because they did not contain complex spatial relationships. The results showed that the left brain-damaged group performed better on the second cube and that the right brain-damaged group showed no improvement. They concluded that the left brain-damaged patients benefited from training but the right brain-damaged patients did not. It must be noted however, that the sensory aphasics and all patients who showed severe paralysis of the preferred hand were excluded from the study which could indicate that the right brain-damaged group was more impaired than the other group.

The same hypothesis was stated by Hécaen and Assal (1970). Their subjects had to draw three models: a cube, a house and a bicycle. In some of the tasks, the investigators provided landmarks by completing some of the figure to be copied. They found that the addition of landmarks helped the performance of the left brain-damaged group but did not help the right brain-damaged subjects. Their explanation was that landmarks appeared to compensate for the defect by fixing a program of execution for the left brain-damaged subjects. They also mentioned that the left brain-damaged group could do a better reproduction of a cube made of sticks, a task that followed the drawing of seven incomplete cubes which the subjects were asked to complete. Confronted with the same task, the right brain-damaged group did not perform better on the cube made of sticks. They concluded that this could confirm Warrington et al.'s hypothesis that one group could benefit from training and the other group could not.

Benson et al. (1970) did a study to determine the differences in constructional abilities in left brain-damaged and right brain-damaged persons. One of the tasks they used was a puzzle construction test which consisted of three pieces to be assembled in order to reproduce a figure drawn on a card. The task was repeated three times: the first and third series were unstructured, e.g., the model contained only the outline of the complete figure, and the second series was structured in that the interior lines delineating the border of each piece were indicated. They found that, while the left brain-damaged subjects seemed to learn from the second structured series as indicated by improvement on their score of the third trial over the first one, those with right brain damage actually showed a decrement in performance on the third series. They explained the results as follows: "retention of visual traces is much more brittle in the right hemisphere patients and much more susceptible to degradation or interference by subsequent stimulation than for the left hemisphere patients" (Benson et al., 1970:40).

La Pointe and Culton (1969) reported on a case of a patient with a right hemispheric lesion who showed visuo-spatial deficits and who, through repetition, error detection and self-correction, had improved considerably. There could not however be a definite conclusion on the possibility of learning on the basis of only one subject; this patient might have improved for a variety of other reasons.

Ghent, Weinstein, Semmes and Teuber (1955) studied 36 subjects with unilateral brain injuries: 18 with left brain damage and 18 with right brain damage. They excluded subjects with severe sensori-motor disabilities considering that those subjects would have been unable to carry out the task, which consisted of tactual discrimination of different shapes. Each subject had three trials with each hand. Subjects showed significant improvement in the third trial over the first with the ipsilateral hand, but not with the contralateral hand. They established that the lack of improvement of the contralateral hand was not due to sensory defects, aphasia, lobe or side involved nor loss of intelligence. This experiment contradicted the hypothesis that one group was capable of improvement through repetition while the other group was not.

Another study of interest was that of McFie and Piercy (1952). They examined 58 subjects, 31 left brain-damaged and 27 right brain-damaged, on different intellectual skills. Retention of verbal and visual material showed that impairment on those tasks was significantly greater with large lesions than with small ones but that it was not significantly greater for one side than the other, although there were some indication that verbal learning was more impaired with left lesions and retention of visual material was more impaired with right lesions. They also reported on a study done by Rylander in which subjects who had surgery in the frontal lobe were examined on intellectual functioning; Rylander found that in all subjects, learning was slightly impaired, but there appeared to be no association with side of lesion. He concluded that impairment was related to the size rather than to the locus of cerebral lesion.

Wyke did two studies on learning with brain-damaged patients. In her first study (1971), the task consisted of a two-arm apparatus which the subjects used to trace a star. The subjects had circumscribed brain lesions but none had enough sensori-motor dysfunction to prevent performance on the task. The control and patient groups showed 41 to 46 percent improvement in time while in terms of errors, the right brain-damaged improved by 65 percent, the control group by 48 percent and the left brain-damaged group by 38 percent. The study showed that the left-sided cases were significantly inferior to normal subjects in their ability to learn this type of task, while the right-sided group showed only minor deficiencies in learning during practice; this was demonstrated by the fact that left brain-damaged subjects showed less improvement relative to initial score than the right brain-damaged and the control subjects. She concluded that it was possible that the left hemisphere was dominant in the control of voluntary movement involving mutual dependence and continuous interaction of the right and left arms. Analysis of the task used in Wyke's study, indicated that, although the task was bi-manual, the preferred hand probably lead the non-preferred hand. Even if the subjects did not show severe sensori-motor involvement, the left brain-damaged group might have been slightly handicapped in their preferred hand which could have caused poorer coordination and so resulted in less improvement as far as errors made by this group. Their mean number of errors was higher in all trials than the right side and control groups. A unimanual task might not have shown the same results.

In another study conducted by Heap and Wyke (1972), the task consisted of a unimanual motor skill, namely the pursuit rotor. The same subjects as in the previous study were examined. The preferred hand showed significant superiority over the non-preferred hand in all groups. In all cases, the right brain-damaged subjects performed better than the left brain-damaged group, although the results were not statistically significant. The groups were then divided into two sub-groups: those who started with the left hand (L-R) and those who started with the right hand (R-L). Both L-R and R-L sub-groups improved significantly over the ten trials when compared to the control group. The performance was calculated in terms of time on target. Improvement in the right brain-damaged subjects was present only in the second hand tested for both R-L and L-R sub-groups. For the left brain-damaged, there was a significant improvement in the first hand for the L-R and R-L sub-groups and in the second hand for the R-L sub-group only. However, the overall performance on either arm for both groups was uninfluenced by the sequence in which the two arms were used. Finally, the study showed a significant association between abnormal scores and the presence of clinically detectable abnormalities of motor and/or sensory function.

Taylor, Shaeffer, Blumenthal and Grisell (1971) did an extensive study on perceptual training in patients with left hemiplegia (right brain-damaged). Part of their study compared the performance on activities of daily living of a control group which received traditional physical and occupational therapy treatments and an experimental group which was given treatment modalities that stressed sensory input, percept-concept organization and motor output. These procedures were applied to the following functions: vision, touch, kinesthesia-proprioception, praxis, body scheme, right-left discrimination and number concept. They concluded that there was no statistically significant difference in the improvement of either group of patients. This study was limited to right brain-damaged patients; it showed that these subjects could learn and therefore contradicted the theory that only left brain-damaged subjects have learning capacities.

Diller (1968) reported a study he made with Weinberg in 1962 which indicated that brain-damaged patients could learn but that their way of learning differed according to the side involved. Right brain-damaged subjects had initially shown a better performance but tended to improve only slightly in subsequent performances. Left brain-damaged subjects showed poorer initial performance but they made more progress in subsequent sessions, although the progress was slow. Left brain-damaged people could retain learned material while right brain-damaged groups had a tendency not to do so.

Halberstan and Zaretsky (1969) studied the learning capacities of brain-damaged adults in a sentence construction task, using verbal reinforcement. They found that brain-damaged adults, whatever the injured hemisphere, showed a learning potential on positive affect sentences and that there was no difference between their performance and that of a non-brain-injured group. They concluded that a rehabilitation program should be centered on conditions that were rewarding for the individual treated.

Summary

The foregoing studies do not represent a complete review of the literature in the area of visuo-constructive deficits. Rather, they were selected as the investigations which were more closely relevant to the present study.

Analysis of this literature revealed disagreements among authors on whether it was possible for brain-damaged subjects to learn motor tasks through repetition of these tasks. A number of authors stated that left brain-damaged subjects were capable of learning whereas right brain-damaged patients could not (Benson et al., 1970; Hécaen et al., 1970; Warrington et al., 1966). On the other hand, other authors postulated that learning was possible for right brain-damaged patients since those subjects showed improvement

(Heap and Wyke, 1972; La Pointe and Culton, 1969; Taylor et al., 1971; Wyke, 1971). Some studies reported that only the ipsilateral hand improved while the contralateral hand did not, irrespective of the side of the injury (Ghent et al., 1955). A study indicated that the capacity of learning was related to the extent rather than the side of the lesion (McFie et al., 1952). Finally, an author concluded that both right and left injured subjects could learn, but that their learning processes were different according to the hemisphere involved (Diller, 1968).

The fact that many studies eliminated aphasics and subjects who showed severe sensori-motor problems may have lead to a non-comparability of the severity of the handicap in the two groups. Also, in most studies, repetition of the task was minimal and the question of whether more frequent repetition might have yielded different results was raised by Ghent et al. (1955). In the research presented by Wyke (1971) and Heap and Wyke (1972) the mean time elapsed since the subjects' strokes was 3.7 years. It is possible that the results would have been different if the subjects' strokes had been more recent. Another factor that was brought out by the studies of Benson et al. (1970), Hécaen et al. (1970), and Warrington et al. (1966) was that their means of training seemed to be aimed at helping one group and not the other; indeed, their hypothesis was that visuo-constructive deficits in left brain-damaged subjects were due to defects in programming or planning the activity. In those three studies, the training process emphasized programming the task. Results might have been different if the training process would have stressed practice in spatial relationships which was, according to those authors, the main difficulty of the right brain-damaged group.

Siev and Freishtat (1973) summarized the pertinent literature on testing and training perceptual deficits for brain-damaged adults. They concluded that it was still unknown if perceptual training would result in any learning and if so, which method of training would give the best results for the patients confronted with these problems. They added: "Other areas for future research arise: does learning occur in patients with brain damage in either hemisphere, or one more than the other;..." (p. 158). The present study attempted to give an answer to this question.

Hypothesis

Analysis of the literature surveyed lead to the formulation of the principal hypothesis: The brain-damaged hemiplegic subject presenting visuo-constructive deficits could learn through repetition of simple constructive tasks, whether his lesion was in the right or the left hemisphere; furthermore, he would progress farther than a brain-damaged hemiplegic who was not trained to do the same tasks.

Chapter 3

PROCEDURES

Subjects

Thirty-two hemiplegic subjects were tested. All had sustained a cerebro vascular accident and were hospitalized for rehabilitation at one of the following institutions: Holy Family Hospital (Vancouver, B.C.), Jewish Convalescent Hospital (Laval, P.Q.), Rehabilitation Institute of Montreal and Hôpital Marie-Clarac (Montréal, P.Q.). Table 1 gives an account of the number of patients hospitalized in each institution.

Table 1

Institutions where Subjects were Hospitalized

Institution	Trained LBD	Trained RBD	Non-trained LBD	Non-trained RBD	Total
Holy Family Hospital	3	1	0	1	5
Jewish Convalescent Hospital	2	2	4	4	12
Rehabilitation Institute of Montreal	0	1	4	1	6
Hôpital Marie-Clarac	3	4	0	2	9

The subjects were divided into four groups. First, they were divided according to the side of lesion: left brain-damaged (LBD) and right brain-damaged (RBD). Each group was then divided into two sub-groups: the experimental or trained group who were trained daily for ten consecutive days (weekends excluded) and the control or non-trained group who were tested once, then repeated the test ten days later. Subjects were alternately assigned to either sub-groups.

In the selection of the subjects, the following criteria were met:

1. The hemiplegia must have resulted from a cerebro vascular accident;
2. The persons having sustained a previous stroke were excluded;
3. The onset of the cerebro vascular accident should not have exceeded 30 weeks;
4. The subjects must have shown evidence of a unilateral brain impairment;
5. Those patients who were bed-ridden or those without sufficient tolerance to sit through a thirty-minute daily test session were excluded;
6. The subjects had to be right-handed in their every day activities.

All subjects had sustained a stroke. Hemiplegics whose handicap was the result of tumor, trauma or other causes were excluded in order to make the groups more homogeneous and to eliminate the possibility of cases of progressive degeneration of the brain cells not due to ageing. In many instances, it was impossible to determine the site and exact extent of the cerebral damage; however, subjects who had a history of previous stroke were not included, even if their recuperation was assessed as having been adequate, for they might have presented sequelae of perceptuo-motor dysfunctions.

All subjects were adults; their ages ranged from 32 to 82 years old with a mean age of 62.47 years old. In all cases, there had been an interim of 6 to 30 weeks (mean: 12.44 weeks) since the onset of their strokes. Table 2 indicates the mean age and the mean number of weeks post-onset for each group of subjects. The reason for restricting the elapsed time since the onset of the stroke was because it had been established by several authorities that chances of improvement were usually better in the earlier stages of the illness (Dupuis, 1969; Levenson, 1965; McCullough <u>et al</u>. (1970).

Table 2

Age and Weeks Post-onset for the Four Groups of Subjects

Variable	Trained Group				Non-trained Group			
	LBD		RBD		LBD		RBD	
	M	SD	M	SD	M	SD	M	SD
Age	68.00	9.27	60.38	15.10	59.25	12.94	62.25	11.31
Weeks interim since stroke	14.88	8.88	11.63	4.31	11.00	4.42	12.25	7.55

Each subject accepted for inclusion in the study showed evidence of unilateral brain impairment. Heimburger and Reitan (1961) stated that it was sometimes impossible to determine whether involvement was bilateral or unilateral, but that the usual methods were reliable to determine the hemisphere involved maximally in cases of bilateral involvement. Furthermore, although some cases may have had bilateral involvement, there was no reason to assume that there would be more in one group than in the other. Subjects who were not right-handed were eliminated since hemispheric dominance is not as well established in left-handed persons as it is in right-handed subjects.

As alternation was the basis of selection of the subjects for the trained and the non-trained groups, no attempt was made to obtain equal distribution according to sex; 14 male and 18 female subjects were included in the study. The distribution of the subjects according to sex is indicated in Table 3.

Table 3

Classification of the Subjects According to Sex

Sex	Experimental		Control	
	LBD	RBD	LBD	RBD
Male	3	2	3	6
Female	5	6	5	2

Since all patients were hospitalized in a rehabilitation institution, they were being treated in physical and occupational therapy. From medical and rehabilitation records and from conversations with treating physiatrists and therapists, the following supplementary data was obtained for each subject:

1. Medical Status[1]

1.1 Associated diseases: the presence of cardio vascular diseases and diabetes mellitus was noted. These diseases may affect the prognosis since these people must limit their expenditure of energy which might have an effect on their becoming independent (McCullough *et al.*, 1970).

---

[1] Medical and clinical data is shown in Appendix D.

1.2 Vision: the confirmed diagnosis of hemianopsia or other forms of visual field defects was looked for. Subjects with poor eyesight were required to wear their glasses during the testing and training sessions.

1.3 Motor impairment: electromyographic and medical examination results concerning the severity of the motor loss and the presence of spasticity or flaccidity in the upper and lower limbs were noted. An extensive motor impairment and a prolonged state of flaccidity were detrimental factors in assessing the prognosis of a stroke victim (McCullough et al., 1970; Peszezynski, 1965).

1.4 Sensation: Impairment of sensation was also a poor prognostic sign according to McCullough et al. (1970). This impairment might take several forms: sensory loss to touch and pin prick, hemianesthesia, loss of kinesthetic sense, loss of two-point discrimination and/or astereognosis. Information on this subject was gathered partly from the medical file and partly from the occupational therapy perceptuo-motor evaluation form (Appendix A).

2. Perceptuo-motor Status

In addition to motor and sensory function, the state of the patient's perceptuo-motor function was discussed with the treating occupational therapist. Most of the testing was done by the occupational therapist who used the evaluation included in Appendix A. This evaluation included the following items: proprioception, stereognosis, body image, perception of color, size and shape, spatial relations, figure-ground discrimination.

3. Functional Status

3.1 Activities of daily living: with every hemiplegic patient, the occupational therapist did a complete evaluation of activities of daily living. This evaluation included personal care, eating, dressing, transfers and various other functional tasks. The performance of the patient was rated as "independent," "need of supervision," "need of assistance" or "dependent." Every subject in the present study was assessed in this area and rated according to those criteria.

3.2 Ambulation: the functioning of each subject regarding his ambulation ability was determined through observation and/or through the physiotherapy records.

4. Speech

Information regarding the presence or absence of speech dysfunctions was gathered from the speech therapy department. Some subjects were dysarthric but this pathology did not affect their performance on the tasks. Some subjects were aphasics. In this event, they could suffer from motor aphasia which affects the expression of language, sensory aphasia which affects the receptive language or global aphasia which is a combination of both forms. Aphasia might be combined with one or more of the following: dysgraphia, dyslexia and dyscalculia.

5. Rehabilitation Treatments

All subjects received physical and occupational therapy. As patients were in different institutions, and received their treatments from different therapists, it was impossible to state that their physical and occupational therapy treatments were identical. Moreover, they were not all at the same stage of their disease nor were they all affected with the same severity. The general aims of physiotherapy and occupational therapy for brain-damaged hemiplegics are listed in Appendix B.

Description of the Test

The usual clinical tests used for the evaluation of visuo-constructive deficits included drawing of simple or complex forms with or without the presence of a model, assembling sticks and blocks representing structured and unstructured patterns and/or constructing mosaic patterns.

Warrington (1969) stated that the characteristic feature of the dysfunction consisted in the failure to analyze the spatial relationships of the components and the inability to execute simple constructive tasks under visual control.

Some authors noted that tri-dimensional tasks were particularly difficult to execute for subjects presenting visuo-constructive deficits and that frequently, subjects succeeded with the simpler tasks but showed gross abnormalities when confronted with the more difficult tri-dimensional tasks (Benton, 1962, 1968; De Ajuriaguerra, Hécaen and Angelergues, 1960; Hécaen, De Ajuriaguerra and Massonet, 1951; Hécaen, Penfield, Bertrand and Malmo, 1956). Inability to represent depth was one of the main characteristic defects in visuo-constructive deficits as the spatial component was particularly important when perspective was involved. Therefore, the present test concentrated on tri-dimensional activities.

As aphasics were included in the study, the chosen tasks had to be simple and had to exclude the necessity of verbal communication. Spontaneous drawing was therefore excluded from the test. However, as was stated by Benson and Barton (1970), drawing in itself is a good test to detect brain damage. Drawing was therefore included in the test as it was an activity that required good perceptual abilities and good praxis. The test was made up of four series of three tasks each: two series which consisted of drawing tasks and two series which consisted of block construction tasks.

Series 1

This series required the reproduction by drawing of three designs that were frequently used in the assessment of visuo-constructive deficits. The designs were similar to those used by many authors particularly Arrigoni and De Renzi (1964), Assal and Zander (1969), Bender and Teuber (1948), Benson and Barton (1970), Benton (1962), Hécaen et al. (1970) and Piercy et al. (1960). The designs used are reproduced in Figure 1.

Series 2

The subjects were asked to draw three blocks that were placed in front of them. These tasks represented an added difficulty as the models were tri-dimensional rather than a bi-dimensional reproduction of a tri-dimensional pattern. The models are shown in Figure 2.

Series 3

Series 3 was a block-building task. It was inspired from Benton's tri-dimensional constructional praxis test (Benton, 1968), although the patterns were different. Blocks of different sizes and shapes were used to construct three models of increasing complexity. An assortment of 19 blocks were given to the subject. It consisted of two blocks 'A', two blocks 'B', four blocks 'C', four blocks 'D', four blocks 'E' and three blocks 'F'. Figure 3 shows the shapes of the blocks used and Figure 4 reproduces the block construction tasks of series 3. Task 3.1 was made up of one block 'A', one block 'B' and two blocks 'C'. Task 3.2 was constructed with one block 'C', two blocks 'D', two blocks 'E', and three blocks 'F'. Task 3.3 included two blocks 'A', one block 'B', two blocks 'C', four blocks 'D', two blocks 'E' and two blocks 'F'. All models were already constructed and glued together in order to prevent the subject from seeing the actual building of the model.

Series 4

Series 4 consisted of building with one and one-half inch wooden cubes (block 'F' shown in Figure 3), three models drawn on white cards. This type of task was used in the intelligence test of Barbeau-Pinard (1963) and the Wechsler Adult Intelligence Scale (1955). It was modified slightly in order to prevent the blocks on the bottom row from being completely hidden by the blocks on the top row. These tasks had definite spatial and tri-dimensional components and were therefore included in the test. Figure 5 gives a reproduction of the four tasks of this fourth series.

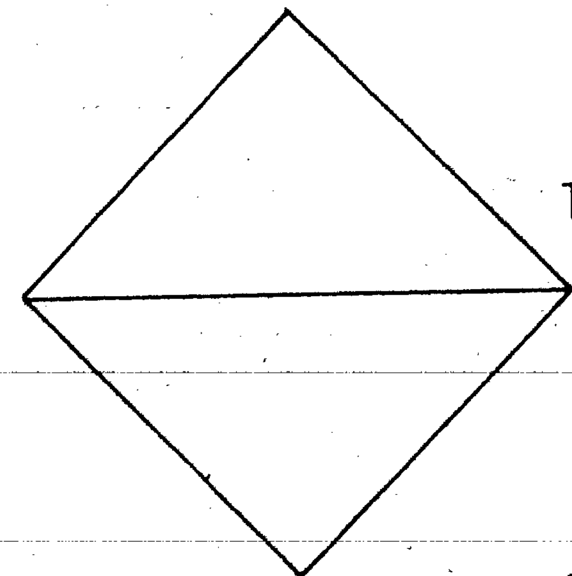
Experimental Situation

Subjects were seated in front of a table and the experimenter sat at their working side, which was the side of their hemispheric lesion. The testing session was done in a room where subject and experimenter were alone. All testing sessions were fitted into the morning schedule of each subject.

With the left brain-damaged group, the tasks were done with the non-preferred hand. This has been described as satisfactory by Critchley (1953) and Dee and Benton (1970), who pointed out that visuo-constructive deficits were usually manifested bilaterally and that the ipsilateral hand would show defective performance as well as the contralateral hand. Piercy, Hécaen and De Ajuriaguerra (1960) and Gainotti and Tiacci (1970) indicated that subjects who could not do a task with their preferred hand due to sensori-motor difficulties should be tested with their non-preferred hand. As all subjects in the present study were hemiplegics, they were tested with their

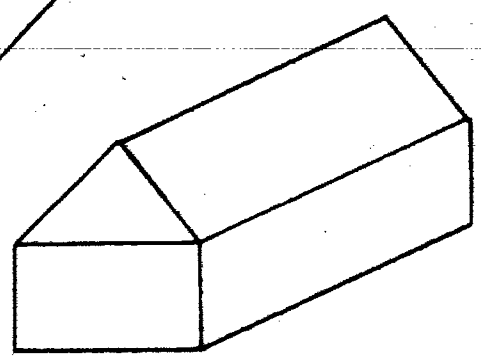
FIGURE 1

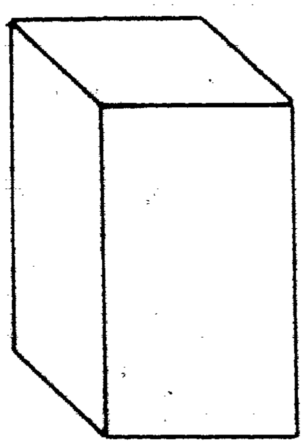
Models of the Three Tasks to be Drawn in Series 1
(Actual Size)



TASK 1.1

TASK 1.2

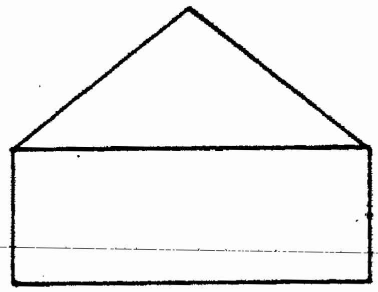




TASK 1.3

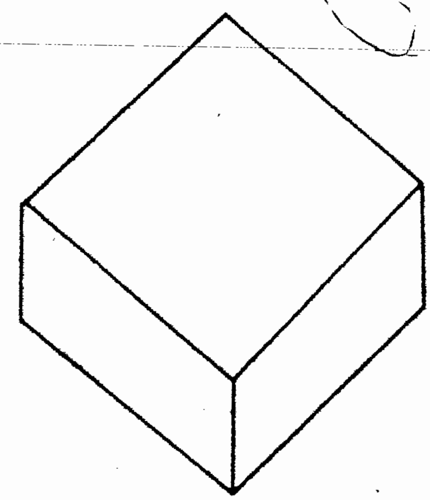
FIGURE 2

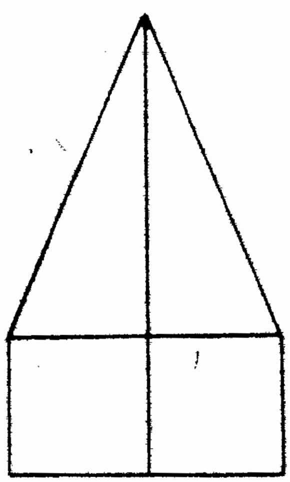
Models of the Three Blocks to be Drawn in Series 2
(Actual Size)



TASK 2.1

TASK 2.2





TASK 2.3

FIGURE 3

Models of the Blocks Used in Series 3
(One-half of Actual Size)

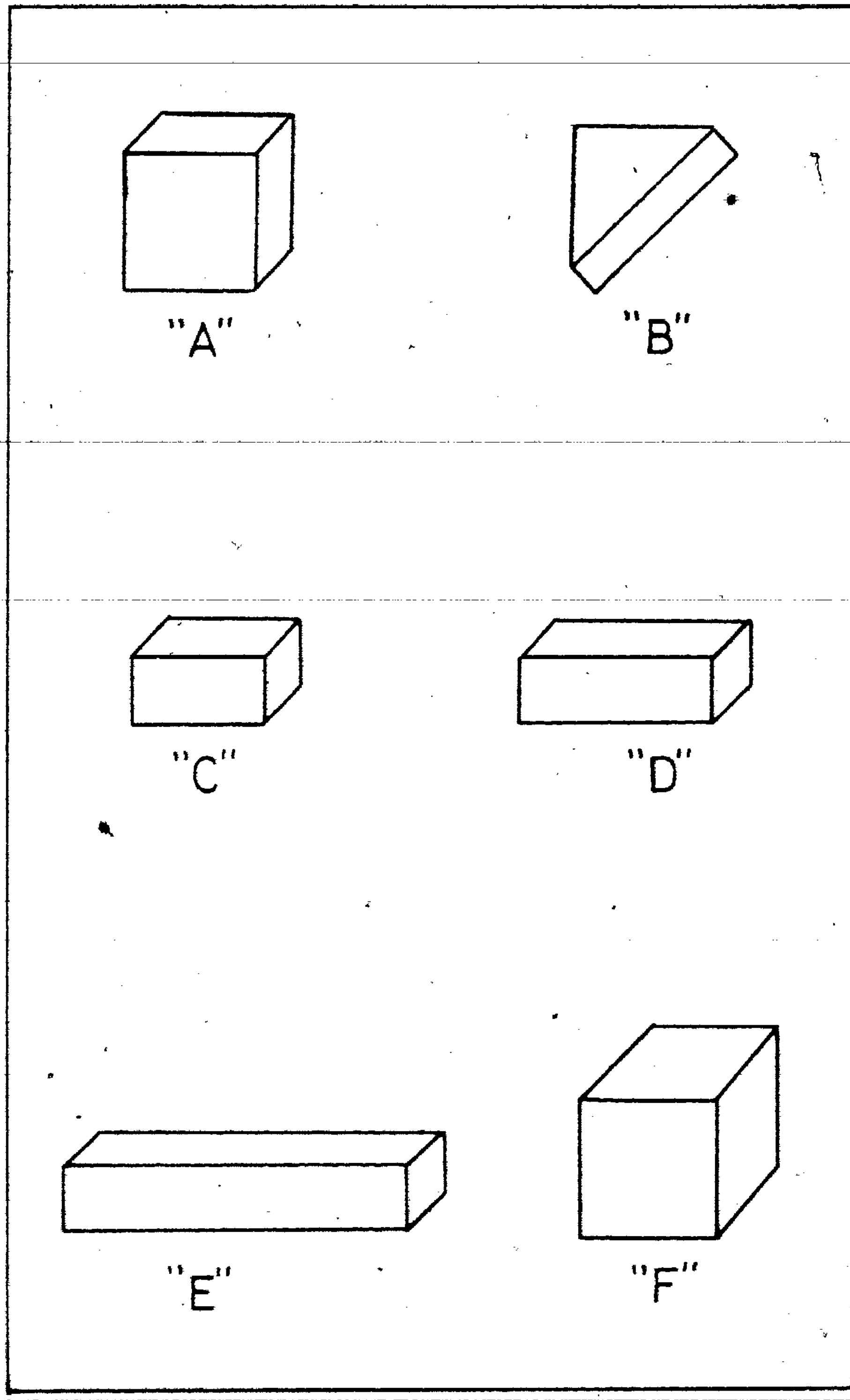

"A"
"B"
"C"
"D"
"E"
"F"

FIGURE 4

Models of the Three Construction Tasks in Series 3

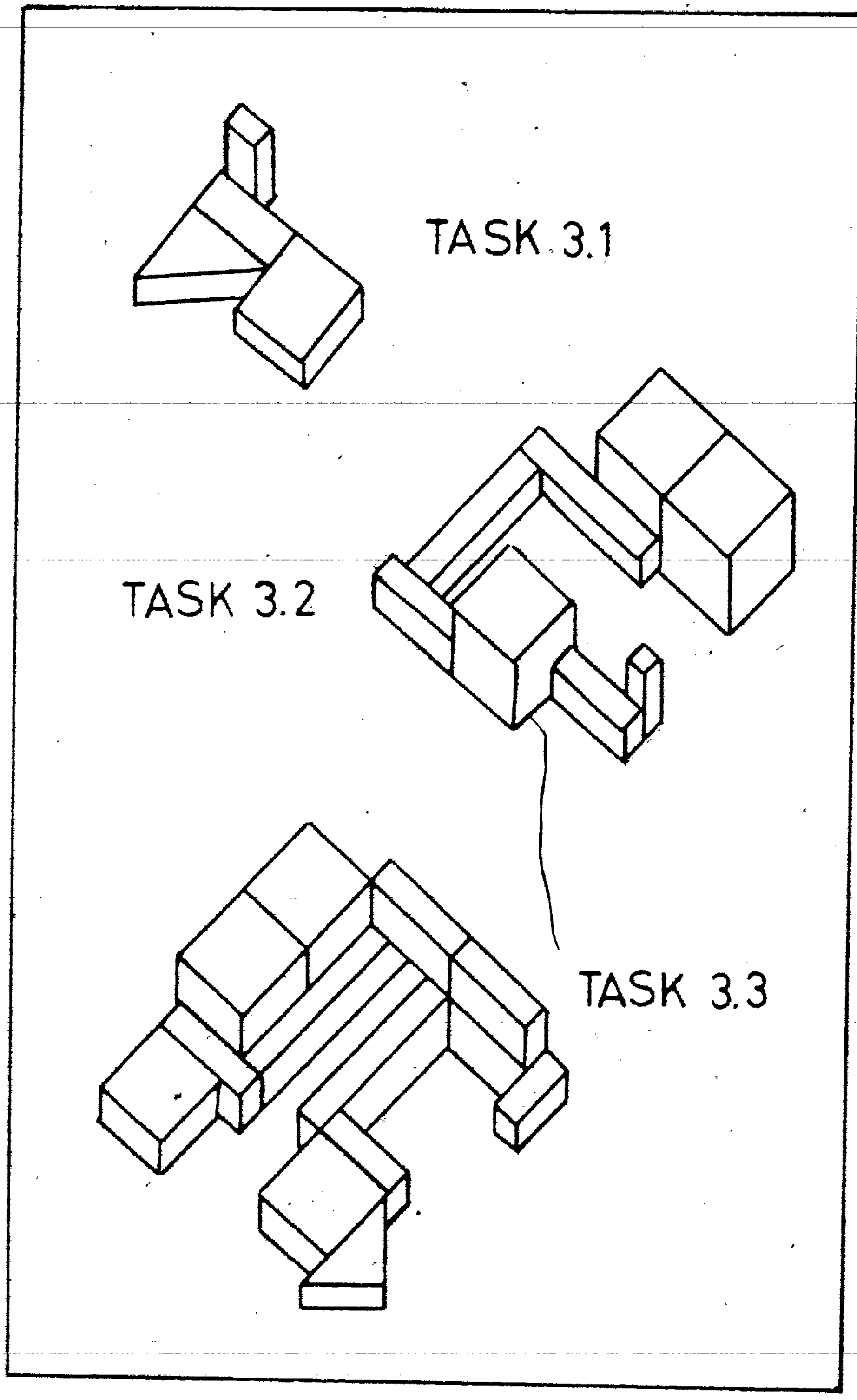
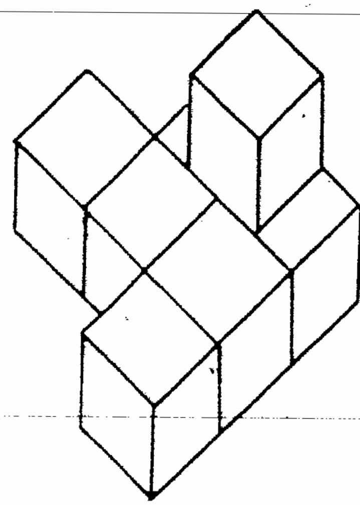
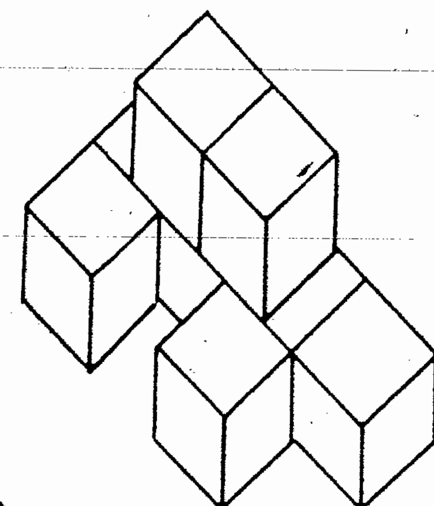

TASK 3.1
TASK 3.2
TASK 3.3

FIGURE 5

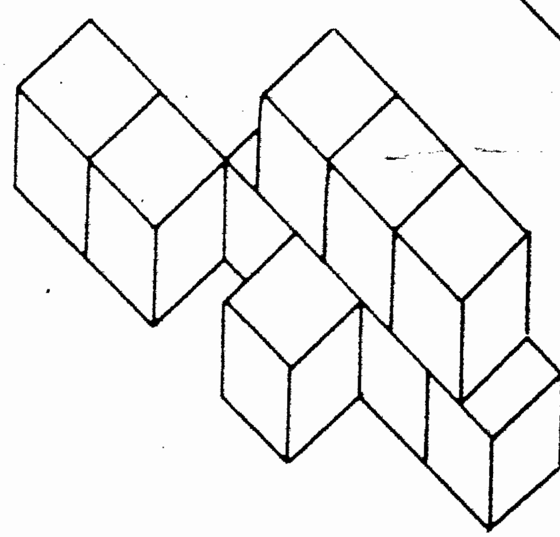
Models of the Three Block Construction Tasks in Series 4



TASK 4.1



TASK 4.2



TASK 4.3

ipsilateral hand regardless of the side of the paralysis. A study of Dee and Fontenot (1969) showed that this procedure was acceptable as they found that left hand drawing performances did not significantly differ from right hand drawing performances. They found that the pattern of frequency of various errors was very similar for the left and right hands except for a tendency for more distortions with the left hand. The errors which did not significantly differ were omissions, rotations, misplacements, size and perseveration. Hécaen and Assal (1970) had right-handed control subjects draw with their left hand. Their performance did not show any specific error except for a minor degree of dexterity faults. In any case, using the left hand for block construction tasks would not present as great a difficulty as drawing and the present test included both types of tasks.

For the first two series, the models to be drawn were placed directly in front of the patient except for hemianopsic subjects in which case the models were placed slightly on the side opposite to the blind field of vision. It was explained to the subject, verbally or through gestures, that he had to reproduce the design as exactly as he could.

In series 1 and 2, the subjects drew on a white 8½ by 11 inches sheet of paper fixed on a clipboard using a black felt pen which minimized resistance and prevented erasing. In series 3, an assortment of 19 blocks was placed on the working table, on the patient's non-paralyzed side. For series 4, ten wooden cubes were given to the subject.

The subjects were warned that time would be measured for the block construction tasks but that accuracy was more important than speed. When the subject stopped working, he was asked: "Are you finished?" If he replied "Yes" or "No, but I can not do it" or something similar, the next task was presented to him. In some cases of closing-in or incoherent manipulation of blocks, the subject was stopped and the next task was introduced.

Motor aphasics did not have difficulties in understanding what was expected of them. It was presumed however, that subjects suffering from global aphasia would have comprehension problems particularly with the block construction tasks. In those instances, the first task was performed in front of them by the experimenter, then dismanteled, in order to alleviate this difficulty. Furthermore, as those subjects might not have understood that accuracy was more important than speed, the chronometer was not shown to them .

in order to avoid misconstructions due to unnecessary speed.

Scoring

Each series of three tasks represented a maximum value of 25 points for a possible total score of 100. In series 1 and 2, one point was given for the first correct line and one point for each additional line drawn correctly in relation to itself and to the other lines. No points were taken off for minor distortions, imperfect apposition of lines or errors of size as half the subjects had to draw with non-preferred hand. No points were taken off either for additional lines for they could have resulted from perseveration or from errors that the subject could not erase.

In series 3 and 4, one point was given for the first correctly placed block and one additional point for each block that was adequately placed in relation to the other ones. In series 4, all the blocks were identical; consequently, there was no choice of blocks involved in doing the task. Therefore, one point was taken off for each additional block that the subject used in his construction. Table 4 gives an account of the maximum scores for each task.

Scoring was done by the experimenter. Then,

Table 4

Point Values of the Four Series of Tasks

SERIES	TASK	POINTS	MAXIMUM
1	1.1	5	
	1.2	11	
	1.3	9	
			25 points
2	2.1	6	
	2.2	9	
	2.3	10	
			25 points
3	3.1	4	
	3.2	8	
	3.3	13	
			25 points
4	4.1	7	
	4.2	8	
	4.3	10	
			25 points
TOTAL OF THE FOUR SERIES			100 points

an independent judge who did not have any information on the subjects was given the protocol for scoring and carried out the operation. Scores were then compared; when the results differed, the task was re-evaluated by the two judges and a consensus aimed at. Scoring of the block-building tasks was easier to standardize than it was for the drawing tasks as there were more individual differences in the latter. However, the two judges agreed in the majority of cases. In the instances where a consensus was not reached, the score of the independent judge prevailed since the fact that he did not have any information on the subject increased his chances of objectivity.

Subjects who achieved a score greater than 80 out of a possible 100 on the initial test were excluded as their visuo-constructive deficits were considered absent or minimal.

Analysis of the Data

An analysis of variance for repeated measures (Winer, 1962) was performed for initial and final scores of both left and right brain-damaged. The analysis of the initial and final score of the trained and the non-trained groups was also performed.

Correlations between initial and final scores and the following variables were then established:

1. Age
2. Number of weeks post-onset
3. Sensory impairment
   3.1 Superficial sensation
   3.2 Proprioception
   3.3 Stereognosis
   3.4 Body image
4. Perceptual deficits
   4.1 Perception of color, size and shape
   4.2 Perception of spatial relations
   4.3 Figure-ground discrimination

The evaluation of categories 3 and 4 were done by the treating occupational therapist, using the evaluation form shown in Appendix A. Dysfunction in those categories were rated as follows: (0) no impairment, (1) slight impairment, (2) moderate impairment and (3) severe impairment.

In order to determine whether the presence or absence of certain clinical syndromes had an influence on the learning capacities of the subjects, the chi square test of significance was used. Each analysis was set up to investigate the relation between defect on each of the measures described, and improvement on the visuo-constructive tasks. The differential score was determined for each subject; the mean, standard deviation and median was then calculated for the four groups of subjects. The clinical syndromes were divided into three section: (1) clinical symptoms, (2) functional characteristics and (3) specific visuo-constructive symptoms analyzed from the subjects' performances on drawing and construction tasks. The results derived from these analyses are presented in the following chapter.

Chapter 4

RESULTS

Comparability of the Groups of Subjects

Individual results for each subject are presented in Appendix C. The mean initial and final scores as well as the standard deviations are indicated in Table 5. It should be noted that in both left brain-damaged and right brain-damaged, the non-trained group had a higher initial score than the trained group. In addition, in both trained and non-trained groups, the right brain-damaged subjects had a higher initial score than the left brain-damaged subjects.

It has already been shown that groups were comparable in the following variables: age, weeks post-onset, absence of previous strokes, and left hemispheric dominance.

Analysis of the Differences Between the Experimental Groups

The analysis of variance for repeated measures (Winer, 1962) of the data pertaining to the left and right trained groups is summarized in Table 6. It showed that significant improvement occurred across ten training trials at the $p < .01$ level. Figure 6

Table 5

Mean Initial and Final Scores for the Four Groups of Subjects[1]

Scores	Trained Groups				Non-trained Groups			
	LBD		RBD		LBD		RBD	
	M	SD	M	SD	M	SD	M	SD
Initial	41.50	10.01	52.50	12.49	50.63	20.86	60.00	14.76
Final	60.13	20.91	72.63	15.94	60.63	23.58	66.38	15.72

[1] Maximum possible score: 100

indicates that learning took place in both groups although the right brain-damaged subjects' scores (mean: 65.79, SD: 16.43) were significantly greater than the left brain-damaged subjects' scores (mean: 53.58, SD: 16.62).

Table 6

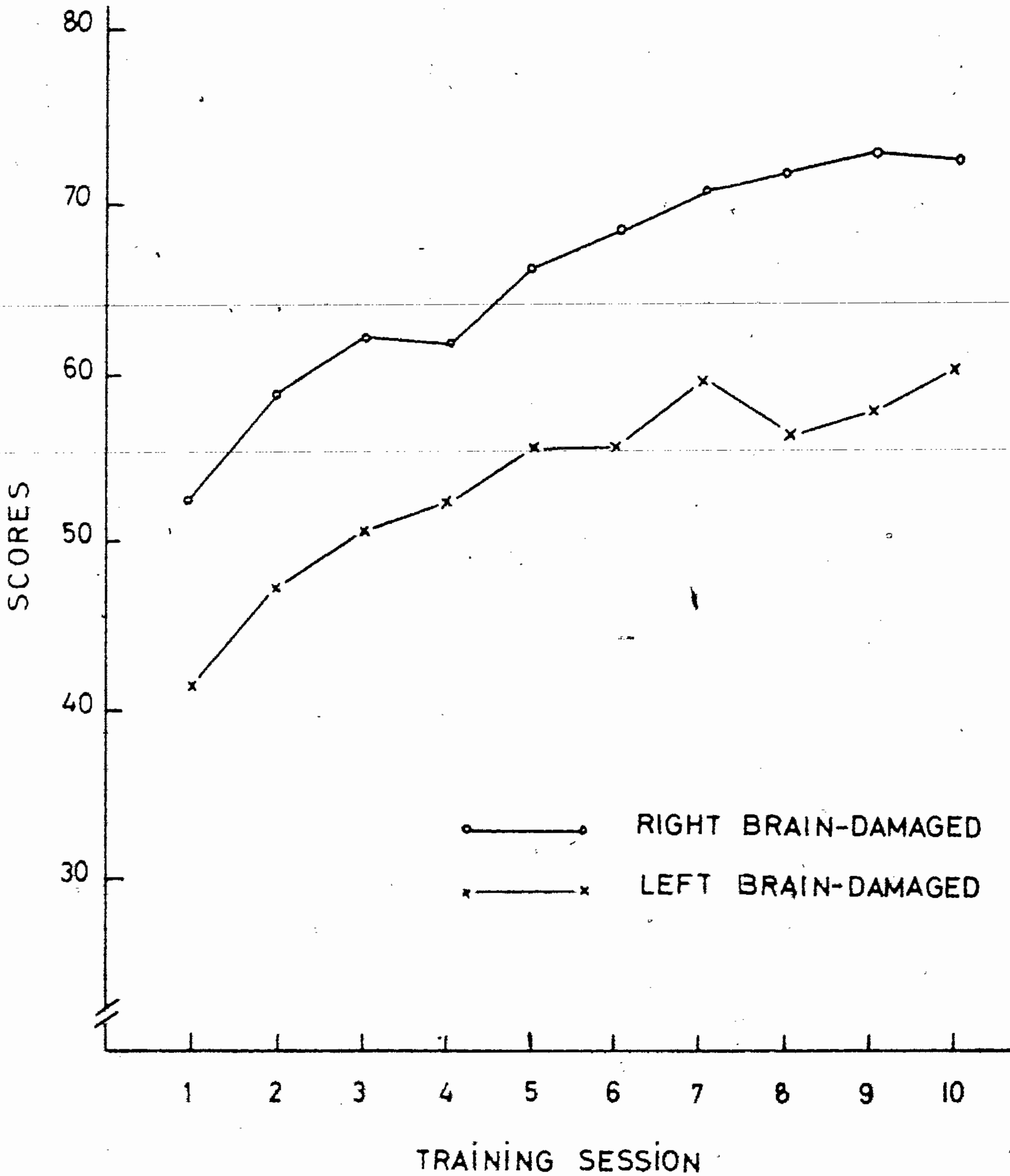
Summary of Analysis of Variance of the Results of Ten Training Sessions Between the Two Trained Groups of Subjects

Source	df	MS	F
Groups (G)	1	5953.600	8.873[a]
Trials (T)	9	4326.500	6.448[a]
G x T	9	14.211	0.002
Within sets	54	671.009	...

[a] $p < 0.01$

FIGURE 6

Mean Scores for the Left and Right Brain-damaged Trained Subjects for the Ten Training Sessions


80
70
60
50
40
30
SCORES
1
2
3
4
5
6
7
8
9
10
TRAINING SESSION
RIGHT BRAIN-DAMAGED
LEFT BRAIN-DAMAGED

Analysis of the Differences Between the Trained and Non-trained Groups

Table 7 summarizes the F values derived from the analysis of variance for repeated measures (Winer, 1962) for initial and final scores of the control (non-trained) and the experimental (trained) groups. No significant differences were found between hemispheres or between the experimental and control goups.

The final scores were significantly greater (F. 65.184; df 1/28) than the initial scores at the $p < 0.01$ level. The main question was whether the trained groups would show more relative improvement when compared to the non-trained groups. This could be tested by a significant interaction between the trained and the non-trained groups and the initial and final scores. It is shown that training actually resulted in a significantly greater improvement for the trained groups than the non-trained groups (F. 10.739; df 1/28). Figure 7 demonstrates that both non-trained and trained groups improved but that the trained group improved considerably more considering the fact that their initial scores were lower and their final scores were higher than those of the control groups.

Correlations Between Selected Variables and Scores

The correlation between certain variables and

Table 7

Summary of Analysis of Variance of the Results of the Trained and Non-trained Groups on the Training Sessions

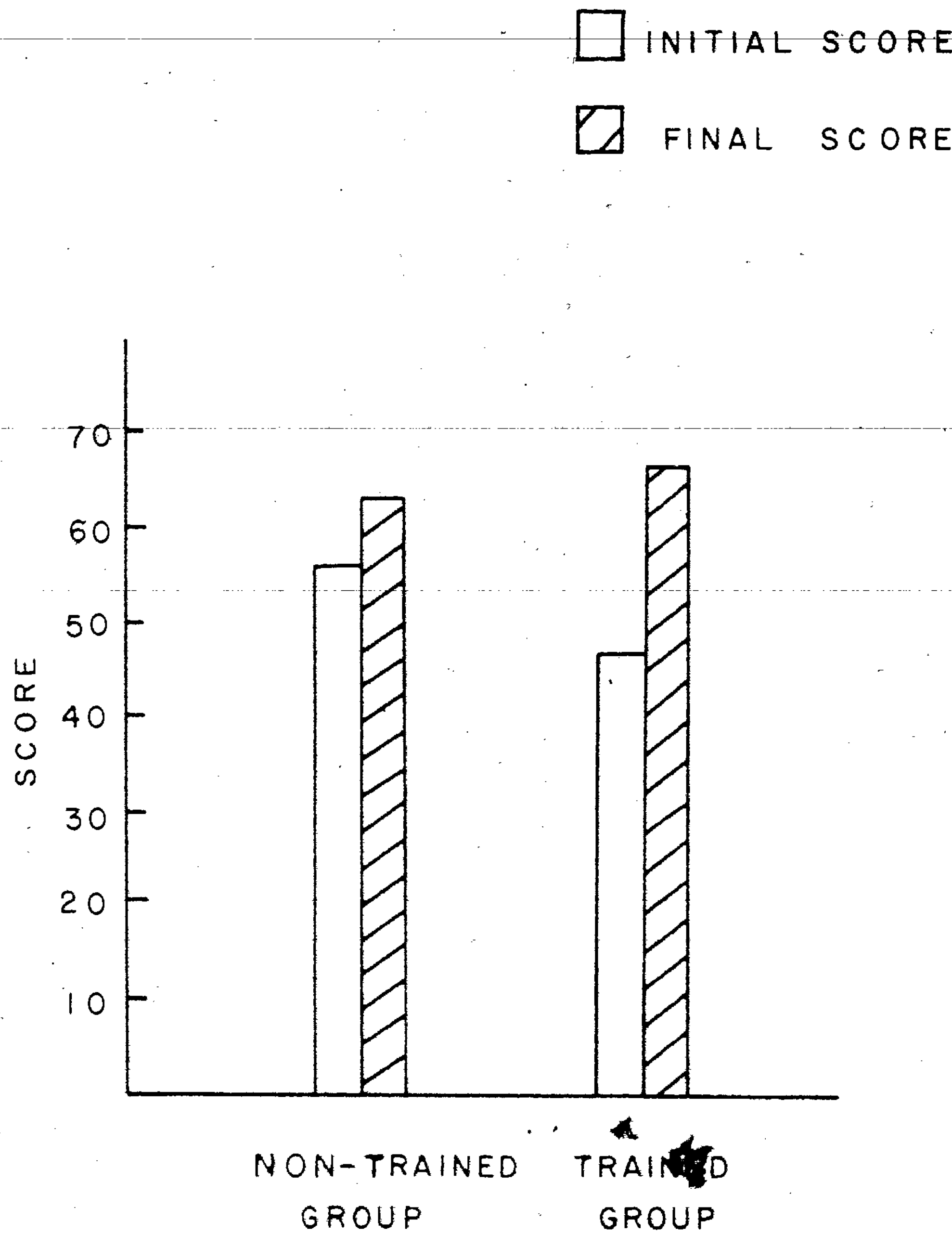
Source	df	MS	F
Between subjects	31		
Hemispheres (A)	1	1491.891	3.113
Training (B)	1	118.266	...
A x B	1	70.141	...
Error	28	479.252	
Within subjects	32		
Trials (C)	1	3038.766	65.184[b]
A x C	1	4.516	...
B x C	1	500.641	10.739[a]
A x B x C	1	26.266	...
Error	28	46.618	

[a] $p < 0.01$

[b] $p < 0.001$

FIGURE 7

Comparison Between Initial and Final Scores of the Trained and Non-trained Groups


INITIAL SCORE
FINAL SCORE
SCORE
70
60
50
40
30
20
10
NON-TRAINED GROUP
TRAINED GROUP

the initial and final scores was studied in order to detect differences which might have an influence on the subjects' scores. First, the correlation between initial and final scores was established; then, age and number of weeks elapsed since the brain injury were correlated with initial and final scores. Table 8 gives an account of those results.[1] A correlation at $p < .01$ level of significance was established between initial and final scores for three groups of subjects while in the fourth group it approached significance at $p < .05$ level. Age was correlated with final score ($p < .05$) in one group but not in the others. No significant correlations were established between weeks post-onset and initial or final score in any group of subjects. Appendix D indicates the age and number of weeks post-onset for each subject.

It has already been stated that the presence of severe sensory disturbances seemed to affect the prognosis of brain-injured adults. Consequently, the correlations between the degree of sensory impairment and the initial and final scores in the four groups of patients were looked for (see Table 9). The sensory disturbances that were evaluated were: superficial

---

[1] The level of significance was established at $r=.666$ for $p < .05$, and at $r=.789$ for $p < .01$.

Table 8

Correlation of Age and Weeks Post-onset with Initial and Final Scores for Each Group of Subjects

Group	Variable	Initial Score	Final Score
LBD trained	Initial score	...	.605
	Age	-.642	-.859**
	Weeks post-onset	.197	.465
RBD trained	Initial score	...	.838**
	Age	.401	.551
	Weeks post-onset	.247	.339
LBD non-trained	Initial score	...	.966**
	Age	-.150	-.134
	Weeks post-onset	.447	.355
RBD non-trained	Initial score	...	.949**
	Age	-.139	-.002
	Weeks post-onset	-.533	-.559

** Significant at the $p < .01$ level.

Table 9

Correlation Between Sensory Disturbances and Scores

Group	Variable[1]	Initial Score	Final Score
LBD trained	1	.342	.335
	2	.200	.344
	3	.483	.130
	4	.151	.170
RBD trained	1	-.386	-.681*
	2	.303	-.672*
	3	-.171	-.650
	4	-.006	-.516
LBD non-trained	1	-.742*	-.369
	2	-.400	.329
	3	-.714*	-.119
	4	-.646	.002
RBD non-trained	1	-.693*	-.551
	2	-.126	-.118
	3	.339	-.191
	4	-.334	-.310

* $p < .05$

[1] Variables: 1 - superficial sensation; 2 - proprioception; 3 - stereognosis; and 4 - body image.

sensation, proprioception, stereognosis and body image.

Impaired superficial sensation was correlated with initial score in both non-trained groups ($p < .05$) but was not significantly correlated with initial score in the trained groups. It was correlated with the final score of the right brain-damaged group. Difficulties in proprioception and stereognosis were each correlated at the $p < .05$ level with one group: the former with the final score of the RBD trained group and the latter with the initial score of the LBD non-trained group. The results were not consistent enough to indicate a definite inter-relation between impaired sensation and poor achievement on the test.

Dysfunction in the fields of perception of color, size and shape, perception of spatial relations and figure-ground discrimination were also correlated with initial and final scores of each group of subjects. It can be seen from the results presented in Table 10, that a significant correlation was established between impaired perception of color, size and shape, and initial score of the RBD trained ($p < .05$) and of the LBD non-trained groups ($p < .01$); a correlation was also found between such impaired perception and final score of both LBD groups ($p < .01$). It approached significance with the RBD trained group's final score.

Table 10

Correlation Between Perceptual Disturbances and Scores

Group	Variable[1]	Initial Score	Final Score
LBD trained	1	-.004	-.697*
	2	-.118	.351
	3	-.143	.112
RBD trained	1	-.741*	-.590
	2	-.601	-.483
	3	-.568	-.670*
LBD non-trained	1	-.900**	-.750*
	2	-.788*	-.543
	3	-.191	-.523
RBD non-trained	1	-.388	-.415
	2	-.388	-.415
	3	-.501	-.415

* $p < .05$

** $p < .01$

[1] Variables: 1 - perception of color, size and shape; 2 - perception of spatial relations; 3 - figure-ground discrimination.

The correlation was however practically null with initial score of the LBD trained group and not significant with both initial and final score of the RBD non-trained group. As for difficulties with spatial relations and figure-ground discrimination, only one significant correlation at the $p < .05$ level, was established in each instance: the former with initial score of the LBD non-trained group and the latter with final score of the RBD trained subjects.

Relationships between Clinical Syndromes and Differential Scores

The differential score of each subject was established; the results are presented in Table 11. Each group of subjects was then divided into those whose differential score was smaller than the median of their group and those whose differential score was larger. The clinical syndromes were grouped into three sections: (1) clinical symptoms, (2) functional characteristics, and (3) visuo-constructive symptoms. Appendix D gives a detailed account of the presence or absence of each of those symptoms for every subject.

Clinical Symptoms: This section included impairment in muscle tone, visual field defects, speech dysfunctions and associated cardio-vascular diseases and/or diabetes mellitus. All subjects were

Table 11

Differential Score Between Final and Initial Scores for the Four Groups of Subjects

Subject's number	LBD trained		RBD trained		LBD non-trained		RBD non-trained	
	IS[1]	DS[2]	IS	DS	IS	DS	IS	DS
1	44	16	66	21	55	11	56	7
2	36	-2	34	16	50	21	45	4
3	53	22	70	17	71	16	73	5
4	32	30	57	15	73	5	49	3
5	33	41	48	16	23	3	79	6
6	35	-5	49	27	25	9	72	2
7	42	18	44	12	66	9	63	7
8	57	29	52	37	42	6	43	7
Mean	41.50	18.63	52.50	20.13	50.63	10.00	60.00	5.86
SD	10.01	16.85	12.49	8.75	20.86	6.39	14.76	2.09
Median		20.00		16.50		9.00		5.5

1 IS - initial score

2 DS - differential score

hemiplegics; and therefore presented evidence of impairment in their muscle tone. Spasticity was seen in 17 cases and flaccidity was present in the other subjects. McCullough and Sarmiento (1970) and Levenson (1965) have stated that prolonged flaccidity was a factor that minimized the chances of an effective rehabilitation. In the present study, flaccidity did not appear to be a factor that influenced the results; no relationships were found between the state of muscle tone and the patient's progress on the test. The diagnosis of hemianopsia was confirmed in six subjects. No significant correlations were found between the presence of hemianopsia and the differential scores.

In right-handed people, aphasia could be present only in left hemispheric injuries. In the present investigation, aphasia was diagnosed in 13 cases out of 15 patients of the left brain-damaged group. In one case, the exact diagnosis could not be established because the subject's only spoken language was Chinese. Eight subjects suffered from motor aphasia and five subjects had global aphasia. No significant relationships were established between the presence of motor or global aphasia and differential scores. The presence of some associated diseases that were known to have an influence on the rehabilitation prognosis were looked for. It was established that 24 subjects presented symptoms of cardio-vascular diseases and 11 subjects suffered from diabetes mellitus. No relationships between the presence or absence of those diseases and improvement on the test were established. Table 12 summarizes the results obtained from the chi square test of significance between clinical symptoms and differential scores.

Table 12

Relationship Between Clinical Symptoms and Differential Score for the Four Groups of Subjects

Clinical symptom	df	chi square	F
Impaired muscle tone	1	0.000008	NS
Hemianopsia	1	0.5438	NS
Aphasia[1]	2	2.6445	NS
Associated cardio-vascular disease	1	0.10522	NS
Associated diabetes mellitus	1	0.01358	NS

[1] Aphasia is present in LBD subjects only; the relationship applied to this group of subjects.

<u>Functional Characteristics</u>. The following characteristics were included under this section: attention span, emotional behavior and performance in activities of daily living (ADL). Attention span was judged during the subjects' performance. Eleven subjects were easily distracted, overly talkative, incapable of building more than two or three blocks successively or presented similar behavior; they were evaluated as having a low attention span threshold. No significant correlations were found between poor attention span and low improvement on the test.

Gainotti (1972) divided <u>emotional behavior</u> of brain-damaged subjects into three categories: (1) catastrophic reaction which was mainly characterized by anxiety, aggressiveness or refusals; (2) depressive mood which manifested itself by discouragement, anticipation or declaration of incapacity or similar reactions, and (3) indifference reaction towards the disability or towards the incapacity to perform certain tasks. Gainotti's classification was used in the present study; no appearance of behavioral changes was found in nine subjects, catastrophic reaction's symptoms were present in two subjects, depressive reaction in fifteen subjects and indifference reaction in six subjects. A significant correlation between emotional behavior and differential scores was found. The relationship was particularly evident in the indifference reaction group where all subjects who presented such an emotional behavior finished the test with a DS lower than the median of their respective group.

In analyzing the performance in activities of daily living (ADL), three subjects were evaluated as being independent in most spheres of activities. Six subjects were completely dependent in that they were unable to complete any activity without assistance or supervision. The other subjects were more or less dependent as they needed supervision and/or assistance in part of the activities especially in dressing and in transferring from wheelchair to bed, bathtub or toilet. The chi square for ADL was non-significant. Table 13 gives a summary of the results derived from the analysis between functional characteristics and differential scores.

Table 13

Relationship Between Functional Characteristics and Differential Score for the Four Groups of Subjects

Functional characteristic	df	chi square	F
Attention span	1	1.1494	NS
Emotional behavior	3	19.140	$p < .01$
Performance in ADL	2	0.2713	NS

Visuo-constructive Deficits Symptoms

Visuo-constructive symptoms are numerous. The most fequently discussed in the pertinent literature were the following: lack of capacity to represent perspective, contralateral neglect, rounding of acute angles, closing-in, mirror image, macrographia or micrographia and perseveration (Arrigoni et al., 1964; Benton, 1962, 1968; Critchley, 1953; De Ajuriaguerra and Hécaen, 1964; Gainotti et al., 1970; McFie et al., 1960; Mendilaharsu et al., 1968; Piercy et al., 1960 and Warrington et al., 1966). An analysis of the presence or absence of these symptoms was undertaken in order to determine whether it had a bearing on the subjects' learning capacities. Appendix E includes some subjects' drawing performances and gives examples of the visuo-constructive symptoms described in this section.

Lack of capacity to represent depth was the most frequently encountered visuo-constructive symptom in the present study: twenty-two subjects presented this deficit. No correlations were found between the presence of this dysfunction and improvement on the test. Contralateral neglect was usually associated with right brain damage in right-handed subjects. In the present study, it appeared in the designs of 12 out of the 16 RBD patients and was absent in all LBD subjects' performances. No significant relationship between the presence of contralateral neglect and differential score was established.

Rounding of acute angles was described by Warrington et al. (1966) as a manifestation of young children designs. It was hypothesized that subjects who presented this dysfunction would be more severely impaired than the others and therefore might not improve as much on the test. However, no such association was found. Closing-in was especially apparent in the block construction tasks of nine subjects. This symptom was discussed by De Ajuriaguerra and Hécaen (1964); they defined it as a "deficit of the relational thought, similar to the behavioral mode of the child confronted with the task of copying a model."[1] The hypothesis of a more severe deficit was again put forward but, as happened in the previous case, no significant correlation was found between the presence of closing-in and the subjects' differential scores. Mirror-image was also a sign of defective perception of spatial relationships. It was found in eight subjects. Although the relationship between mirror-image and improvement on the test was not definitely significant, it was extremely close to being significant; mirror-image might therefore have had an influence on the differential score of the subjects who presented the symptom.

Macrographia and micrographia were present respectively in seven and three subjects. However, no significant associations between either of those symptoms and differential scores were established. Finally, perseveration was studied; it was found in 18 subjects. No significant correlations between the presence of perseveration and results on the test were established. The relationships between visuo-constructive symptoms and differential scores are presented in Table 14.

[1] "un déficit de la pensée relationnelle, proche des modes de comportement de l'enfant face à la copie d'un modèle." (p. 269)

Table 14

Relationships Between Specific Visuo-constructive Symptoms and Differential Score for the Four Groups of Subjects

Visuo-constructive symptom	df	chi square	F
Incapacity to reproduce depth	1	1.3749	NS
Contralateral neglect[1]	1	1.3333	NS
Rounding of acute angles	1	1.3749	NS
Closing-in	1	1.3749	NS
Mirror-image	1	3.0222	NS
Macro and micrographia	2	4.3559	NS
Perseveration	1	0.0388	NS

[1] This symptom was present in RBD subjects only; the relationship applied to this group of subjects.

Chapter 5

DISCUSSION

Differences in Learning According to Hemispheric Side of Lesion

The salient finding of the study was that no quantitative differences were found in the learning capabilities of brain-injured subjects, based on the hemisphere which was injured. Statistical analysis showed that improvement of performance was essentially the same for both the left and the right brain-damaged groups. It was therefore concluded that brain-injured hemiplegics presenting some visuo-constructive problems could learn through repetition of constructive tasks, whatever the side of their injury.

There had been reports of quantitative differences in the learning process of brain-injured subjects based on the side of their lesion. Warrington _et al_. (1966:78) stated:

> The results were consistent with the hypothesis that the left-sided cases would benefit from training in the strategy of drawing the test figure of a cube and differ in this respect from right-sided cases (whose difficulties lie elsewhere).

This conclusion was then confirmed in the studies of Benson _et al_. (1970) and Hécaen _et al_. (1970).

In the present study, different procedures were used which might explain the differences between the results obtained and those appearing in some of the literature. First, all subjects who met the criteria of selection and who obtained a score lower than 80 per cent on the initial visuo-constructive deficit test were included in the study, regardless of the severity of speech problems and of sensori-motor dysfunctions in the preferred hand. This might have led to groups that were more similarly affected regarding the severity of their brain lesions. The training period in the present study was extended over ten sessions, while in previous studies training was done in a single session. Finally, scores were evaluated by an independent judge which was also the case in Warrington's study but not in the other reports. This procedure was described by Warrington as being more objective considering the fact that the independent judge did not have any information on the subjects nor on the purpose of the study.

Some questions were however left unanswered, particularly Diller's (1968) theory stating that right brain-damaged subjects showed a tendency to forget what they had learned but that left brain-damaged patients showed better retention. In the ten days training period, only two subjects failed to show any improvement; both were in the left brain-damaged group (see Appendix C). Evidently, these two cases could not support a conclusion denying Diller's theory, but they should be mentioned. It must also be noted that both those subjects had low initial scores which probably indicated severe dysfunction in the sphere of visuo-constructive tasks; their initial scores were respectively 36 and 35. In contrast, two other subjects had lower initial scores (32 and 33) and both of them completed the training session with respective final scores of 62 and 74.

In studying the learning tendencies of both groups of subjects (see Figure 6, p. 63), it can be seen that slight fluctuations of daily mean scores occurred in both right and left brain-damaged groups; the upward trend of the scores was however constant in both groups. In order to determine whether both groups did or did not retain what they had been learning, repetition of the test some days after the final session would have been necessary. This was unfortunately not done in the present investigation and no conclusions could be drawn concerning retention of learned material.

Differences in Learning Between Trained and Non-trained Subjects

Another important result of the present study was that a significant difference occurred between initial and final scores in all groups, although the trained group showed a significantly greater improvement. From the onset of the project, it was understood that all groups would tend to show some improvement. The mean post-onset time of the cerebro vascular accident was relatively short for this type of handicap (mean: 12.40 weeks); it was accepted by many investigators that some healing took place in the first months following a brain injury. Furthermore, every patient was being treated daily in physical and/or occupational therapy and when necessary, in speech therapy. These treatments would probably have had a beneficial effect on their condition. The fact that the trained group had a greater final score than the non-trained groups led to the conclusion that daily repetition of simple visuo-constructive tasks helped subjects presenting deficits in this area to achieve a better performance on those specific tasks. This program seemed therefore to constitute a useful treatment, considering the fact that several authors cited in the introductory chapter have shown that perceptuo-motor dysfunctions were related to poor performance in activities of daily living.

In comparing initial scores (Table 5, p. 60), it can be seen that there were variations among the groups. The trained groups had a lower initial score (mean = 47) than the non-trained groups (mean = 55.32). Figure 8 shows that similar improvement occurred in the trained groups whatever the range of their initial scores. The improvement of the untrained group was also similar, although slight variations occurred according to the range of their initial scores (Figure 9). These results indicated that the subjects' improvement pattern did not differ in relation with the range of their initial scores; the fact that the non-trained group had a higher mean initial score was therefore not a determinant factor in the smaller degree of improvement of this group.

Differences of Learning Among Trained Subjects

Analysis of the results obtained in the present study led to the formulation of another question: Why did some subjects with low initial scores show different improvement patterns than other subjects with similar scores on their first trial?

Luria (1963) pointed out that success of the restoration of function after a brain injury depended largely on motivation of the patient; on a physical

FIGURE 8

Comparison Between Initial and Final Scores of the Trained Group of Subjects Divided According to the Range of Their Initial Score

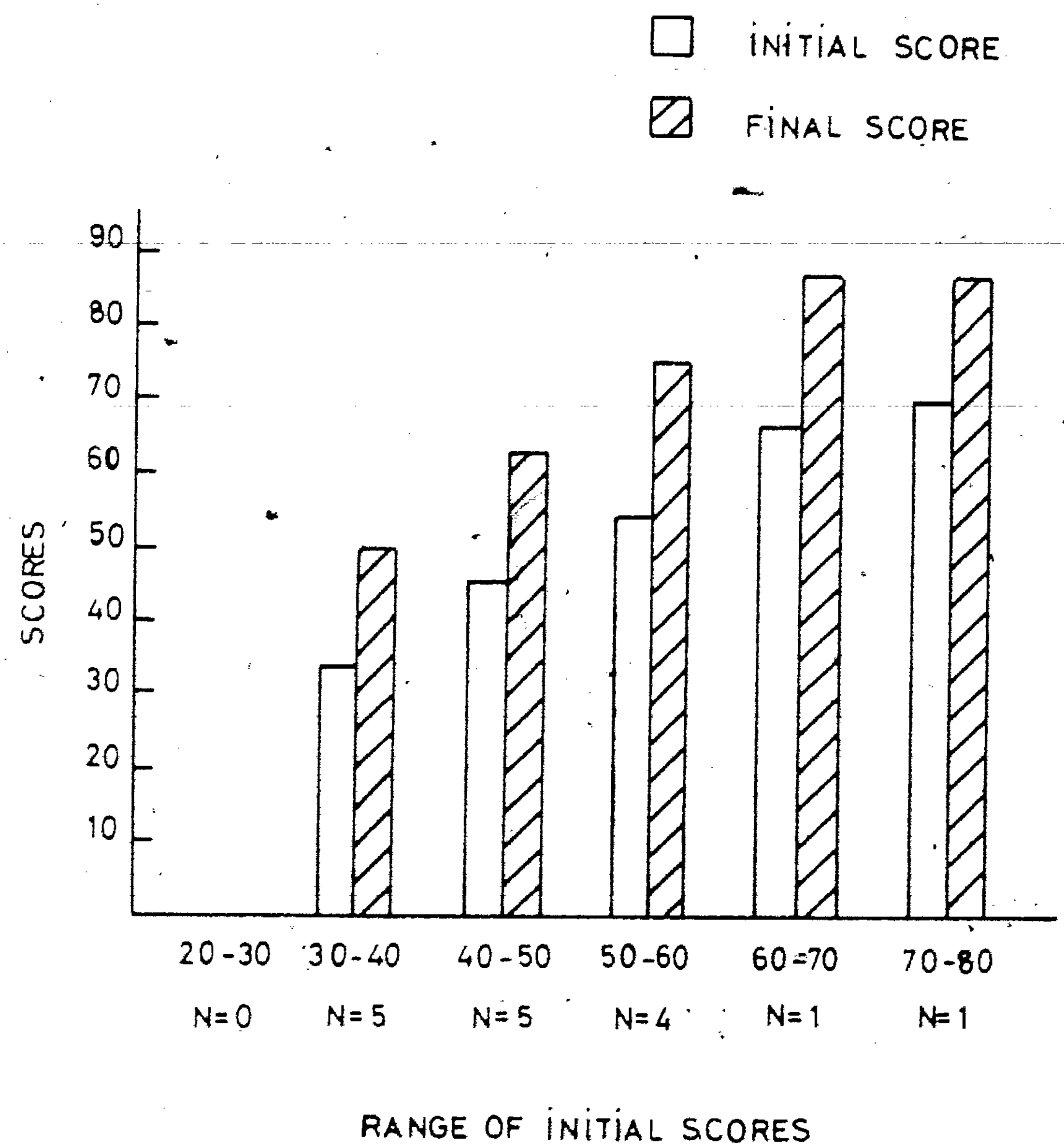
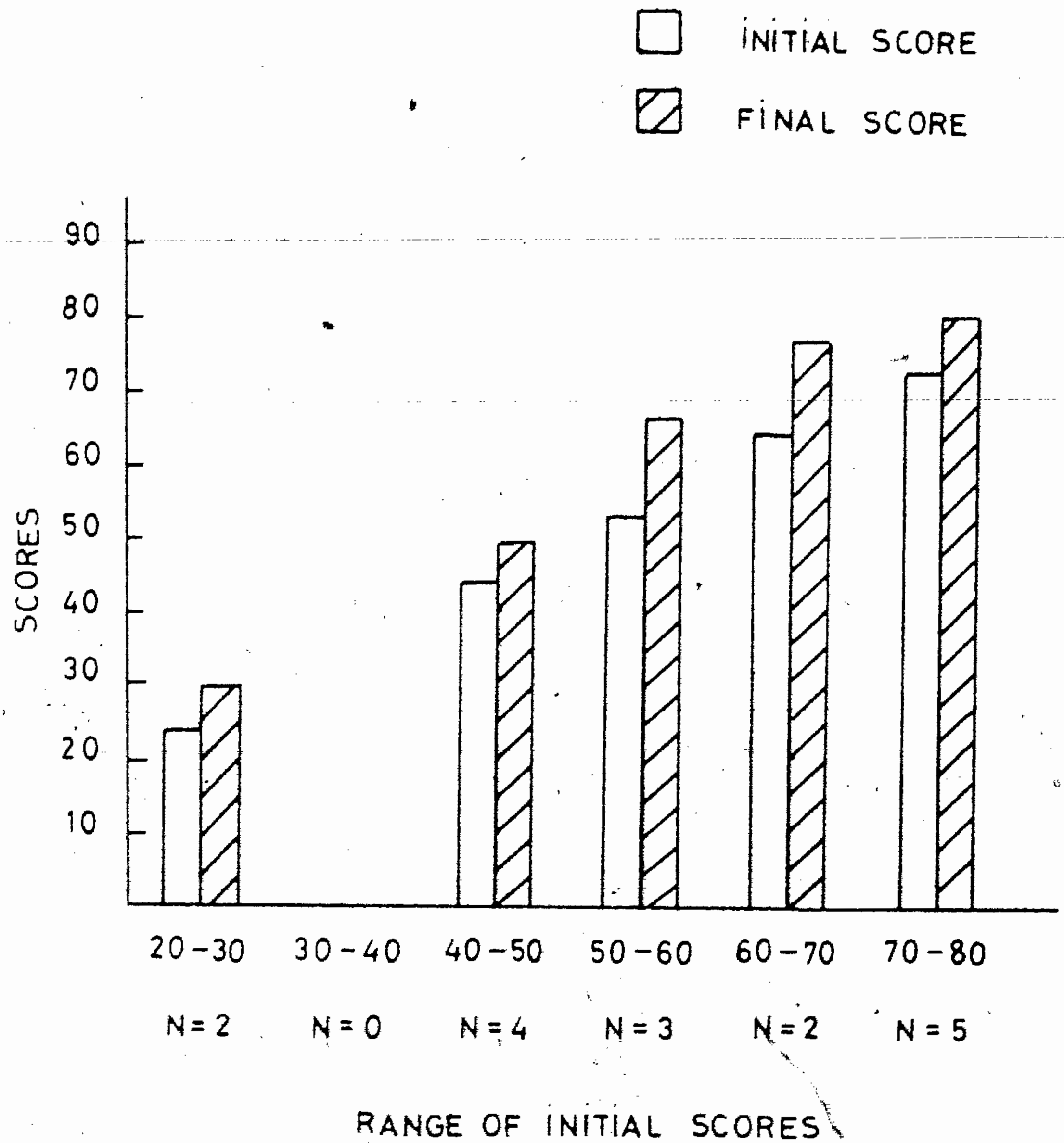

INITIAL SCORE
FINAL SCORE
90
80
70
60
50
40
30
20
10
SCORES
20-30
N=0
30-40
N=5
40-50
N=5
50-60
N=4
60-70
N=1
70-80
N=1
RANGE OF INITIAL SCORES

FIGURE 9

Comparison Between Initial and Final Scores of the Non-trained Group of Subjects Divided According to the Range of Their Initial Score



INITIAL SCORE
FINAL SCORE
SCORES
90
80
70
60
50
40
30
20
10
20-30
30-40
40-50
50-60
60-70
70-80
N = 2
N = 0
N = 4
N = 3
N = 2
N = 5
RANGE OF INITIAL SCORES

level, he also stated that it was related to (1) the severity of the injury, (2) the volume of tissue affected, and (3) the presence of complicating factors. In the present investigation, it was impossible to determine with accuracy the severity and extent of the brain injuries. This was due to the fact that the subjects came from different rehabilitation institutions, and they were not all submitted to the same diagnostic measures. As for complicating factors, which were Luria's third consideration, an attempt was made to verify the importance of some of those by analyzing their relationships with the subjects' differential scores.

Only one of the variables studied yielded significant results: the emotional behavior of the subjects. Apart from the fact that both subjects presenting catastrophic reactions were in the left brain-injured group, no definite attributions of specific emotional behavior patterns were established according to the side of the brain injury as Gainotti (1972) had observed. Significant correlations were established between type of emotional behavior and differential scores. Both subjects presenting catastrophic reactions were among the group whose differential score was greater than the median of their group. Catastrophic reaction, which made the subjects very sensitive to their failures or difficulties, seemed to be linked to the desire to perform well. Although both subjects seemed anxious, they did not refuse to perform the tasks as is sometimes seen in these cases according to Gainotti. The small number of subjects presenting this particular behavior made it difficult to draw definite conclusions, however the present result could imply that this type of reaction, when not accompanied by refusals, could incite the subject to a better performance. Those subjects did not accept failure; they wanted to succeed and may therefore have been more motivated when performing a task.

On the other hand, indifference reaction seemed to yield quite different results. All six subjects showing this type of behavior had low differential scores. These patients showed indifference towards their disability or their performance; they were apathetic and did not seem to be disturbed by their poor performance or their failures. Their errors did not seem to distress them. The lack of motivation of these patients might explain their low results.

Subjects showing a depressive mood were divided almost equally among poor learners and good learners. Temporary depression might be considered a usual reaction especially when, as in all the present cases, such an injury was relatively recent. Depressive mood did not seem to influence the learning capabilities of the present subjects. It may be hypothesized however, that prolonged depression might decrease motivation and be a significant factor in the success or failure of future treatment programs.

Several variables that were not statistically correlated with improvement deserve discussion. Luria (1963) had pointed out that an older person's injured brain had fewer powers of compensation and restoration of disturbed functions than the injured brain of a young person. Wylie (1964) stated that older brain-injured subjects were evaluated as being more disabled on admission to a rehabilitation center; in addition, their rehabilitation potential was lower than younger hemiplegics. Peszczynski (1965) approved the view that younger patients had a better prognosis, but he added that aged hemiplegics could be rehabilitated to some degree of independence.

In the present study, no correlations were established between age and learning capacities of the brain-injured subjects. Even if the age range was wide (from 32 to 82 years old), it should be noted that 75% of the subjects fell into the 50 - 75 year old category. Both the youngest and the oldest patients were in the RBD trained group. The youngest subject was 32 years old; her initial score was 44 and she completed the training sessions with a score of 56 (differential score: 12). The oldest started with a score of 66 and her final score was 87 (differential score: 21). In both these cases, as well as in all other cases, Luria and Wylie's statements were not substantiated.

Another factor considered was the effect of the time lapse since the onset of the injury. In the present study, it was of six to thirty weeks; 75% of the subjects' post-onset time was in a range of six to fifteen weeks. Had there been more time between the onset of the brain injury and the testing or training sessions, the results might have been different for it has already been stated that chances of recuperation were greater in the earlier stages of the disease. It should be mentioned however that Williams (1967) did not find relationships between time lapse since the brain injury and ability to learn upper extremity dressing skills.

As mentioned previously, several authors had stated that sensory and perceptual deficits had a detrimental effect on the rehabilitation prognosis of hemiplegic patients. However, no significant negative correlation between these deficits and initial and final scores was established in the present study. Many factors could be responsible for these results. The most obvious one would be that no correlation existed; however, this explanation must be rejected for many authors have established such associations. Another reason might be that the test used in the present investigation was not a valid measurement of the presence and severity of visuo-constructive deficits; the fact that the present test was similar to tests validated by several authors does not support such a conclusion. A third factor which might be responsible for these results was the small number of subjects in each group; this was a possible cause considering the complexity of neurological variables involved when the brain is injured. Finally, the results might be due to the fact that visuo-constructive deficits were the manifestations of many types of deficiencies such as difficulties in perceiving space, in orienting one's own body in space, or dysfunctions of apraxic or agnosic nature. Such a conclusion is supported by the research presented in the first part of the review of the literature where the nature of visuo-constructive deficits in brain-injured adults is discussed.

Some clinical symptoms were known to affect the sensori-motor performance of hemiplegics. Among those, were the presence of muscle tone changes, visual field defects, speech dysfunctions and some associated diseases. None of those symptoms seemed to affect the visuo-constructive performance of the subjects. Among those symptoms, visual field defects seemed particularly important to consider; however, it was shown that hemianopsics did not perform more poorly on the ten training sessions than subjects without such visual problems. The number of hemianopsic patients was small (six subjects out of thirty-two) and this might have contributed to the non-significant correlation. Furthermore, in all diagnosed cases of hemianopsia, the models were placed slightly on the non-blind side and the subjects were asked if they could see the model properly before they were told to start. Fortunately, no hemianopsic patient suffered from global aphasia.

The hemiplegic patients' performance in activities of daily living was frequently used as the measure of progress in their rehabilitation. (Anderson, 1967, Kelman and Willner, 1962, Sarno, Sarno and Levita, 1973, Taylor et al., 1969 and Wylie, 1967). Several authors cited in the introduction have associated the presence of perceptuo-motor dysfunctions with poor performance in activities of daily living. These reasons motivated the study of correlations between performance in this area and differential scores which, however, did not yield significant results. This might be explained by the fact that several patients were in the early stages of rehabilitation. As Lorenze and Cancro (1962) pointed out, unsatisfactory performance in activities of daily living in the first few weeks after admission may be due to "lack of awareness rather than actual inability." Another reason for the non-significant results might be that ADL ratings were subjective and no evaluation form was widely accepted and used (Donalson, Wagner and Gresham, 1973). It could be useful in future studies on this aspect to use Donalson et al.'s form which was complete, objective and standardized, for the ADL evaluation of every subject.

Correlation of subjects' performance with the type of visuo-constructive deficits exhibited in their drawings and constructions did not yield significant results. No definite relationships were established between the presence of mirror-imaging and low improvement on the test, but there was some indication that problems in this area could lead to difficulties in improvement. In the present investigation, no efforts were made to induce self-correction or re-education of any particular deficit in any other than through simple daily repetition of the tasks. It could be hypothesized that some specific symptoms would respond better to different forms of training than others, but this investigation was not in the scope of the present study.

Chapter 6

CONCLUSIONS

The results obtained in the present study indicated that hemiplegic subjects suffering from visuo-constructive deficits did benefit from training through repetition of simple visuo-constructive tasks. This treatment procedure did help hemiplegic patients to improve their performance on these tasks, whether their lesion was in the dominant or the sub-dominant hemisphere.

Several authors have established that perceptuo-motor dysfunctions, which include visuo-constructive deficits, are linked to difficulties in the performance of activities of daily living. It has also been established that the final aim of rehabilitation of the hemiplegic patients is to help them achieve optimal independence in their daily life activities. It could then be concluded that procedures designed to overcome the perceptuo-motor dysfunctions of the hemiplegic patients are a useful part of their rehabilitation treatments.

Two major conclusions have been reached: (1) hemiplegic patients could improve in the area of visuo-constructive dysfunctions whether they were left or right brain-damaged, and (2) daily training in this area was useful in order to improve the patients' performance. Further investigation in this area is necessary. This type of treatment would be of no practical value if the subjects did not retain what they had been learning or they could not apply it to similar tasks in order to make greater improvement. Studies in these areas should prove beneficial in the establishment of useful treatment procedures. Other areas of research, in conjunction with type of dysfunction, would be to investigate ways whereby the prognosis regarding improvement of the subjects on visuo-constructive tasks could be established with some degree of accuracy. This is a difficult question but it would be useful to know which symptoms or behaviors might be detrimental to learning so that this type of treatment could be used more intensively with the hemiplegic subjects who have the greatest chances of success, because this type of treatment requires great effort and motivation on the part of the patient. In the present study, attempts were made to find correlations between specific clinical symptoms, functional characteristics and visuo-constructive symptoms, and improvement. Only one variable yielded significant results; there was a significant relationship between the type of emotional behavior of the subjects and their improvement with training. Subjects presenting a catastrophic reaction seemed to have greater motivation and improved more than subjects with indifference reactions.

It could be useful to consider the emotional behavior of the subjects before using this type of treatment; with the indifferent patients, this treatment seemed to be of limited value.

No other variable yielded significant results; this may be due to the fact that the establishment of such correlations was not the main purpose of the study. In selecting the patients, no special emphasis was put on selecting patients suffering from hemianopsia, flaccidity, closing-in or any other symptoms; consequently, the number of subjects presenting each of these specific symptoms was limited, which made scientific conslusions impossible to draw.

Among rehabilitation workers interested in perceptuo-motor dysfunctions in the brain-damaged adults, occupational therapists are most closely associated with the evaluation and the treatment of these deficits. In many institutions, these therapists evaluate and dispense treatment to a great number of hemiplegics each year. It is hoped that further research in the treatment procedures applied to perceptuo-motor dysfunctions will allow increasingly more efficient treatment for the thousands of people who sustain a stroke each year.

GLOSSARY

APHASIA: Defect in the production or the understanding of spoken or written speech.

APRAXIA: Inability to perform certain purposeful movements when this inability is not due to paresis or paralysis, anesthesia or incoordination.

AGNOSIA: Failure to recognize an object perceived by the sense organs when this failure is not caused by visual deficiency, mental deterioration or aphasia.

CLOSING-IN: Dysfunction in which the subject draws or does construction tasks very close or directly on the model.

DYSARTHRIA: Motor dysfunction of the organs of phonation.

DYSCALCULIA: Impairment of the mental ability to do simple arithmetic.

DYSGRAPHIA: Impairment of the power of writing in which the subject has difficulties in expressing ideas in written form.

DYSLEXIA: Impairment in the recognition and comprehension of printed or written words, although they are visible.

HEMIANOPSIA: Blindness in one-half of the visual field.

HEMIASOMATOGNOSIA: Loss of perception or neglect of one-half of the body.

MICROPSIA: Visual dysfunction in which the objects appear smaller than their actual size.

PERSEVERATION: Continued repetition of words, gestures or movements.

STEREOGNOSIS: Faculty of identifying and recognizing objects perceived by the sense of touch.

TELEOPSIA: Visual dysfunction in which the objects seem to get farther and farther from the subject.

VISUO-CONSTRUCTIVE DEFICITS (constructive apraxia): Disturbance which appears in formative activities (arranging, building, drawing) and in which the spatial part of the task is missed although there is no apraxia of single movement.

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APPENDIX A

Occupational Therapy Evaluation of the Brain-damaged Adult

OCCUPATIONAL THERAPY EVALUATION OF THE BRAIN-DAMAGED ADULT

A. ORIENTATION

Definition: Awareness of self in place and time.

Materials: None.

Instructions: Ask the patient the following questions.

Self
1. What is your name?
2. What is your address?
3. When is your birthday?

Place
4. Where are you just now? (allow "in hospital").
5. How long have you been here? (allow up to 50% error).

Time
6. What day is it?
7. What month is it? (if in first 3 days of month, allow the previous month).
8. What year is it? (if January, allow the previous year).
9. What time is it? (allow up to 2 hours either way, without consulting a clock).

B. MOTOR FUNCTION

The physical assessment is a guide to the physical limitations of the patient prior to perceptual testing.

Upper Extremities

- Total paralysis, non-functional.
- Non-functional, gross movement of arm or hand.
- Functional, gross grasp and release.
- Functional, but slow, lacks fine manipulation.
- Full function.

Balance

1. Sitting.

- Poor--unable to sit unsupported.
- Fair--able to sit unsupported.
- Good--able to sit unsupported, and regain balance.

2. Standing (with or without brace).

- Poor--unable to stand unsupported.
- Fair--able to stand unsupported.
- Good--able to stand unsupported, and regain balance.

Ambulation

- Unable to walk.
- Walks with assistance--manual and/or mechanical.
- Walks with aid of mechanical assistance only.
- Walks steadily on flat ground, with supervision.
- Walks steadily on uneven surfaces.

A.D.L.

- Dependent.
- Needs physical assistance for basic tasks (dressing, washing, feeding).
- Needs supervision, and some instruction.
- Independent, but slow.
- Independent.

C. SENSORY FUNCTION

Light Touch

Materials: cotton wool.
Instructions: occlude vision, test both sides. Ask patient when and where he is being touched.

Pin Prick

Materials: opened safety pin.
Instructions: occlude vision, test both

sides. Use sharp and blunt end of pin. Ask patient to indicate whether he feels sharp, blunt or absent.

Temperature

Materials: One test tube of cold tap water, and one test tube of recently boiled hot water.

Instructions: Ask patient to distinguish between hot and cold.

D. PERCEPTUAL FUNCTION AGNOSIA

The inability to recognize familiar objects perceived by the senses.

Tactile Proprioceptive Agnosia

Stereognosis

Definition: Ability to recognize objects by sense of touch.

Materials: Safety pin, paperclip, plastic cup, quarter, cent, spoon, pencil, large screw.

Instructions: Familiarize the patient with the test objects. Occlude vision, but do not blindfold. Place an object in patient's affected hand, and ask him what the object is, then test the unaffected hand if applicable. If both hands are affected, test separately.

Note:

1. To adapt test for aphasics, use 2 sets of materials.
2. Stereognosis may be masked by sensory loss.
3. Be sure patient comprehends instructions. If you are not sure, do not score.

Sensory Suppression

Definition: If examiner simultaneously touches both of the patient's hands, the patient may perceive stimulus to hand ipsilateral to cerebral lesion, but not opposite; the same stimulus will however be felt on the contralateral side if it alone is stimulated.

Materials: None.

Instructions: Occlude vision.

1. Touch patient's left hand.
2. Touch patient's right hand.
3. Touch both hands simultaneously.

On each occasion ask patient which hand you are touching. Repeat steps 1,2,3, four times in a random order. Grade pressure of touch from light to hard. If both sides are affected score both sides separately. Record bilateral stimulus only.

Joint Proprioception

Definition: Awareness of joint position and movement.

Materials: None.

Instructions: Occlude patient's vision. Therapist then holds the part to be tested on the lateral aspect, moves the joint to the position desired, and asks the patient to copy the movement on the unaffected side.

Note:

1. Move joints in middle range only, to avoid stimulation of stretch reflex.
2. DO NOT blindfold. This test is not effective if patient's eyes are closed.

3. To occlude vision, use large sheet of cardboard, stereognosis box, etc.

Movements:
1) Thumb--extension, opposition.
2) Fingers--each in flexion, extension.
3) Wrist--flexion, supination.
4) Elbow--flexion, extension.
5) Shoulder--flexion, abduction.
6) Knee--flexion, extension.
7) Ankle--flexion, extension.
8) Toes--flexion, extension.

Body Awareness

Definition: Awareness of ones body, and the relationship of its parts. Body awareness can be divided into three areas of loss: (1) Body Concept, (2) Body Image, (3) Body Scheme.

Body Concept

Definition: The intellectual knowledge of parts of the body in relation to one another.

Materials: Six piece manikin, made of ¼" unpainted plywood.

Instructions:

(A) PUZZLE--Show patient completed manikin briefly. Ask patient to put manikin together.
Note: A person with constructional apraxia will be unable to complete this task.

(B) PARTS RECOGNITION--Ask patient to point to parts of his own body as follows (specify R./L. side) head, shoulder, elbow, hand, knee, ear, chin, ankle.

(C) R/L DISCRIMINATION--From previous test, mark appropriate responses. Ask patient to indicate R. hand of therapist, to turn head to L. side.

Body Image

Definition:	Awareness of ones body through sensation and emotion.
Materials:	Paper and pencil.
Instructions:	Ask the patient to draw a front view of a person.
Note:	A person with constructional apraxia will be unable to perform this task. (It is usual for a person to draw a mirror image.)

Body Scheme

Definition:	Awareness of the body through tactile/proprioceptive stimuli.
Materials:	A pair of gloves.
Instructions:	1. Ask patient to raise both arms. 2. Ask patient to put on gloves.

Visual Agnosia

Color

Materials:	A form board in Felt or Bristol Board.
Instructions:	Give patient 24 colored discs (2" diameter, 4 of each color) and ask him to match them to the corresponding colors on board.

Shape

Materials:	A form board with 8 shapes in Felt or Bristol Board: cross, crescent, lozenge, circle, triangle, square, star and rectangle.
Instructions:	Give patient six of these shapes to match (omitting the rectangle and crescent).

Size

Materials: Six circles of the same color (½" to 3" in diameter) from a rigid material such as plywood or thick cardboard.

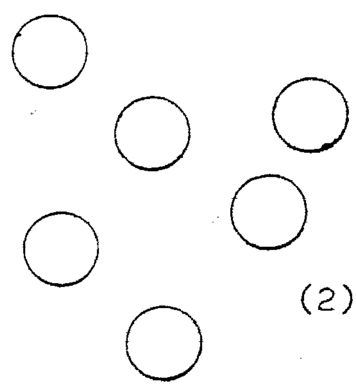
Instructions: Ask patient to line them up in sequence.

Spatial Relationships

Definition: Ability to perceive the position of two or more objects in relation to each other and to oneself.

Materials: Use 6 blocks, or familiar objects such as--cup, saucer, knife, plate, fork or spoon.

Instructions: (1) Place the objects in front of patient on table as illustrated. Ask patient to point to object as follows:



(1) nearest
(2) farthest
(3) centre
(4) left
(5) right

(2) Place one block (or object) on top of another. Ask patient to object as follows:

(1) top
(2) underneath

Figure Ground

Definition: Ability to discriminate between the prominent visual (Figure) and the unobtrusive one (Ground).

Materials: Use 2 sets of cards, (size 5" x 8") graded as to difficulty.

Set A - 4 cards, geometrical shapes superimposed.

Set B - 4 cards, common objects, superimposed.
Master form card--same shapes individuated.

Instructions: Start with set A. Therapist places one card in front of patient. Ask patient to indicate on master form which shape he perceives on this card. Repeat with other cards in turn.[1]

<u>Depth Perception</u>

Note: This is not practical to test, but the therapist should be aware of it as a possible area of deficit. Observe in walking, using stairs, etc.

<u>Apraxia</u>

The inability to perform purposeful movements without loss of understanding, motor power, coordination, or sensation.

<u>Motor Apraxia</u>

Definition: Inability to perform a given act correctly or to perform a complex series of movements over a period of time. Includes ability to plan, to assume a required position, and to transfer smoothly from one movement to another.

<u>Gross Motor Plan</u>

Materials: Box with lid, ball to fit inside.

Instructions: (1) Ask patient to raise one arm above head and close his fist.

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[1] These designs are from: Frostig, M. and Horne, D. (1964). <u>The Frostig Program for the Development of Visual Perceptions</u>. Chicago: Follett.

(2) Ask patient to open the box and remove ball.

Fine Motor Plan

Materials: (1) Device #1 - a free-moving grommet on a square shaped wire attached to a handle.
(2) Device #2 - a grommet on an irregularly curved wire.

Instructions: Ask patient to manipulate the handle so that the grommet slides along the full course of the wire. Begin with Device #1, then Device #2. Repeat twice with each hand if indicated.

Graphic

Materials: Pencil and paper.

Instructions: Therapist draws the following design and asks the patient to reproduce it.

Note: Make sure the pencil does not leave the paper. Observe for inco-ordination but score only for perseveration.

Sequence

Materials: None.

Instructions: Ask patient to strike on table in sequence, his palm, his fist, the edge of his hand. Repeat sequence 3 times.

Note: This test is to measure patient's ability to change from one movement to another.

Scoring: 0 - Unable to begin
2 - Unable to complete act
4 - Slight hesitancy~~, but~~

accurate.

Ideational Apraxia

Definition:	Inability to formulate idea or concept necessary to perform act.
Materials:	Comb.
Instructions:	(1) Ask patient to identify object. Then ask him to use it.
	(2) Ask patient to demonstrate what he would do with a tooth-brush (pretend).

Constructional Apraxia

Definition:	Inability to put together elements to form a meaningful and correct whole.

2-Dimensional

Materials:	Four designs on separate cards size 5" x 8", pencil and paper.
Instructions:	Show patient first design and ask him to reproduce it on paper. Repeat with each design in order.[1]

3-Dimensional

Materials:	Four designs on separate cards size 5" x 8". Eighteen blocks, of same color, and same size (1½" square).
Instructions:	(1) Therapist constructs a form from the blocks following design A. Ask patient to do the same. Repeat for design B.

[1] These designs are from: Frostig, M. and Horne, D. (1964). The Frostig Program for the Development of Visual Perception. Chicago: Follett.

(2) Therapist shows patient design C. Ask patient to construct a form from blocks following this design. Repeat for design D.[1]

E. CONCEPTUAL FUNCTION

Acalculia

Definition: Aphasia marked by the inability to work even the simplest mathematical problems.

Materials: Two quarters, five dimes, five nickels, five coppers.

Instructions: Ask the patient to:

(1) Identify the coins and arrange as to value.
(2) Add them up.
(3) Select 63¢ from total.
(4) (Therapist removes coins.) Mentally subtract 55¢ from $1.00.

Note: Therapist should be aware of such limitations as loss of memory span and recall. We have no specific test for this disability.

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[1] These designs are from: Frostig, M. and Horne, D. (1964). The Frostig Program for the Development of Visual Perception. Chicago: Follett.

APPENDIX B

Procedures of Physiotherapy and Occupational Therapy for the Treatment of Brain-injured Adults

Physiotherapy

1. Passive range of motion and passive stretching of the upper and lower limbs in order to prevent contractures and to develop maximal range of motion;
2. Active assisted and resisted exercises to improve impaired movements;
3. Positioning and proprioceptive neuro-muscular facilitation techniques to improve movements and to decrease spasticity;
4. Sitting and standing balance exercises;
5. Re-education of functional walking with or without a cane and/or brace;
6. Exercises to improve general function.

Occupational Therapy

1. Re-education in activities of daily living;
2. Design of ortheses to support flaccid limbs or to position spastic upper limbs;
3. Functional re-education of the affected limbs through activities that will mobilize and/or reinforce each limb segments with special emphasis on the distal upper limb;
4. Sitting and standing balance and tolerance;
5. Improvement of the coordination in the non-preferred in cases of preferred hand involvement;

6. Perceptuo-motor re-education;
7. Vocational rehabilitation including household activities;
8. Functional re-education such as outings, removal of the main architectural barriers in and near the home, etc.

APPENDIX C

Individual Results

Table 15

Raw Scores of the Right Brain-damaged Trained Subjects

Subject	Training Session									
	1	2	3	4	5	6	7	8	9	10
1	66	72	78	72	82	82	90	83	78	87
2	34	40	48	39	34	37	42	42	48	50
3	70	62	70	77	90	87	86	90	88	87
4	57	60	68	68	63	69	75	72	77	72
5	48	51	43	52	57	63	59	66	67	64
6	49	69	59	53	65	68	69	69	75	76
7	44	53	50	52	47	53	55	58	58	56
8	52	64	80	82	91	91	90	91	93	89

Table 16

Raw Scores of Left Brain-damaged Trained Subjects

Subject	Training Session 1	2	3	4	5	6	7	8	9	10
1	44	47	56	52	59	51	63	53	43	60
2	36	33	33	29	33	34	28	34	31	34
3	53	58	56	67	71	71	75	83	79	75
4	32	43	46	46	45	55	52	41	60	62
5	33	51	47	65	70	73	77	76	74	74
6	35	38	43	33	31	34	34	32	39	30
7	42	47	55	49	58	55	66	49	52	60
8	57	61	67	76	76	72	83	81	83	86

Table 17

Raw Scores of the Right and Left Brain-damaged Non-trained Subjects

Subject	Left Brain-damaged		Right Brain-damaged	
	Testing Session		Testing Session	
	1	10	1	10
1	55	66	56	63
2	50	71	45	49
3	71	87	73	78
4	73	78	49	52
5	23	26	79	85
6	25	34	72	74
7	66	75	63	80
8	42	48	43	50

APPENDIX D

Detailed Clinical Symptoms, Functional Characteristics and Visuo-constructive Deficits Symptoms for Each Subject.

Table 18

Clinical Symptoms of the Four Groups of Patients

Group	No.	A	WPO	F	S	H	MA	GA	CVD	DM
LBD trained	1	67	7	X	-	-	-	X	-	X
	2	77	7	X	-	-	-	?	-	X
	3	67	30	-	X	-	X	-	X	-
	4	73	12	X	-	-	-	X	X	-
	5	61	23	X	-	X	X	-	X	X
	6	76	11	-	X	-	-	X	X	-
	7	72	19	X	-	-	-	-	X	-
	8	51	10	-	X	-	X	-	-	-
LBD non-trained	1	51	16	-	X	-	-	X	-	-
	2	62	11	-	X	-	X	-	X	-
	3	52	6	-	X	-	X	-	X	-
	4	70	15	-	X	-	X	-	X	X
	5	44	7	X	-	X	X	-	X	X
	6	80	6	-	X	-	-	X	X	-
	7	50	13	-	X	-	X	-	X	-
	8	65	14	-	X	-	-	-	X	-
RBD trained	1	82	17	X	-	-	n.a.	n.a.	X	-
	2	62	7	X	-	X	"	"	X	X
	3	62	10	-	X	-	"	"	X	X
	4	53	8	X	-	X	"	"	X	-
	5	62	8	-	X	-	"	"	-	-
	6	68	12	X	-	-	"	"	X	X
	7	32	17	X	-	X	"	"	X	-
	8	62	14	-	X	-	"	"	-	X
RBD non-trained	1	60	7	-	X	-	n.a.	n.a.	-	-
	2	81	9	-	X	-	"	"	X	X
	3	57	7	-	X	-	"	"	-	-
	4	44	27	X	-	-	"	"	X	-
	5	63	10	X	-	-	"	"	X	-
	6	60	9	-	X	-	"	"	X	-
	7	70	10	X	-	-	"	"	X	X
	8	63	19	X	-	X	"	"	X	-

No. - subject's number; A - age; WPO - number of weeks post-onset; F - flaccidity; S - spasticity; H - hemianopsia; MA - motor aphasia; GA - global aphasia; CVD - cardio-vascular disease; DM - diabetes mellitus.

Table 19

Functional Characteristics for the Four Groups of Subjects

Group	No.	AS		ADL			EB			
		G	P	I	PD	D	NC	CR	DM	IR
LBD trained	1	-	X	-	X	-	-	-	-	X
	2	-	X	-	X	-	-	-	-	X
	3	X	-	-	X	-	-	X	-	-
	4	X	-	-	X	-	X	-	-	-
	5	-	X	-	-	X	-	-	X	-
	6	-	X	-	-	X	-	-	X	-
	7	X	-	-	X	-	-	-	X	-
	8	X	-	-	X	-	-	-	X	-
LBD non-trained	1	X	-	-	X	-	-	-	X	-
	2	-	X	-	X	-	-	X	-	-
	3	X	-	-	X	-	X	-	-	-
	4	X	-	-	X	-	X	-	-	-
	5	-	X	-	X	-	-	-	X	-
	6	-	X	-	-	X	-	-	X	-
	7	X	-	-	X	-	X	-	-	-
	8	X	-	-	X	-	X	-	-	-
RBD trained	1	X	-	-	X	-	-	-	X	-
	2	-	X	-	-	X	-	-	X	-
	3	X	-	X	-	-	X	-	-	-
	4	X	-	-	X	-	-	-	X	-
	5	X	-	X	-	-	-	-	-	X
	6	X	-	-	X	-	-	-	X	-
	7	X	-	-	X	-	-	-	-	X
	8	X	-	-	-	X	X	-	-	-
RBD non-trained	1	-	X	-	X	-	X	-	-	-
	2	-	X	-	-	X	-	-	X	-
	3	X	-	-	X	-	-	-	-	X
	4	X	-	-	X	-	-	-	-	X
	5	X	-	-	X	-	X	-	-	-
	6	X	-	X	-	-	-	-	X	-
	7	X	-	-	X	-	-	-	X	-
	8	-	X	-	X	-	-	-	X	-

No. - subject's number; AS - attention span; P - poor; G - good; ADL - activities of daily living; I - independent; PD - partially independent; D - dependent; EB - emotional behavior; NC - no change; CR - catastrophic reaction; DM - depressive mood; IR - indifference reaction.

Table 20

Visuo-constructive Deficit Symptoms in the Four Groups of Subjects

Group	No.	IRD	CN	RAA	CI	MI	Mac	Mic	P
LBD trained	1	-	n.a.	-	X	-	X	-	X
	2	X	"	X	-	X	-	-	X
	3	X	"	X	-	-	-	-	X
	4	X	"	X	X	X	X	-	X
	5	X	"	X	-	-	X	-	X
	6	X	"	X	X	X	-	-	X
	7	X	"	-	-	-	-	-	X
	8	-	"	X	-	-	-	-	-
LBD non-trained	1	X	n.a.	-	-	-	-	-	-
	2	-	"	X	-	-	-	-	-
	3	-	"	-	-	-	-	-	-
	4	-	"	-	-	-	-	-	-
	5	-	"	X	X	X	-	-	-
	6	X	"	X	X	X	-	-	-
	7	X	"	-	-	-	-	-	X
	8	X	"	X	-	-	-	X	-
RBD trained	1	X	X	-	-	-	-	-	-
	2	X	X	-	X	X	X	-	X
	3	X	-	-	-	-	X	-	X
	4	X	X	-	-	X	-	X	X
	5	X	X	-	X	-	-	X	X
	6	X	X	-	-	-	X	-	-
	7	X	X	-	-	-	-	-	X
	8	-	X	-	X	-	-	-	X
RBD non-trained	1	-	-	-	-	-	X	-	-
	2	X	X	-	X	-	-	-	X
	3	X	-	-	-	-	-	-	X
	4	-	X	-	-	X	-	-	X
	5	-	X	-	-	-	-	-	X
	6	X	X	-	-	-	-	-	-
	7	X	-	-	-	-	-	-	-
	8	X	X	-	-	-	-	-	-

No. - subject's number; IRD - incapacity to reproduce depth; CN - contralateral neglect; RAA - rounding of acute angles; CI - closing-in; MI - mirror image; Mac - macrographia; Mic - micrographia; P - perseveration.

Table 21

Perceptuo-motor Deficits in the Four Groups of Subjects

Group	No.	SS	P	S	BI	CSS	SR	FG
LBD trained	1	1	3	3	2	3	3	0
	2	1	2	2	2	1	3	3
	3	2	0	0	0	2	2	0
	4	1	0	0	3	3	3	3
	5	2	3	0	0	3	3	0
	6	2	0	0	0	0	0	0
	7	1	2	2	2	2	2	2
	8	2	3	3	3	2	2	2
LBD non-trained	1	0	1	0	1	1	2	0
	2	1	0	0	0	0	1	1
	3	2	3	3	3	2	3	3
	4	1	0	0	0	0	0	0
	5	2	0	0	0	3	3	3
	6	2	0	3	3	3	3	3
	7	1	0	0	0	0	1	1
	8	1	2	2	0	2	2	2
RBD trained	1	1	2	1	2	0	0	0
	2	2	3	3	3	3	3	3
	3	0	1	1	2	1	2	2
	4	1	2	2	2	0	0	0
	5	1	3	3	3	3	3	3
	6	2	3	3	3	2	2	2
	7	2	2	2	2	2	2	2
	8	1	0	2	2	2	2	0
RBD non-trained	1	2	0	1	0	1	1	1
	2	2	2	2	2	2	2	2
	3	2	2	2	2	2	2	2
	4	2	3	3	3	3	3	3
	5	1	3	3	2	2	2	2
	6	1	1	1	1	2	2	2
	7	2	2	2	2	2	2	2
	8	2	3	3	3	3	3	3

No. - subject's number; SS - superficial sensation; P - proprioception; S - stereognosis; BI - body image; CSS - perception of color, size and shape; SR - perception of spatial relations; FG - figure-ground discrimination.

SCALE: 0 - no impairment; 1 - slight impairment; 2 - moderate impairment; 3 - severe impairment.

NOTE: All subjects presented two-dimensional and/or three dimensional constructive apraxia or visuo-constructive deficits.

APPENDIX E

Examples of Drawing Performances

SUBJECT: 2 (LBD TRAINED)

TASK: 1.2

SYMPTOMS: INCAPACITY TO REPRODUCE DEPTH

MIRROR-IMAGE

PERSEVERATION

ROUNDING OF ACUTE ANGLES

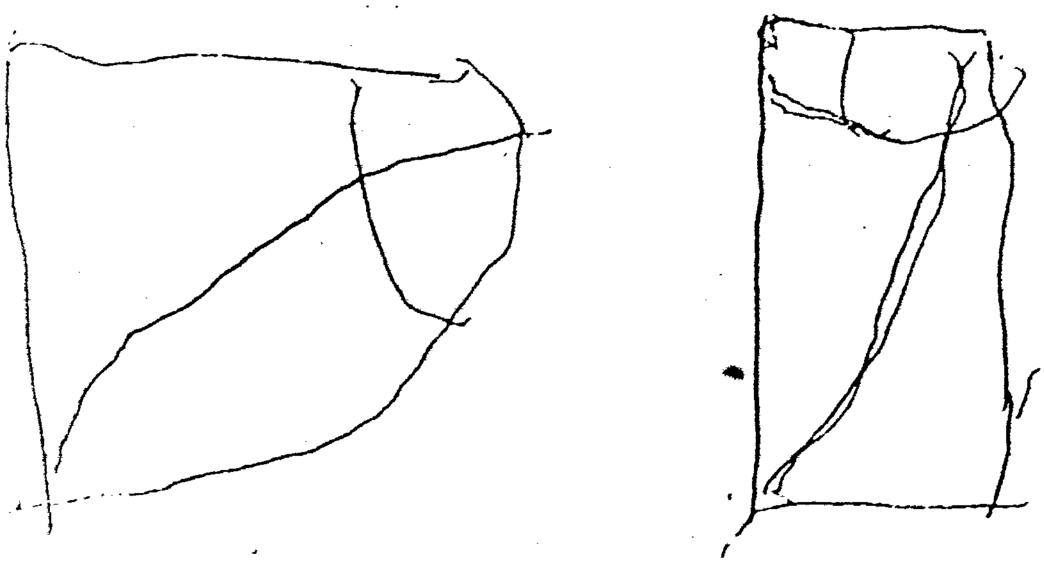

FIGURE 10

SUBJECT: 4 (LBD TRAINED)

TASK: 2.1

SYMPTOMS: MIRROR-IMAGE
ROUNDING OF ACUTE ANGLES

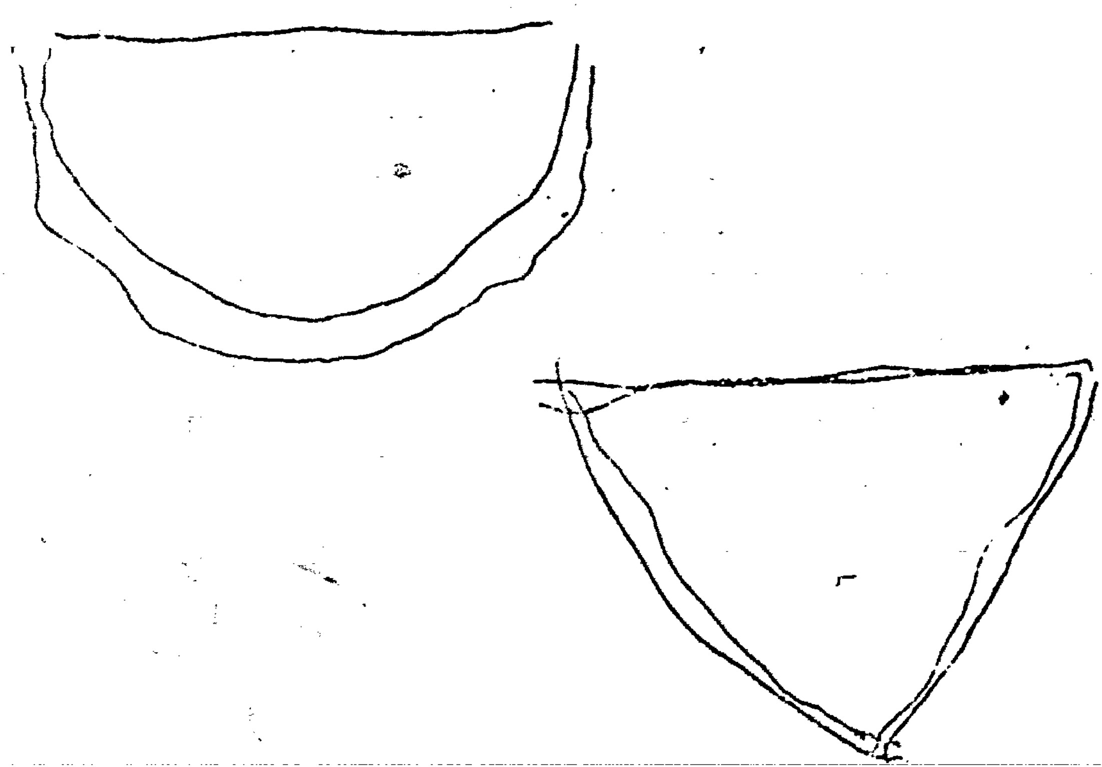

FIGURE 11

SUBJECT: 5 (LBD NON-TRAINED)

TASKS: 1.1 AND 2.1

SYMPTOMS: ROUNDING OF ACUTE ANGLES
MIRROR-IMAGE
PERSEVERATION

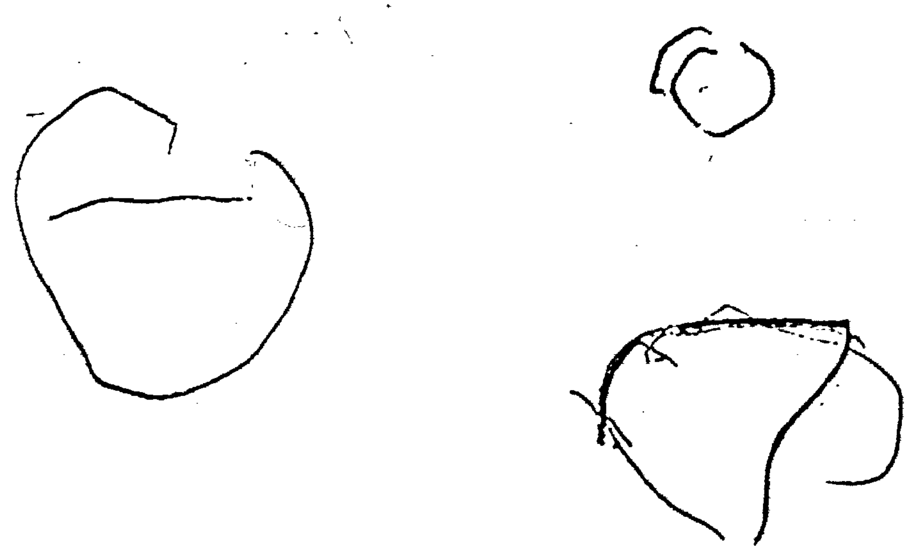

FIGURE 12

SUBJECT: 8 (LBD NON-TRAINED)

TASK: 2.2

SYMPTOMS: ROUNDING OF ACUTE ANGLES

MICROGRAPHIA

FIGURE 13

SUBJECT: 2 (RBD TRAINED)

TASK: 1.1

SYMPTOMS: MACROGRAPHIA

CONTRALATERAL NEGLECT

PERSEVERATION

FIGURE 14

SUBJECT: 2 (RBD NON-TRAINED)

TASK: 2.3

SYMPTOM: CONTRALATERAL NEGLECT

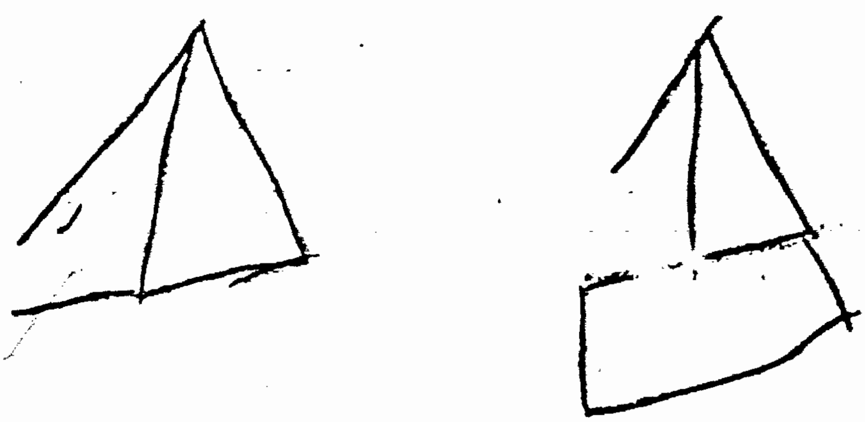

FIGURE 15