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# The Differential Effects of Unilateral Versus Bilateral Cerebral Lesions on Performances Involving Comparable Visual and Auditory Tasks

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# THE DIFFERENTIAL EFFECTS OF UNILATERAL VERSUS BILATERAL CEREBRAL LESIONS ON PERFORMANCES INVOLVING COMPARABLE VISUAL AND AUDITORY TASKS

BY
MICHAEL G. JOHNSON
B.S., Northern Michigan University, 1967

THESIS

Submitted in Partial Fulfillment of the
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Finally, I dedicate the work contained herein to my wife Audrey, as partial reciprocation for her enduring love and support throughout the project, and to our first-born, Kristine Elizabeth, whose presence and development represent one of our ultimate goals in life.

M. G. J.

# THE DIFFERENTIAL EFFECTS OF UNILATERAL VERSUS BILATERAL CEREBRAL LESIONS ON PERFORMANCES INVOLVING COMPARABLE VISUAL AND AUDITORY TASKS

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ABSTRACT OF THESIS

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The present research was directed toward gaining a clearer understanding of the relationships between the location of brain injury and relative auditory and visual input abilities of adults by submitting selected subjects to comparable procedures requiring the auditory and the visual input of stimuli.

Two tests, the Geometric Figures Test (GFT) and the Token Test (TT), were developed as a means of obtaining measures of auditory input ability and visual input ability. Each test contains separate auditory and visual batteries. The two batteries of each test are similar in all respects except for the mode of input used for each battery.

In addition to the GFT and the TT, several other tests were included in the test battery: (1) the Peabody Picture Vocabulary Test (PPVT), (2) the Columbia Mental Maturity Scale (CMMS), and (3) the Porch Index of Communicative Ability (PICA).

Four groups of subjects were exposed to the experimental procedures: subjects with lesions of the left cerebral hemisphere, the right cerebral hemisphere, bilateral cerebral lesions, and control subjects in whom cerebral pathology had been ruled out. There were no significant differences between the groups on the variables of age, educational level, and number of weeks between onset of injury and testing. Peripheral defects of visual acuity and auditory sensitivity were ruled out.

Results indicate that the auditory and visual input abilities of brain-injured adults are affected differentially, depending upon the hemispheric location of the cerebral lesion(s). In addition to differences between groups on test scores, differences were also shown between groups on response latency. Results also provide information related to prognosis for recovery of language abilities following brain injury.

The results are discussed in relation to previous findings, their immediate clinical implications, and in relation to needs for continuing investigations. It is concluded that sub-populations do exist among brain-injured adults in terms of auditory and visual input abilities, and that a major task for future research should be to further define the nature of post-traumatic input ability deficits and their relationships to language rehabilitation.

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# CHAPTER I

## INTRODUCTION

During the last decade there has been a growing interest in the differential effects of brain damage on adult behavior. Although progress has been made in the development of test instruments capable of detecting relatively gross psychological changes following brain damage, fewer advances have been made in the detection of specific effects of brain damage.

Among the more common symptoms associated with injury to relatively central brain structures is the communication disorder of aphasia. Non-functional impairment in the reception, manipulation, and expression of symbolic content generally results from lesions to the left hemisphere of the brain, and because of its dramatic nature, has been the subject of many clinical investigations (Osgood and Miron, 1963). Such studies have often examined the effect of cerebral damage on the various communication modalities such as visual, auditory, or tactile input, and gestural, verbal, or graphic output. It is only recently, however, that there have been some efforts to explore the visual-auditory modality relationship with respect to various locations of brain damage.

Of interest to the present research are Porch's

(1967) observations relative to the differences between patients with unilateral brain damage and patients with bilateral brain damage. Extensive clinical testing of brain-injured adults was conducted using the Porch Index of Communicative Ability (Porch, 1967). Profiles of test results reveal several differences between patients with left hemisphere lesions and patients with bilateral lesions. The most consistent difference between these patients is the reversal of relationships between auditory and visual task scores when the same test items are used and similar tasks are required of the subjects. The bilaterally damaged patients find the visual matching tasks more difficult than the auditory tasks; the left hemisphere damaged patients find the auditory tasks more difficult than the visual matching tasks.

These observations would appear to be supported by Schuell (1964). On the basis of results obtained on the Minnesota Test for Differential Diagnosis of Aphasia, five general patterns of responses were observed. Patients were then classified (by groups) according to their particular patterns of responses. Group 4 was the only group containing patients with bilateral findings reported on neurological examinations. Visual involvement was found to be a major characteristic of this group. Also, Schuell found that in this group ". . . the highest percentage of improvement (following treatment) was made on tests for auditory comprehension . . ." (Schuell, 1964, p. 292).

Stark (1961) has added additional support to the suspected differential effects of brain damage on input modalities. She found that subjects with left hemisphere damage performed significantly poorer on tasks requiring auditory input than subjects with right hemisphere damage or control subjects; subjects with right hemisphere damage performed significantly poorer on tasks requiring visual input than either subjects with left hemisphere damage or control subjects.

Other studies have also noted changes in auditory and visual input abilities following brain damage. Deutsch and Zawel (1966) in comparing the visual and auditory perceptual functions of brain-injured and normal children found that auditory abilities of the brain-injured group were significantly poorer than those of the control group. This study did not differentiate between right, left, and bilaterally damaged subjects.

The literature provides varied evidence to suggest that brain damage does affect the visual and auditory input modalities differentially. This evidence is more definitive when the site of brain damage is taken into consideration. However, the specific relationship between site of brain lesions and the auditory-visual modality ability remains unclear.

Although Porch (1967) has observed consistent differences in the performances of unilaterally damaged patients and bilaterally damaged patients on auditory and visual tasks, subjects of his study were not grouped by site of lesion. Separation of the unilaterally damaged patients into groups of subjects with left hemisphere lesions and subjects with right hemisphere lesions would contribute to a better understanding of these relationships. It would also be interesting to compare the performances of pathological groups to the performances of a normal control group. Similarly, the inclusion of subjects with bilateral lesions in Stark's (1961) research would have provided another point of comparison in viewing the effects of cerebral lesions upon auditory and visual input abilities.

Another point of interest in Stark's research is that the subjects were required to provide verbal responses to the auditory tasks and graphic responses to the visual tasks. In addition to aphasic disturbances which are commonly associated with lesions of the left cerebral hemisphere, it is not uncommon for motor involvement to be present on the right side of the body, thereby reducing the efficiency of graphic output abilities or, in more extreme cases, making it necessary to attempt graphic output with the left hand. From these observations, the possibility arises that the scores of certain subjects contained in her research may have been affected by the output modalities selected for task completion; the adequacy of their responses may have been reduced due to impairment of the verbal and/or graphic output modalities.

A major limitation of Deutsch and Zawel's (1966) study is that no attempt was made to define the nature of brain damage in their subjects although there is considerable evidence which suggests that the performance of brain-injured individuals is influenced by location, dynamics, and etiology of cerebral lesion (Andersen, 1951; Andersen and Hanvick, 1950; Fisher, 1958; Reitan, 1955; Semmes, Weinstein and Teuber, 1954).

A review of the literature suggests that the auditory and visual input modalities may be affected differentially depending upon the site of brain damage, but presently available information does not adequately define these relationships. Of critical importance, then, is the need to submit these relationships to comprehensive investigation.

If auditory and visual input abilities are affected differentially by the location of brain injury, knowledge of these differences would be of importance to both future research and to the speech clinician. The outcome of research is highly dependent upon the control of influencing variables. Treatment of an adult brain-injured population as homogeneous, if in fact differences between visual and auditory input abilities do exist, may lead to inconclusive or possibly erroneous results. Similarly, a lack of such knowledge may limit a speech clinician's ability to determine prognoses, and to plan effective treatment programs for brain-injured adults with aphasia.

## Objectives of the Study

This research was directed toward examining the relationships between the site of brain injury (right, left, and bilateral) and relative efficiency of the visual and auditory input modalities, since existing literature suggests that subjects with left hemisphere lesions experience comparatively greater difficulty on tasks involving auditory input, whereas subjects with either right hemisphere lesions or subjects with bilateral lesions experience comparatively greater difficulty on tasks involving visual input.

It was hypothesized that these particular relationships do exist, and that a better understanding of these relationships might be attained by careful attention to procedures and the selection of appropriate tests requiring the input of auditory and visual stimuli.

The major procedural steps were as follows: (1) the selection of comparable tasks requiring auditory input of stimuli and tasks requiring visual input of stimuli, but which would require minimal output on the part of the subject; (2) the selection of four groups of subjects, those with confirmed injury to the left cerebral hemisphere, to the right cerebral hemisphere, to both hemispheres, and normal control subjects; (3) the analysis of the effects of location of brain injury upon test results obtained by subjects on auditory and visual tasks; and (4) the exploration of relationships between patient variables and the obtained auditory and visual task scores.

# CHAPTER II

# METHODS AND PROCEDURES

The basic objectives of this project were as follows: (1) to select and develop comparable input tasks for each of two modalities, auditory and visual; (2) to standardize procedures for administration and scoring of all tests used; (3) to select subjects in a manner which would provide maximal control of those variables considered critical to this project; (4) to examine the relationships among patient variables and obtained test results; and (5) to analyze the differential effects of site of lesion on the auditory and visual input abilities of the selected subjects.

## Selection of Auditory and Visual Input Tasks

Four tests of input ability were included in the battery administered to all subjects. These tests were the *Geometric Figures Test* (GFT), the *Token Test* (TT), the *Peabody Picture Vocabulary Test* (PPVT), and the *Columbia Mental Maturity Scale* (CMMS). In addition, the *Porch Index of Communicative Ability* (PICA) was included in the present battery to quantify the communication abilities of all subjects.

## Geometric Figures Test

The Geometric Figures Test (GFT) was developed here to provide measures of auditory and visual input ability utilizing tasks which were assumed to be parallel in terms of difficulty for each of the two modalities.

The GFT included four subtests requiring the auditory input of stimuli and four subtests requiring the visual input of stimuli. The four subtests contained in each battery were ordered by increasing task difficulty. Each successive subtest was more difficult than the previous subtest because of the increasing complexity of the stimulus items, thereby providing a measure of input ability along a selected continuum.

### Input Tasks

The tasks included in the GFT revolved around five basic figures (cross, square, circle, triangle, and an X) and five basic colors (red, green, blue, black, and yellow). The primary criteria for selecting the test items were that they be: (1) common to the experiences of both sexes; and (2) relatively unaffected by age or educational level of the subjects.

Each of the geometric figures was mounted on three-inch square cards; both the figures and the cards were composed of the five basic colors. To avoid undue familiarity with any of the variables of figure, figure color, and card color, the various combinations used were alternated throughout the entire test.

<u>Auditory Battery</u>. Each of the four subtests constituting the auditory battery of the GFT required ten responses from the subject for a total of forty responses. For each of the four subtests, the subject was presented with a different array of ten geometric figures. They were placed before him in a predetermined standard arrangement as shown in Figure 1. The subject responded by pointing to one of the ten geometric figures. The auditory stimuli were named by the examiner. They consisted of highly specific information (e.g., "blue square, on yellow").

The following is a brief description of the auditory subtests (see Appendix A for complete descriptions of each subtest which illustrate the progression of difficulty for this battery).

Auditory Subtest 1. A sample stimulus is "red X, on green." In order to choose the correct response item from the ten which are before him, the subject need only recognize two basic features, figure color and figure <u>or</u> figure and card color, since none of these possible combinations were duplicated.

Auditory Subtest 2. A sample stimulus is "red cross, on blue." On this subtest, the subject's choices are limited to more specific detail, since each of the geometric figures is duplicated in color. In order to select the correct response item, the subject must recognize the figure or figure color <u>and</u> the card color. This task involves essentially two features, but is somewhat more complex since it is more specific or limited in available choices. He must choose from among ten possible items.

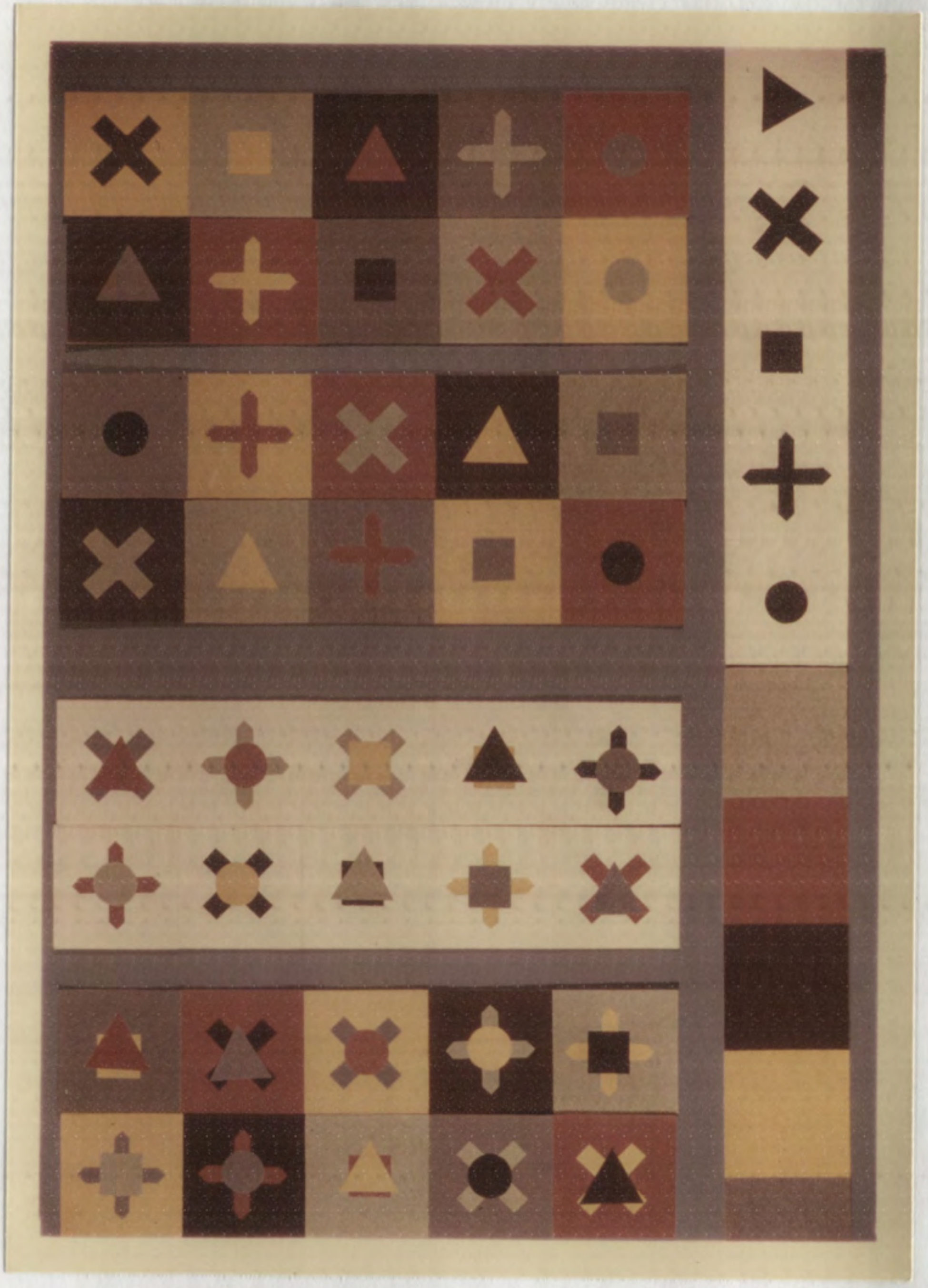


Figure 1. Standard Arrangement of Test Items for the Geometric Figures Test, Auditory and Visual Batteries.

Auditory Subtest 3. Unlike the other subtests, all ten cards on this test are white; however, two geometric figures are presented on each of the cards. A sample stimulus is "yellow circle, on black X." Essentially, only two basic features must be recognized as in the previous tests; however, the number of combinations available was increased to twenty and made appropriate selection of the response item more difficult. For example, comprehension of "yellow circle" would have been sufficient to complete the task, since, although other circles were present, none of the others were of the same color; yet the inclusion of a background figure introduced a distracting element.

Auditory Subtest 4. This test is similar to Auditory Subtest 3, in that two geometric figures are present on each of the ten response items. Here, however, the cards are of different colors, thereby introducing another distracting element. A sample stimulus item is "black circle, green X, on blue card." Here, as in previous subtests, the subject need only recognize two basic features, the color and type of one figure, in order to successfully complete the task, since none of the figure-color combinations were duplicated. The primary difficulty, then, was in the number of distracting elements present.

Visual Battery. The visual battery of the GFT was constructed so as to insure its comparability with the auditory battery in all possible respects including the response materials used, order of presentation, other test procedures, and the number of required responses. This battery differed from the auditory battery in that only visual stimuli were used to elicit responses from the subjects, as opposed to the auditory stimuli (the naming of items) used in the auditory battery.

The stimuli for the visual battery consisted of a duplicate set of geometric figures which were presented in the standard order specified for administration of the auditory battery. To control for temporal differences in the presentation of auditory and visual stimuli, each stimulus was presented for a length of time equal to the time necessary to present its auditory counterpart. The respective amounts of presentation time for each subtest were determined by recording the amount of time necessary to present each auditory stimulus over twenty trials. The mean time for the twenty trials was computed and used as the standard presentation time for the auditory and corresponding visual stimuli.

Standardization of Procedures

Standard testing procedures were maintained throughout the administration of each test, since a lack of standardized procedures has often proven to be a critical problem in brain damage research (Haynes and Sells, 1963). A thorough discussion of this problem here is unnecessary since the subject has received extensive treatment elsewhere (Porch, 1967, Vol. I).

The administration of the test battery had only one requirement with respect to the sequencing of tests. Either the PICA or CMMS and PPVT must have been administered prior to the administration of the primary auditory and visual input tasks, the GFT and the TT. This particular sequence provided two additional advantages: (1) it provided an opportunity for the subject to become familiar with the testing environment, and (2) it served as an opportunity for the examiner to make rather extensive observations of the subject regarding his stamina and his peripheral auditory sensitivity and visual acuity.

Due to the length of the test battery, the testing of most subjects was carried out in three sessions, with no less than one half day and no more than one week separating each of the three sessions. A number of control subjects preferred to take more than the usual number of tests during one session, since it was possible for them to complete the tests in a relatively shorter period of time. The sequence followed for most subjects was: (1) the PICA; (2) the CMMS and PPVT; and (3) the GFT and TT.

Standard Test Conditions. The GFT was administered in a test environment which was uninterrupted by distracting auditory or visual stimuli. The subject was seated at a table directly across from the examiner in order that the examiner could keep the visual stimuli out of the subject's view prior to the standard presentation of each stimulus item. This seating arrangement also assisted the examiner in presenting the visual stimuli in a direct line of vision for the subject. Particular care was taken to assure that the lighting of the test environment was adequate to show the various colors of the test items clearly. Items were administered according to directions specified in the test format shown in Appendix A.

Standard Placement. Response items for each subtest of the GFT were randomly ordered and were permanently fixed on two 3" by 15" display cards to assure standard placement of all items during the testing of all subjects. There were eight such cards with five items on each card.

Testing Procedures. Both the Geometric Figures Test and the Token Test were administered during one testing session In all cases, the GFT was administered first.

In order to determine each subject's ability to discriminate form and color, the GFT was preceded by a preliminary screening test. This test was composed of the figures and colors used throughout the GFT. The figures (triangle, cross, square, circle, and an X) were all constructed out of black material and were mounted on white, three-inch square cards. The five colors (blue, red, yellow, black, and green) were each represented by individual three-inch square cards. These ten items were placed before the subject and he was given the following instructions:

> Can you see all of these cards? (Gesture) I will either name one of them or show you one of them. As I do this, touch the one in front of you that matches it. Are you ready?

Once the subject had been instructed, each of the ten items was presented once using an auditory stimulus and once using a visual stimulus, thus making a total of twenty required responses. This assured that both the figures and the colors were recognizable both visually and auditorily. The presentation of stimuli was alternated (visual, auditory, visual, auditory, etc.) to minimize practice effects which might have occurred had all ten items been presented through one modality in a consecutive order.

Following the preliminary screening test, the examiner proceeded in standard order, according to the format for the GFT which is shown in Appendix A. For each subtest, the instructions were given to the subject and he was given adequate time to respond. If the subject requested a repetition, gave no response for 30 seconds, or if the subject's responses were inappropriate, thus indicating he had not understood the instructions, the same instructions were repeated. If similar circumstances arose following a repetition, the subject was given a cue. Each of the subtests were administered in this manner unless the subject rejected the remainder of that subtest. Under these circumstances, the subtest was terminated in favor of the subtest which followed.

<u>Test Scoring</u>. The method of scoring used was the PICA multidimensional system of scoring (Porch, 1967).

Appendix B shows the 15 categories used for this project. Except for the omission of category 16, which was not applicable since it describes complex responses, the system was the same as that of the PICA.

Each of the subjects' 80 responses to the GFT were judged on the basis of this scoring method and recorded in the appropriate cell of the score sheet which is shown in Appendix C. In addition to being used for scores, this sheet was used to record the starting time of each test and the completion time of each subtest.

At the completion of the GFT, several scores were computed: (1) the mean of each subtest for the auditory and visual batteries; (2) the mean for the auditory battery based upon scores obtained on the four auditory subtests; (3) the mean for the visual battery based upon scores obtained on the four visual subtests; (4) the total amount of time taken to complete the auditory battery; and (5) the total amount of time taken to complete the visual battery.

## Token Test

The Token Test (TT) was originally developed by DeRenzi and Vignolo (1962) as a method of detecting slight auditory disturbances in aphasic patients. In a recent validation study (Orgass and Poeck, 1966), this test was found to have a discrimination power which correctly selected 84 per cent of the aphasic subjects while only four per cent of the non-aphasic subjects were incorrectly classified as aphasic. These figures indicate that the discrimination power of the TT is considerably better than most tests of a similar nature. For other single tests, the average rate of prediction is 71 per cent, and this figure drops to 62 per cent when authors' cutting scores are used (Spreen and Benton, 1965). In addition, Orgass and Poeck found that the performances on the TT were largely independent of the variables of age, sex, educational background, and behavioral defects in non-aphasic brain-damaged subjects. On the basis of these favorable characteristics, the Token Test was selected as part of the current test battery.

The original Token Test presented by DeRenzi and Vignolo contains five parts which become progressively more difficult by requiring the subject to respond to an increasingly complex auditory stimulus. The materials for this test consist of two types of tokens: circles and rectangles. There are two sizes of each token. Each type and size of token is represented in five colors (red, blue, yellow, green, and white), thus making a total of twenty tokens.

The following contains a brief description of the TT as presented by DeRenzi and Vignolo:

Part One. Large circles and large rectangles only are placed before the subject in two rows, but with no further ordering specified. The subject is instructed to pick up each of the ten tokens as they are named by the examiner, and to put each one back in its place following his chosen response. For successful completion of these ten tasks, the subject must identify two basic features: color and type of the token (e.g., white rectangle).

Part Two. All twenty tokens are placed before the subject in a specified order (DeRenzi and Vignolo, 1962, p. 670). The subject is instructed to pick up a series of ten tokens as they are named by the examiner, and to return each to its place following his chosen response. Here the subject must identify three specific characteristics in order to select the correct token: size, color, and type of token (e.g., small white rectangle).

Part Three. The small tokens are removed from the testing surface leaving only the ten large tokens. Now the subject is requested to pick up and replace two of the tokens as they are named by the examiner. Ten responses are required. To successfully complete these tasks, the subject must identify four specific features: the color and type of two tokens (e.g., white rectangle and blue circle).

Part Four. All twenty tokens are placed before the subject as in Part Two, and the subject must identify two tokens for each of ten trials by picking them up and replacing them in their respective positions. To complete these tasks, the subject must identify six distinctive features: the size, color, and type of two tokens (e.g., small white rectangle and large blue circle).

Part Five. Only the large tokens are placed before the subject, with the large rectangles in the first row and the large circles in the second row, but with no particular rule for the distribution of colors. The stimuli for this part of the test include grammatical particles or other complex syntactical structures. A sample of the stimuli for this part of the test states, "After picking up the green rectangle, touch the white circle" (DeRenzi and Vignolo, 1962, p. 672).

Information regarding the exact sizes of the figures was not available. However, using DeRenzi and Vignolo's illustration (1962, p. 670) as a guide, the circles and rectangles were duplicated, but to a proportionately larger size. The sizes used for this project were as follows: small circles, 2-1/4 inches in diameter; large circles, 3 inches in diameter; small rectangles, 1-3/4 inches by 3 inches; large rectangles, 1-3/4 inches by 5-1/4 inches. The colors of the figures used were the same as those used in the original Token Test (i.e., red, yellow green, white, and blue). Response figures were mounted on two separate display cards. These cards were light gray in color, a color which did not seem to distort the appearance of the figure colors. Figure 2 shows the final arrangement of the various response items.

Several modifications of the original Token Test were necessary to establish standard procedures for the administration of parallel tasks utilizing visual input only, i.e., visual tasks which differ from the auditory tasks only in the mode of presenting the stimuli. DeRenzi and Vignolo do not specify an order of presentation for the materials within each part of the TT, so standard procedures were developed here. Secondly, Part Five of the original Token Test was omitted because the introduction of complex parts of language as an auditory task makes the construction and administration of parallel visual tasks virtually

Figure 2. Standard Arrangement of Test Items for the Token Test, Auditory and Visual Batteries.

impossible. The third modification changed DeRenzi and Vignolo's requirement that the subjects respond by picking up and replacing each item. Present usage substituted touching each item. In this manner, task complexity was reduced and subjects with motor involvement could respond more easily.

Input Tasks

The tasks used throughout the Token Test were adapted from those presented by DeRenzi and Vignolo (1962).

For each of the auditory subtests, the subject was required to give ten responses or a total of 40 responses to auditory stimuli. The stimuli for this test were preceded by a carrier phrase, "Touch the . . .," which served as a cue to the forthcoming stimulus.

The visual battery of the Token Test was constructed in a manner which paralleled the auditory battery as closely as possible. Stimulus materials were identical to the response items before the subject.

Temporal differences between the presentation of auditory and visual stimuli were controlled for by presenting the visual stimuli for periods of time corresponding to each of their auditory counterparts. Each test item was presented for two seconds on subtest one, two seconds on subtest two, three seconds on subtest three, and four seconds on subtest four.

To achieve a similar effect to the cue provided by the carrier phrase used in the auditory battery, each of the visual stimulus cards was presented in a two-step sequence, exposing the reverse side of the card first, then the side containing the respective token, thus alerting the subject to the forthcoming information. The reverse side of the card was presented for one second and the side containing the token was presented for the remainder of the allotted time.

## Standardization of Procedures

Standard Test Conditions. The TT was administered in an environment which was uninterrupted by distracting auditory or visual stimuli. The subject was seated at a table directly across from the examiner in order that the examiner could keep the visual stimuli out of the subject's view, and in order that the visual stimuli could be presented in a direct line of vision for the subject. Seating was arranged so that there was always a blank wall behind the examiner. Particular care was taken to assure that the lighting of the test environment was adequate to show the various colors of the test items clearly.

Standard Placement. Response items of the TT were mounted on cards using the ordering suggested by DeRenzi and Vignolo (1962). Two cards were necessary: one with the ten large tokens only, and one with all twenty tokens. Permanent fixing of the response items guaranteed standard placement of items during the testing of all subjects.

A standard format for test administration was followed. The entire test format is given in Appendix D.

Testing Procedures. Following completion of the GFT, each subject was given a brief rest period. The examiner then proceeded in standard order according to the test format for the TT. If the subject requested a repetition, gave no response for 30 seconds, or if the subject's responses were inappropriate, the instructions were repeated. If similar circumstances arose following a repetition, the subject was given a cue. Each of the subtests was administered in this manner unless the subject failed to respond after three test items had been attempted, or unless the subject rejected the remainder of that subtest. Under these circumstances, the subtest was terminated in favor of the subtest which followed.

The alternation between input modalities (four auditory subtests and four visual subtests of the GFT; four auditory subtests and four visual subtests of the TT) allowed each subject the opportunity to attain success at some point during this battery, hence motivating him to continue. Verbal encouragement was given only between subtests.

Test Scoring. The multidimensional system of scoring adapted from the PICA (Appendix B) was employed for the TT. The following scores were computed: (1) the mean of each subtest in the auditory and visual batteries; (2) the mean for the auditory battery based upon the four auditory subtests; (3) the mean for the visual battery based upon the four visual subtests; (4) the total amount of time taken to complete the auditory battery; and (5) the total amount of time taken to complete the visual battery.

## Peabody Picture Vocabulary Test

The Peabody Picture Vocabulary Test (PPVT) was developed by Dunn (1965) to provide an estimate of a subject's hearing vocabulary. One of the advantages of this test is that it does not require a verbal response from the subject. For this reason it is appropriate for use with subjects who have problems with verbal output. The PPVT was included in the present test battery as a measure of auditory input ability. Standard procedures for administration of this test suggested by Dunn were altered for the present project. Rather than observing the ceiling criteria, all 150 items of the test were administered, which allowed for a greater number of observations to be made on each of the subjects, including the amount of time necessary to complete the test.

Standardization of Procedures

Standard Placement. The items for the PPVT were placed at a distance which provided for easy viewing and which was within the visual fields of the subjects.

Test Format. The general suggestions offered by the author of the PPVT relating to placement of test items and instructions to the subject were followed.

Testing Procedures. Both the CMMS and the PPVT were administered during one session. For each test, the subject was informed that the entire test would be administered and that the initial items would be very easy, but that they may become quite difficult near the end of the test. Each subject was urged to do his very best.

The 150 items of the PPVT are conveniently bound into booklet form. The author of this test states that only one frame at a time should be exposed to the subject as the examiner presents the stimulus item. In cases where the subjects were well oriented and physically capable, this procedure was not followed since many subjects preferred turning the pages by themselves. It was felt that this deviation from suggested procedures would not influence test results to any great degree. Furthermore, this had the advantage of allowing them to set their own pace and thereby expose another dimension of behavior.

_Test Scoring_. Scoring of this test was based upon the methods suggested by its author, whereby a checkmark indicated correct responses, and for incorrect responses the number of the item selected was recorded. In addition, a record of time was kept by recording the starting time and the time at the completion of each 50 items.

Columbia Mental Maturity Scale

The _Columbia Mental Maturity Scale_ (CMMS) is described as a method of obtaining an estimate of the intellectual ability of children in the mental range from three to twelve years. Since it requires only a pointing response, the CMMS is particularly suitable for use with subjects having serious verbal or motor involvement (Burgemeister, Blum, and Lorge, 1954). Some research has indicated that the CMMS is an appropriate test for use with brain-injured adults (Boone, 1959; Shontz, 1957), although it usually has been employed for the purposes of obtaining an estimate of intelligence. For this project, the CMMS was used primarily to obtain a measure of visual input ability, since visual input is the basic requirement for completion of the tasks contained in the test.

Standardized procedures for administration were followed. In addition to the general suggestions offered by the authors of the CMMS relating to the placement of test items and instructions to the subjects, the amount of time necessary to complete each block of 20 items was recorded to the nearest minute.

The CMMS directions indicate that the examiner is to expose each test card for the subject. Here, however, all cards were placed before the subject and he was given the freedom to advance at his own pace. In cases where subjects had difficulty in adapting to the tasks, or in cases where they were physically unable to handle the test items efficiently, the items for the CMMS were presented by the examiner.

### Porch Index of Communicative Ability

Many brain-injured adults experience specific deficits in language abilities. For this reason, the Porch Index of Communicative Ability (PICA) was included in the test battery. The PICA quantifies the levels of deficit in the primary input and output modalities and establishes the overall level of communication deficit for each subject. The PICA has been shown to be an instrument capable of accomplishing these tasks with a high degree of reliability. The PICA also contains certain subtests designed to measure auditory and visual input abilities of subjects, and therefore provided additional information relating to these specific abilities of the subjects.

Standard procedures suggested by the author for administration of the PICA were followed in this study.

## Selection of Subjects

Sixty subjects were included in the sample. These subjects composed the following four groups: (1) 15 subjects with injury confined to the left cerebral hemisphere; (2) 15 subjects with injury confined to the right cerebral hemisphere; (3) 15 subjects with injury to both cerebral hemispheres; and (4) 15 subjects with no injury to either cerebral hemisphere.

All experimental subjects were currently receiving outpatient treatment at one of the following Albuquerque, New Mexico, rehabilitative facilities: (1) the Veterans Administration Hospital; (2) the Rehabilitation Center, Inc.; or (3) Bataan Memorial Methodist Hospital. The majority of control subjects were inpatients at the Veterans Administration Hospital.

Criteria for accepting the three experimental samples were as follows:

1. The subject must have been medically diagnosed as having suffered some form of brain injury.

2. The location of the brain injury must have been clearly demonstrated.

3. Only patients who were physically unable to tolerate testing procedures, or who were unwilling to participate in the procedures were excluded from the experimental sample.

Control subjects were selected by the following criteria:

1. There must be no known history of cerebral involvement.

2. Only subjects who were unwilling to participate in the testing procedures were excluded.

A description of the characteristics of each subject is presented in Appendix E. The experimental groups contained 42 males and 18 females, which included 58 Caucasians and two Negroes.

The left hemisphere lesion group ranged in age from 24 years to 66 years with a mean age of 50.33 years. Educational levels ranged from seven years to 16 years with a mean of 11.73 years. The number of weeks between the onset of illness and testing ranged from one to 174 weeks with a mean of 60.53 weeks.

The right hemisphere lesion group ranged in age from 19 years to 74 years with a mean age of 54.53 years. Educational levels ranged from four years to 16 years with a mean of 10.33 years. The number of weeks between the onset of illness and testing ranged from two to 102 weeks with a mean of 38.93 weeks.

The bilateral hemisphere lesion group ranged in age from 19 years to 82 years with a mean age of 53.93 years. Educational levels ranged from four years to 16 years with a mean of 9.66 years. The number of weeks between the onset of illness and testing ranged from one to 196 weeks with a mean of 45.20 weeks.

The control group ranged in age from 22 years to 67 years with a mean age of 44.13 years. Educational levels ranged from three years to 18 years with a mean of 10.60 years.

The means, standard deviations, and ranges of the variables of age, education, and number of weeks post-onset (WPO) is shown in Appendix E. The distribution of each group on these variables is also shown in Appendix E. There were no significant differences between the groups on these three variables: age, education, and weeks post-onset.

# CHAPTER III

## RESULTS

The major findings of this study support earlier observations that subjects with left hemisphere brain lesions obtain comparatively lower scores on auditory input tasks than on visual input tasks, while the reverse is true for subjects with right hemisphere lesions or subjects with bilateral lesions.

The second major finding is that, while subjects with bilateral brain lesions tend to demonstrate less communication ability (for all input and output modalities measured by the PICA) than each of the other groups, subjects with left hemisphere lesions obtained lower scores than the bilateral lesion group on auditory input tasks of the GFT and the TT.

The variable of time was also found to differentiate between certain groups of subjects. Left hemisphere lesion subjects consistently required more time to complete auditory input tasks than either right hemisphere lesion subjects or controls. Bilateral lesion subjects required significantly more time to complete both auditory and visual input tasks than either right hemisphere lesion subjects or controls. No significant differences were found between right hemisphere lesion subjects and controls on the variable of time.

The observed relationships between groups on all auditory and visual input tasks are presented below.

## Results of the Geometric Figures Test

### Stability of Test Scores

Both the Geometric Figures Test and the Token Test, as used in this study, were previously unproven tests. Therefore, a test-retest study was conducted with the GFT and TT, using a sample of ten subjects, in order to assure that differences between groups would not be due to error of measurement. The sample included two control subjects (4, 15), three subjects with left hemisphere lesions (3, 6, 8), three subjects with right hemisphere lesions (3, 5, 9), and two subjects with bilateral lesions (2, 5). A summary of these patients can be seen in Appendix E.

The scores obtained from the test-retest study were analyzed, using Pearson's product-moment correlation coefficient (Cooper, 1967). The results are summarized in Table 1. From this table, it can be seen that the stability coefficients of subtests on the GFT ranged from 0.88 to 0.99. This stability was felt to be sufficiently high to allow for more extensive analysis of obtained data. A matrix showing correlation coefficients between all values obtained in this study can be seen in Appendix F.

Table 1. Coefficients of Correlation for Test-Retest Stability on the Geometric Figures Test.

| Variable | Mean Test 1 | Mean Test 2 | Difference (high-low) | r |
|---|---|---|---|---|
| Auditory Subtest 1 | 13.10 | 13.36 | 0.26 | 0.99** |
| Auditory Subtest 2 | 12.84 | 12.76 | 0.08 | 0.99** |
| Auditory Subtest 3 | 12.30 | 12.18 | 0.12 | 0.98** |
| Auditory Subtest 4 | 12.04 | 11.78 | 0.26 | 0.99** |
| Auditory Battery Mean | 12.65 | 12.52 | 0.13 | 0.99** |
| Auditory Battery Time | 10.20 | 10.20 | 0.00 | 0.99** |
| Visual Subtest 1 | 14.01 | 14.19 | 0.18 | 0.97** |
| Visual Subtest 2 | 13.37 | 13.69 | 0.32 | 0.88** |
| Visual Subtest 3 | 12.54 | 12.15 | 0.39 | 0.93** |
| Visual Subtest 4 | 12.52 | 11.92 | 0.60 | 0.97** |
| Visual Battery Mean | 13.09 | 12.95 | 0.14 | 0.97** |
| Visual Battery Time | 7.80 | 7.70 | 0.10 | 0.99** |

** Significant beyond the 0.01 level of confidence

Auditory Battery

Table 2 shows group data for the <u>Geometric Figures Test</u>, auditory battery. The obtained values show that both the controls and right hemisphere lesion subjects achieved higher scores than the left hemisphere and bilateral lesion subjects on auditory input test scores, and required less time to complete the tests.

The analysis of variance shown in Table 3 demonstrates that the differences between groups on the GFT auditory test scores were significant beyond the 0.01 level. Similarly, the differences between groups on the GFT test times were beyond the 0.01 level of confidence, as shown in Table 4.

To determine the significance of differences between groups on the variables of test scores and test times, the "c" statistic (Dunn, 1961) was applied to the obtained data. The results of this procedure are shown in Table 5. These results demonstrate that the left hemisphere lesion group's scores were significantly lower than both the right hemisphere lesion group and the control group on the auditory input tests, whereas the bilateral lesion group's scores were significantly lower than the control group only.

With respect to test times, however, both the left hemisphere and the bilateral lesion groups differed significantly from the right hemisphere lesion group and the controls. Although the bilateral subjects were able to approximate the right hemisphere subjects on test scores, the process of selecting the appropriate responses took more time than it did for the right hemisphere lesion group. This indicates that the element of time is more discriminatory than test scores.

Table 2. Means, Standard Deviations, and Ranges of Test Scores and Test Times for Control and Experimental Groups on the Geometric Figures Test, Auditory Battery.

| Group | Scores | | | Time in Minutes | | |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Range | Mean | S.D. | Range |
| Left | 11.07 | 2.96 | 5.08-14.47 | 11.07 | 3.97 | 5-21 |
| Right | 14.13 | 0.99 | 11.23-14.88 | 7.00 | 1.31 | 5-10 |
| Bilateral | 12.13 | 2.83 | 6.48-14.96 | 10.40 | 4.03 | 5-17 |
| Control | 14.73 | 0.46 | 14.35-14.95 | 5.47 | 0.74 | 4-7 |

Table 3. Analysis of Variance on the Geometric Figures Test, Auditory Test Scores for Control and Experimental Groups.

| Source | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Treatments | 3 | 131.6 | 43.88 | 9.78** |
| Within | 56 | 251.4 | 4.48 | |
| Total | 59 | 383.0 | | |

** Significant beyond the 0.01 level of confidence

Table 4. Analysis of Variance on the Geometric Figures Test, Auditory Test Times for Control and Experimental Groups.

| Source | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Treatments | 3 | 324.7 | 108.2 | 12.62** |
| Within | 56 | 480.3 | 8.6 | |
| Total | 59 | 805.0 | | |

** Significant beyond the 0.01 level of confidence

Table 5. "c" Statistic on the Geometric Figures Test, Auditory Test Scores and Test Times for Control and Experimental Groups.

| Groups | Test Scores "c" | Test Times "c" |
|---|---|---|
| L x R | 3.95** | 3.80** |
| L x BL | 1.37 | 0.62 |
| L x C | 4.73** | 5.24** |
| R x C | 0.77 | 1.44 |
| R x BL | 2.59 | 3.18* |
| C x BL | 3.36** | 4.61** |

* Significant beyond the 0.05 level of confidence

** Significant beyond the 0.01 level of confidence

## Visual Battery

Table 6 shows data for the visual battery of the <u>Geometric Figures Test</u>. All experimental groups' performances were below that of the control group. It is interesting to note that for visual tasks the performance of the left hemisphere lesion group exceeded that of the bilateral lesion group, whereas on auditory tasks of this test, the relationship between these two groups was reversed.

Table 7 contains the analysis of variance on test scores for the groups. The differences between groups on test scores was shown to be significant beyond the 0.01 level of confidence. Similarly, the differences between groups on test times (Table 8) were significant beyond the 0.01 level.

Table 9 contains results of the "c" statistic for the groups on test scores and test times obtained on the GFT, visual battery.

On test scores, the left hemisphere lesion group's scores were significantly lower than those of the control group (beyond the 0.05 level) but did not differ significantly from the right hemisphere or bilateral lesion groups. The bilateral lesion group's scores were significantly lower than those of the right hemisphere lesion group and the controls (beyond the 0.01 level of confidence).

Table 6. Means, Standard Deviations, and Ranges of Test Scores and Test Times for Control and Experimental Groups on the Geometric Figures Test, Visual Battery.

| Group | Scores | | | Time in Minutes | | |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Range | Mean | S.D. | Range |
| Left | 13.07 | 1.49 | 10.20-15.00 | 6.80 | 2.08 | 4-11 |
| Right | 13.60 | 0.91 | 12.25-14.75 | 6.40 | 0.98 | 5-8 |
| Bilateral | 11.86 | 2.20 | 6.63-14.85 | 10.33 | 4.27 | 5-18 |
| Control | 14.73 | 0.46 | 13.50-14.95 | 5.20 | 0.68 | 4-7 |

Table 7. Analysis of Variance on the Geometric Figures Test, Visual Test Scores for Control and Experimental Groups.

| Source | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Treatments | 3 | 63.8 | 21.26 | 10.52** |
| Within | 56 | 113.2 | 2.02 | |
| Total | 59 | 177.0 | | |

** Significant beyond the 0.01 level of confidence

Table 8. Analysis of Variance on the Geometric Figures Test, Visual Test Times for Control and Experimental Groups.

| Source | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Treatments | 3 | 219.3 | 73.08 | 12.19** |
| Within | 56 | 335.7 | 5.99 | |
| Total | 59 | 555.0 | | |

** Significant beyond the 0.01 level of confidence

Table 9. "c" Statistic on the Geometric Figures Test, Visual Test Scores and Test Times for Control and Experimental Groups.

| Groups | Test Scores "c" | Test Times "c" |
|---|---|---|
| L x R | 1.03 | 0.45 |
| L x BL | 2.32 | 3.95** |
| L x C | 3.20* | 1.79 |
| R x C | 2.18 | 1.34 |
| R x BL | 3.35** | 4.39** |
| C x BL | 5.53** | 5.74** |

* Significant beyond the 0.05 level of confidence

** Significant beyond the 0.01 level of confidence

With respect to test time, the bilateral group required more time than any of the other three groups. These differences were all significant beyond the 0.01 level. There were no significant differences on times between any of the other groups.

## Results of the Token Test

### Stability of Test Scores

The scores obtained from the test-retest study of the Token Test were analyzed, using Pearson's product-moment correlation coefficient (Cooper, 1967). The results are summarized in Table 10. A matrix for showing correlation coefficients between all values obtained from the TT in this study can be seen in Appendix G. From Table 10, it can be seen that the stability coefficients of subtests on the TT ranged from 0.97 to 0.99. As with the GFT, the stability of scores for the TT was felt to be sufficiently high to allow for more extensive analysis of the obtained data.

### Auditory Battery

Table 11 shows data for the Token Test, auditory battery. The results of this data again reflected higher scores for the controls and the right hemisphere lesion group over the left hemisphere and bilateral lesion groups on test scores and on test times.

Table 10. Coefficients of Correlation for Test-Retest Stability on the Token Test.

| Variable | Mean Test 1 | Mean Test 2 | Difference (high-low) | r |
|---|---|---|---|---|
| Auditory Subtest 1 | 13.39 | 13.48 | 0.09 | 0.99** |
| Auditory Subtest 2 | 12.49 | 12.42 | 0.07 | 0.99** |
| Auditory Subtest 3 | 12.04 | 12.04 | 0.00 | 0.99** |
| Auditory Subtest 4 | 10.92 | 10.98 | 0.06 | 0.99** |
| Auditory Battery Mean | 12.21 | 12.23 | 0.02 | 0.99** |
| Auditory Battery Time | 8.30 | 8.20 | 0.10 | 0.99** |
| Visual Subtest 1 | 14.03 | 14.20 | 0.17 | 0.97** |
| Visual Subtest 2 | 14.05 | 13.77 | 0.28 | 0.97** |
| Visual Subtest 3 | 11.31 | 11.46 | 0.15 | 0.98** |
| Visual Subtest 4 | 11.34 | 11.26 | 0.08 | 0.99** |
| Visual Battery Mean | 12.68 | 11.67 | 1.01 | 0.75** |
| Visual Battery Time | 8.80 | 8.80 | 0.00 | 0.99** |

** Significant beyond the 0.01 level of confidence

The analysis of variance summarized in Table 12 demonstrates that the differences between groups on the TT auditory test scores were significant beyond the 0.01 level.

The analysis of variance summarized in Table 13 demonstrates that the differences between groups on TT test times were also significant beyond the 0.01 level.

Table 11. Means, Standard Deviations, and Ranges of Test Scores and Test Times for Control and Experimental Groups on the Token Test, Auditory Battery.

| Group | Scores | | | Time in Minutes | | |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Range | Mean | S.D. | Range |
| Left | 10.73 | 2.94 | 6.02-14.07 | 9.46 | 2.64 | 6-15 |
| Right | 13.93 | 1.62 | 9.30-15.00 | 6.53 | 1.50 | 5-10 |
| Bilateral | 11.93 | 3.30 | 4.95-14.95 | 9.06 | 3.51 | 5-16 |
| Control | 14.60 | 0.63 | 13.18-15.00 | 5.06 | 1.03 | 4-7 |

Table 12. Analysis of Variance on the Token Test, Auditory Test Scores for Control and Experimental Groups.

| Source | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Treatments | 3 | 143.2 | 47.74 | 8.45** |
| Within | 56 | 316.4 | 5.65 | |
| Total | 59 | 459.6 | | |

** Significant beyond the 0.01 level of confidence

Table 13. Analysis of Variance on the Token Test, Auditory Test Times for Control and Experimental Groups.

| Source | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Treatments | 3 | 197.6 | 65.87 | 11.62** |
| Within | 56 | 317.3 | 5.66 | |
| Total | 59 | 514.9 | | |

** Significant beyond the 0.01 level of confidence

Table 14. "c" Statistic on the Token Test, Auditory Test Scores and Test Times for Control and Experimental Groups.

| Groups | Test Scores "c" | Test Times "c" |
|---|---|---|
| L x R | 3.69** | 3.38** |
| L x BL | 1.38 | 0.22 |
| L x C | 4.46** | 4.38** |
| R x C | 0.77 | 1.00 |
| R x BL | 2.31 | 2.91* |
| C x BL | 3.07* | 4.59** |

* Significant beyond the 0.05 level of confidence

** Significant beyond the 0.01 level of confidence

A summary of the "c" statistic for the TT auditory test scores and test times is presented in Table 14.

The results of the TT auditory test scores and test times are essentially the same as those derived from the GFT. The left hemisphere lesion group obtained significantly lower scores than both the right hemisphere lesion group and the control group. The bilateral lesion group obtained significantly lower scores than the control group, and required more time than the controls and the right hemisphere lesion group.

Test time is again shown to be more sensitive to the abilities of the bilateral group in comparison to the right hemisphere lesion group than were the test scores.

Findings related to the GFT and the TT scores and test times both demonstrate that subjects with lesions of the left cerebral hemisphere (including bilateral lesion subjects) obtained considerably lower scores on auditory input tests and required greater amounts of time than either right hemisphere lesion subjects or controls.

## Visual Battery

Table 15 shows data for the visual battery of the _Token Test_. As on the GFT visual battery, the bilateral lesion group had the lowest score and required the most time.

Table 16 shows the analysis of variance on scores for the TT visual battery. The differences between groups are shown to be beyond the 0.01 level of confidence.

Similarly, the differences between groups on times (Table 17) for the TT visual battery were significant beyond the 0.01 level.

Table 18 shows the "c" statistic for test scores and test times on the TT, visual battery.

On the visual battery of the TT, the bilateral lesion group obtained significantly lower scores than the right hemisphere lesion group and the control group. The differences between other groups were not significant.

On test times, however, both the left hemisphere and bilateral lesion groups required significantly more time to complete the tests than the control group. The amount of time required by the bilateral lesion group was also significantly greater than that required by the right hemisphere lesion group.

## Results of the PICA

### Inter-Scorer Reliability

Both examiners had only recently completed training in the use of the PICA. Therefore, a study of scorer agreement was conducted using a population of ten subjects. The sample used included four subjects with left hemisphere lesions, three subjects with right

Table 15. Means, Standard Deviations, and Ranges of Test Scores and Test Times for Control and Experimental Groups on the Token Test, Visual Battery.

| Group | Scores | | | Time in Minutes | | |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Range | Mean | S.D. | Range |
| Left | 12.93 | 1.44 | 9.93-14.40 | 8.27 | 3.01 | 5-14 |
| Right | 13.20 | 1.32 | 10.00-15.00 | 7.00 | 1.69 | 5-9 |
| Bilateral | 11.20 | 3.05 | 4.33-14.87 | 10.33 | 3.75 | 5-17 |
| Control | 14.67 | 0.49 | 14.10-15.00 | 5.13 | 0.64 | 4-6 |

Table 16. Analysis of Variance on the Token Test, Visual Test Scores for Control and Experimental Groups.

| Source | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Treatments | 3 | 90.9 | 30.31 | 9.07** |
| Within | 56 | 187.1 | 3.34 | |
| Total | 59 | 278.0 | | |

** Significant beyond the 0.01 level of confidence

Table 17. Analysis of Variance on the Token Test, Visual Test Times for Control and Experimental Groups.

| Source | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Treatments | 3 | 215.0 | 71.66 | 10.85** |
| Within | 56 | 370.0 | 6.61 | |
| Total | 59 | 585.0 | | |

** Significant beyond the 0.01 level of confidence

Table 18. "c" Statistic on the Token Test, Visual Test Scores and Test Times for Control and Experimental Groups.

| Groups | Test Scores "c" | Test Times "c" |
|---|---|---|
| L x R | 0.40 | 1.35 |
| L x BL | 2.60 | 2.20 |
| L x C | 2.59 | 3.34** |
| R x C | 2.19 | 1.99 |
| R x BL | 3.00* | 3.55** |
| C x BL | 5.19** | 5.54** |

* Significant beyond the 0.05 level of confidence

** Significant beyond the 0.01 level of confidence

hemisphere lesions, and three subjects with bilateral lesions. A summary of the characteristics of these patients can be seen in Appendix E.

The results of the scorer agreement were analyzed using Pearson's product-moment coefficient of correlation. The coefficients of correlation between scorers, which are summarized in Table 19, ranged from 0.88 to 0.99 on the 18 subtests, and from 0.92 to 0.99 for the response levels. This level of agreement for the two examiners was considered satisfactorily high to proceed with the study.

Results obtained by each of the groups on the PICA are presented in Appendix H. Only results for auditory subtests VI and X and visual subtests VIII and XI are discussed here.

## Auditory Subtests VI and X

Table 20 shows the group data for these two subtests. The differences between groups on the PICA subtests do not appear very large. However, the analysis of variance shown in Table 21 suggests that the groups did differ at the 0.05 level on both subtest VI and subtest X.

Table 22 shows the summary of the "c" statistic. When the groups were compared individually, the differences between groups on subtest VI failed to show significant differences. On subtest X, the bilateral lesion group differed from the control group beyond the 0.05 level of

Table 19. Comparison of Subtest Means and Response Level Means for Ten Subjects and Two Scorers on the PICA.

| Subtest | Scorer 1 Mean | S.D. | Scorer 2 Mean | S.D. | Difference (high-low) | r |
|---|---|---|---|---|---|---|
| I | 11.65 | 3.34 | 11.75 | 3.59 | 0.10 | 0.98** |
| II | 10.88 | 1.70 | 10.87 | 1.71 | 0.01 | 0.97** |
| III | 12.13 | 1.80 | 12.42 | 1.66 | 0.29 | 0.92** |
| IV | 12.70 | 3.75 | 12.51 | 3.79 | 0.19 | 0.99** |
| V | 12.57 | 2.62 | 12.71 | 2.64 | 0.14 | 0.98** |
| VI | 14.43 | 1.17 | 14.45 | 1.21 | 0.02 | 0.99** |
| VII | 13.37 | 2.40 | 13.43 | 2.41 | 0.06 | 0.99** |
| VIII | 14.63 | 0.47 | 14.74 | 0.45 | 0.11 | 0.88** |
| IX | 12.87 | 3.23 | 12.67 | 3.23 | 0.20 | 0.99** |
| X | 14.23 | 1.30 | 14.18 | 1.29 | 0.05 | 0.99** |
| XI | 14.74 | 0.44 | 14.84 | 0.28 | 0.10 | 0.99** |
| XII | 13.23 | 3.13 | 13.10 | 3.31 | 0.13 | 0.99** |
| A | 8.16 | 2.78 | 7.95 | 2.76 | 0.21 | 0.99** |
| B | 9.40 | 2.91 | 9.06 | 2.88 | 0.34 | 0.98** |
| C | 10.01 | 3.14 | 9.71 | 3.43 | 0.30 | 0.99** |
| D | 10.07 | 3.24 | 10.26 | 3.19 | 0.19 | 0.99** |
| E | 11.90 | 2.79 | 12.02 | 2.80 | 0.12 | 0.97** |
| F | 12.81 | 0.91 | 12.89 | 1.09 | 0.08 | 0.91** |
| Overall | 12.22 | 1.92 | 12.16 | 1.99 | 0.06 | 0.99** |
| Gestural | 13.47 | 1.22 | 13.53 | 1.34 | 0.06 | 0.93** |
| Verbal | 12.54 | 3.49 | 12.61 | 3.48 | 0.07 | 0.95** |
| Graphic | 10.36 | 2.35 | 10.33 | 2.43 | 0.03 | 0.99** |

** Significant beyond the 0.01 level of confidence

Table 20. Means, Standard Deviations, and Ranges of Test Scores for Control and Experimental Groups on the PICA Subtests VI and X.

| Group | Subtest VI | | | Subtest X | | |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Range | Mean | S.D. | Range |
| Left | 14.00 | 2.23 | 7.2-15.0 | 14.26 | 1.28 | 11.4-15.0 |
| Right | 14.87 | 0.35 | 13.8-15.0 | 14.73 | 0.80 | 12.0-15.0 |
| Bilateral | 13.22 | 2.91 | 6.8-15.0 | 13.66 | 1.95 | 8.6-15.0 |
| Control | 14.98 | 0.05 | 14.8-15.0 | 14.91 | 0.17 | 14.5-15.0 |

Table 21. Analysis of Variance on Test Scores for Control and Experimental Groups on the PICA Subtests VI and X.

| Source (VI) | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Treatments | 3 | 31.6 | 10.53 | 3.10* |
| Within | 56 | 190.1 | 3.39 | |
| Total | 59 | 221.7 | | |
| **Source (X)** | | | | |
| Treatments | 3 | 15.4 | 5.12 | 3.37* |
| Within | 56 | 85.2 | 1.52 | |
| Total | 59 | 100.6 | | |

* Significant beyond the 0.05 level of confidence

Table 22. "c" Statistic on the PICA Subtests VI and X for Control and Experimental Groups.

| Groups | Subtest VI "c" | Subtest X "c" |
|---|---|---|
| L x R | 1.28 | 1.03 |
| L x BL | 1.19 | 1.34 |
| L x C | 1.48 | 1.63 |
| R x C | 0.20 | 0.59 |
| R x BL | 2.47 | 2.38 |
| C x BL | 2.67 | 2.97* |

* Significant beyond the 0.05 level of confidence

confidence, which demonstrates that the bilateral lesion group's scores were significantly lower than those of the control group.

## Visual Subtests VIII and XI

Table 23 shows group data for subtests VIII and XI of the PICA. The bilateral lesion group experienced the greatest amount of difficulty on these subtests. Of particular interest is the fact that the scores of the left hemisphere lesion group were somewhat better than those of the right hemisphere lesion group. The relationship between the right and left hemisphere lesion groups was reversed on subtests VI and X of the PICA.

Table 23. Means, Standard Deviations, and Ranges of Test Scores for Control and Experimental Groups on the PICA Subtests VIII and XI.

| Group | Subtest VIII | | | Subtest XI | | |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Range | Mean | S.D. | Range |
| Left | 14.89 | 2.64 | 14.2-15.0 | 14.93 | 0.26 | 14.2-15.0 |
| Right | 14.73 | 0.59 | 12.8-15.0 | 14.80 | 0.41 | 14.1-15.0 |
| Bilateral | 13.26 | 3.20 | 4.9-15.0 | 13.93 | 1.71 | 8.6-15.0 |
| Control | 14.99 | --- | 14.8-15.0 | 15.00 | --- | --- |

Table 24 contains a summary of analysis of variance for PICA subtests VIII and XI. The differences between groups were shown to be significant beyond the 0.05 level on subtest VIII and beyond the 0.01 level for subtest XI.

A summary of the "c" statistic is shown in Table 25 for subtests VIII and XI of the PICA. Although the differences between groups on both subtests were shown to be significant by the analysis of variance, the individual group comparison on "c" for subtest VIII failed to show significant differences between the groups. On subtest XI, however, the bilateral lesion group's scores were significantly lower than those obtained by each of the other groups. None of the other inter-group differences were significant.

Table 24. Analysis of Variance for Control and Experimental Groups on the PICA Subtests VIII and XI.

| Source (VIII) | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Treatments | 3 | 42.3 | 14.11 | 3.22* |
| Within | 56 | 245.6 | 4.38 | |
| Total | 59 | 287.9 | | |
| **Source (XI)** | | | | |
| Treatments | 3 | 11.1 | 3.69 | 4.67** |
| Within | 56 | 44.3 | 0.79 | |
| Total | 59 | 55.4 | | |

* Significant beyond the 0.05 level of confidence

** Significant beyond the 0.01 level of confidence

Table 25. "c" Statistic on the PICA Subtests VIII and XI for Control and Experimental Groups.

| Groups | Subtest VIII "c" | Subtest XI "c" |
|---|---|---|
| L x R | 0.21 | 1.25 |
| L x BL | 0.24 | 9.61** |
| L x C | 0.14 | 0.67 |
| R x C | 0.35 | 1.92 |
| R x BL | 1.92 | 8.36** |
| C x BL | 2.27 | 10.28** |

** Significant beyond the 0.01 level of confidence

## PICA Time

Table 26 shows obtained data on PICA time. Time for the PICA refers to the amount of time (in minutes) necessary to complete all 18 subtests, rather than the amount of time for the completion of specific subtests or specific batteries. It will be noted that the bilateral and left hemisphere lesion groups required considerably more time than the right hemisphere lesion group and controls.

Table 27 shows the summary of the analysis of variance on PICA time. The differences between groups were significant beyond the 0.01 level of confidence.

The summary of "c" is shown in Table 28. The left hemisphere group is shown to have required significantly more time than both the right hemisphere lesion group and the controls. Similarly, the bilateral lesion group required a significantly greater amount of time than the control group (beyond the 0.01 level) and the right hemisphere lesion group (beyond the 0.05 level). The left hemisphere lesion group did not, however, differ from the bilateral lesion group, nor did the right hemisphere lesion group differ from the control group.

## Peabody Picture Vocabulary Test

Results obtained from the PPVT are supportive of those obtained from other auditory tasks presented above.

Table 26. Means, Standard Deviations, and Ranges of Times on the PICA for Control and Experimental Groups.

| Group | Mean | S.D. | Range |
|---|---|---|---|
| Left | 70.80 | 22.79 | 34-120 |
| Right | 43.60 | 17.71 | 22-70 |
| Bilateral | 66.73 | 26.36 | 32-130 |
| Control | 25.73 | 4.55 | 20-35 |

Table 27. Analysis of Variance on PICA Times for Control and Experimental Groups.

| Source | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Treatments | 3 | 19960.0 | 6653.0 | 17.18** |
| Within | 56 | 21690.0 | 387.3 | |
| Total | 59 | 41650.0 | | |

** Significant beyond the 0.01 level of confidence

Table 28. "c" Statistic on PICA Times for Control and Experimental Groups.

| Groups | "c" |
|---|---|
| L × R | 3.78** |
| L × BL | 0.56 |
| L × C | 6.27** |
| R × C | 2.49 |
| R × BL | 3.22* |
| C × BL | 5.70** |

* Significant beyond the 0.05 level of confidence

** Significant beyond the 0.01 level of confidence

The bilateral lesion group required significantly more time than the controls on all three blocks of items: 1-50, 51-100, and 101-150. Each of these differences were beyond the 0.01 level. No other inter-group differences on scores or times were found to be statistically significant. Results for the PPVT are presented in more detail in Appendix H.

### Columbia Mental Maturity Scale

CMMS results tend to demonstrate that bilateral and right hemisphere lesion subjects obtained lower scores than left hemisphere lesion subjects and controls. Also, bilateral lesion subjects again required significantly more time than controls to complete all blocks of items except items 81-100. This group also required significantly more time than left hemisphere lesion subjects on items 21-40 and 41-60. Results for all blocks of items of the CMMS on scores and times can be seen in Appendix H.

## Relationship of Subject Variables to Test Scores

Results of the GFT and TT for all subjects (N = 60) were examined to determine the extent of their relationships to the subject variables. The results are shown in Table 29.

It was noted that younger subjects tended to do better than older subjects. This observation is similar to that of Porch who suggests that such findings seem reasonable, due to the aging vascular systems of older subjects which may, in turn, affect their abilities to perform as well as younger subjects under test conditions (Porch, 1967, Vol. I, p. 24). This might also explain the positive correlations between age and the amount of time necessary to complete each battery.

One would expect improvement to take place with the passage of time. The longer between onset of damage and testing, however, the lower the test score, and the more time it takes to complete each of the tests. Inspection of the PICA overall score reveals a similar negative correlation with weeks post-onset ($r = -0.32$). These trends

Table 29. Correlation Coefficients for Subject Variables and Test Scores for All Subjects (N = 60) on the Geometric Figures Test and the Token Test.

| Variable | GFT A | GFT A-T | GFT V | GFT V-T |
|---|---|---|---|---|
| Age | -0.16 | 0.19 | -0.28* | 0.28* |
| Education | 0.03 | -0.01 | 0.12 | -0.04 |
| WPO | -0.22 | 0.33** | -0.16 | 0.25* |

| Variable | TT A | TT A-T | TT V | TT V-T |
|---|---|---|---|---|
| Age | -0.23 | 0.20 | -0.35** | 0.28* |
| Education | 0.08 | -0.06 | 0.17 | -0.10 |
| WPO | -0.22 | 0.33** | -0.22 | 0.33** |

A = Mean score of the auditory battery

A-T = Total amount of time necessary to complete the auditory battery

V = Mean score of the visual battery

V-T = Total amount of time necessary to complete the visual battery

* Significant beyond the 0.05 level of confidence

** Significant beyond the 0.01 level of confidence

do not seem logically compatable and therefore deserve more detailed attention. Table 30 shows the relationship between weeks post-onset and test results for each of the pathological groups on the GFT and the TT.

Inspection of Table 30 reveals that the correlation coefficients shown in Table 29, based upon the scores of all groups combined, are misleading with respect to the relationship between weeks post-onset and test results. It is, in most cases, only the bilateral group that obtained lower scores and required more time to complete the tests, as the number of weeks post-onset increased. The overall score on the PICA revealed a similar trend for the bilateral group ($r = -0.54$). This might be expected since the bilateral injury is usually due to successive episodes resulting in more extensive brain injury with the passage of time.

## Summary of Results by Groups

### Group Observations

#### Control Subjects

The control group obtained higher scores than each experimental group in all but two instances. On items 101-150 of the PPVT, the right hemisphere lesion group obtained higher scores than the controls. Similarly, the left and right hemisphere lesion groups obtained slightly

Table 30. Correlation Coefficients between Test Scores and Weeks Post-Onset for Each Experimental Group on the Geometric Figures Test and the Token Test.

| WPO for Group | GFT | | | |
|---|---|---|---|---|
| | A | A-T | V | V-T |
| Left | 0.20 | -0.03 | 0.34 | -0.02 |
| Right | 0.46 | -0.76** | 0.41 | -0.52* |
| Bilateral | -0.36 | 0.54* | -0.37 | 0.43 |

| | TT | | | |
|---|---|---|---|---|
| | A | A-T | V | V-T |
| Left | 0.06 | -0.01 | -0.03 | 0.20 |
| Right | 0.43 | -0.45 | 0.50* | -0.49* |
| Bilateral | -0.24 | 0.46 | -0.34 | 0.48* |

A = Mean score of the auditory battery

A-T = Total amount of time necessary to complete the auditory battery

V = Mean score of the visual battery

V-T = Total amount of time necessary to complete the visual battery

* Significant at the 0.05 level of confidence

** Significant at the 0.01 level of confidence higher scores than the control group on items 1-20 of the CMMS. These differences were not, however, statistically significant.

Left Hemisphere Lesion Subjects

It has been found that left hemisphere lesion subjects experience comparatively greater difficulty on tasks involving auditory input than with tasks involving visual input. This was true for both the GFT and the TT, and appears to be supported by the results obtained on the PPVT, CMMS, and certain subtests of the PICA.

Right Hemisphere Lesion Subjects

Subjects with right hemisphere lesions demonstrated a tendency to perform comparatively better on tasks involving auditory input than on tasks involving visual input, but these trends did not prove to be significant when compared to the other groups (for scores or time) on the GFT and the TT.

Bilateral Lesion Subjects

Subjects with bilateral lesions were found to experience considerable difficulty with tasks involving auditory input, but tasks involving visual input tended to be comparatively more difficult. This was demonstrated by a comparison of relative group differences on the auditory and visual batteries of the GFT and the TT.

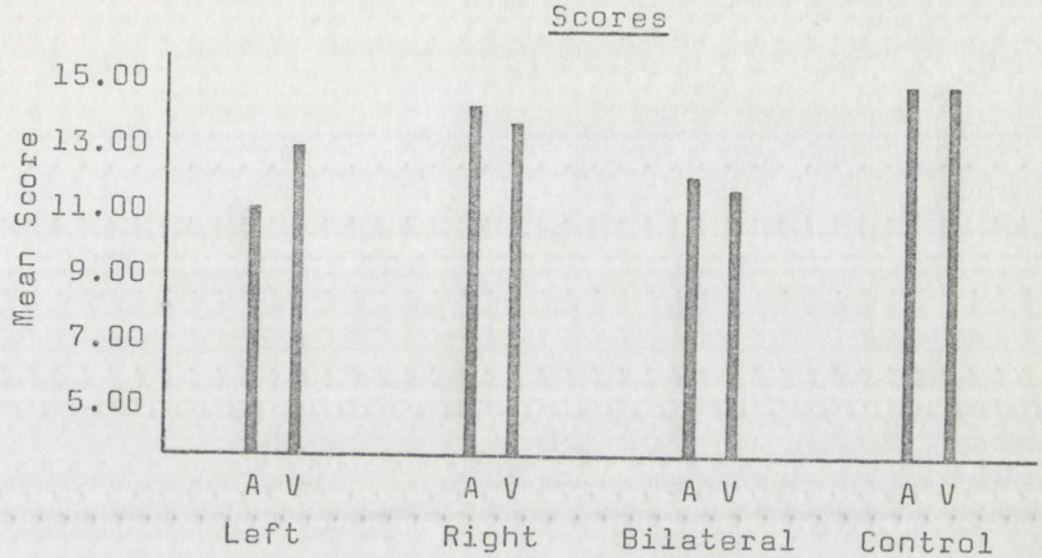
## Group Comparisons

A comparison of group performances on scores and time for the GFT is shown in Figure 3, and for the TT in Figure 4. Similar comparisons are shown in Figures 5 and 6 for the PPVT and the CMMS, respectively.

### Left Hemisphere and Right Hemisphere Lesion Subjects

The left and the right hemisphere lesion subjects differed significantly on the auditory batteries of the GFT and the TT, with the left hemisphere lesion group obtaining considerably lower scores on the auditory tasks. On the visual batteries of the GFT and the TT, however, there were no significant differences between the two groups. This occurred as a result of the left hemisphere lesion group obtaining comparatively higher scores on the visual batteries of the GFT and the TT, while the right hemisphere lesion group obtained comparatively lower scores on the same batteries.

Although the left hemisphere lesion group approximated the performances of the right hemisphere lesion group on visual input tasks, their performances did not exceed those of the right hemisphere lesion group on the GFT and the TT visual batteries. The trends observed on the auditory and visual tasks do, however, suggest that visual input tasks are comparatively more difficult for right hemisphere lesion subjects, while auditory input



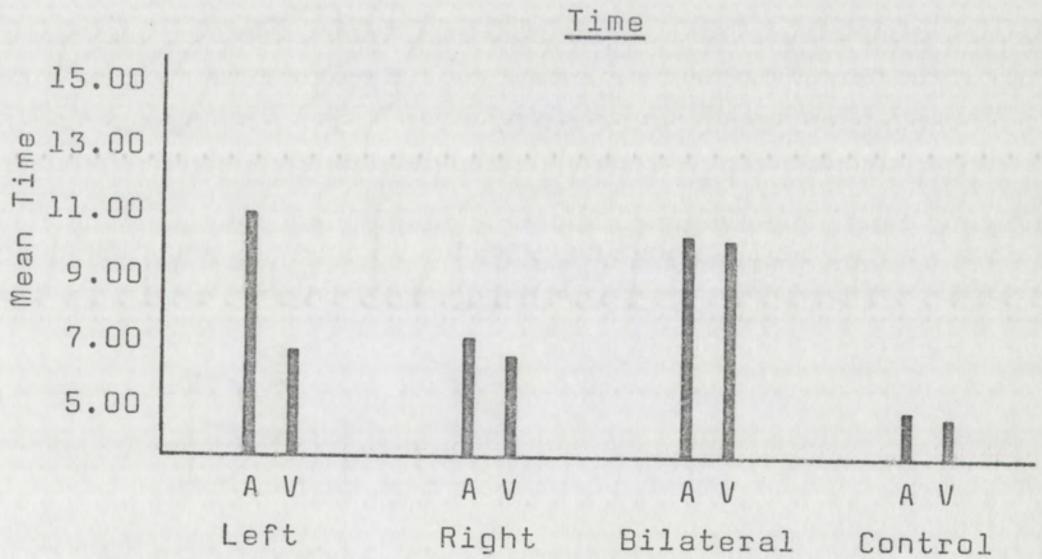




Figure 3. A Comparison of Control and Experimental Groups on Mean Scores and Mean Time for the Geometric Figures Test.

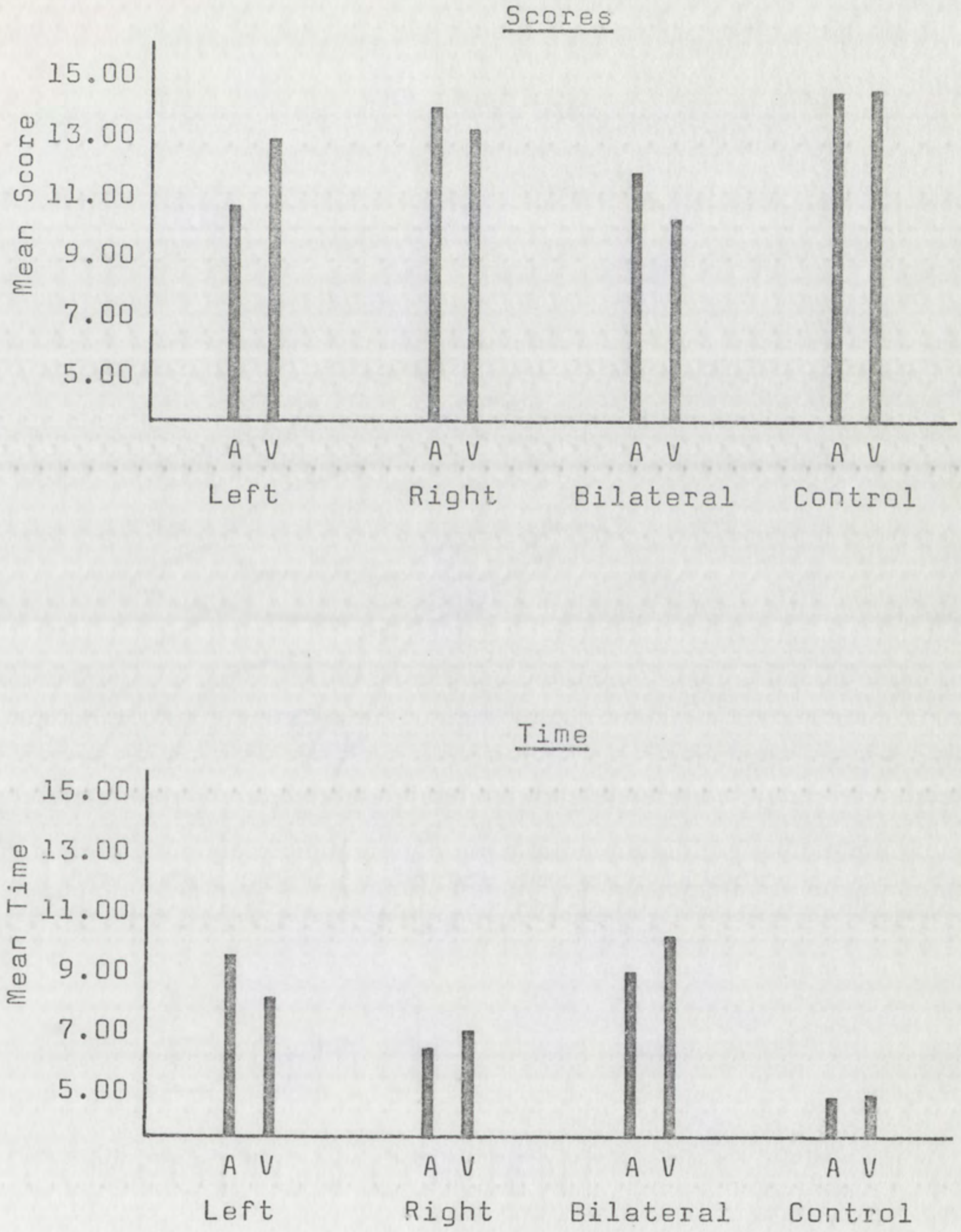



Figure 4. A Comparison of Control and Experimental Groups on Mean Scores and Mean Time for the Token Test.

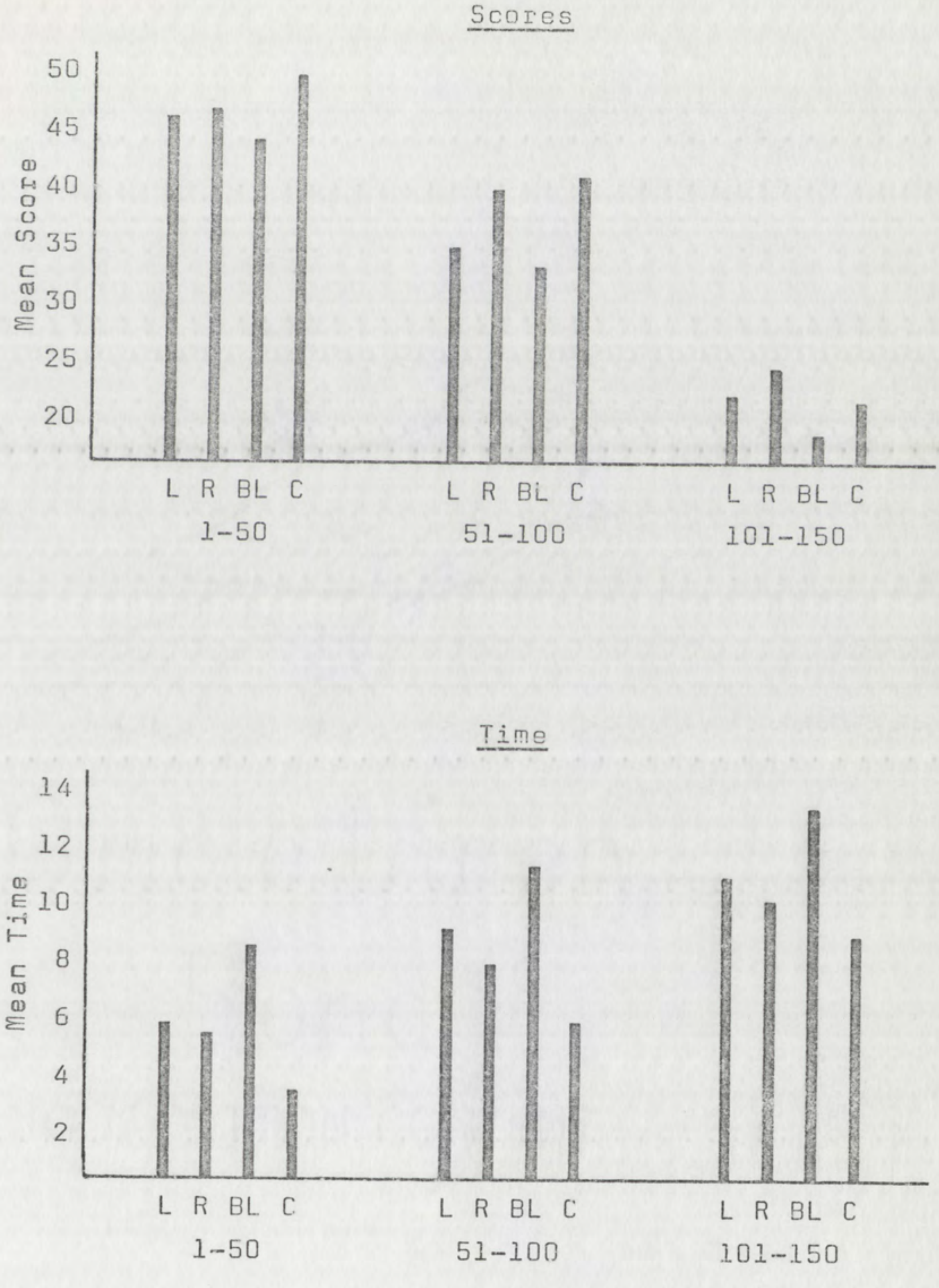



Figure 5. Mean Test Scores and Mean Test Time for Control and Experimental Groups on the Peabody Picture Vocabulary Test Items 1-50, 51-100, and 101-150.

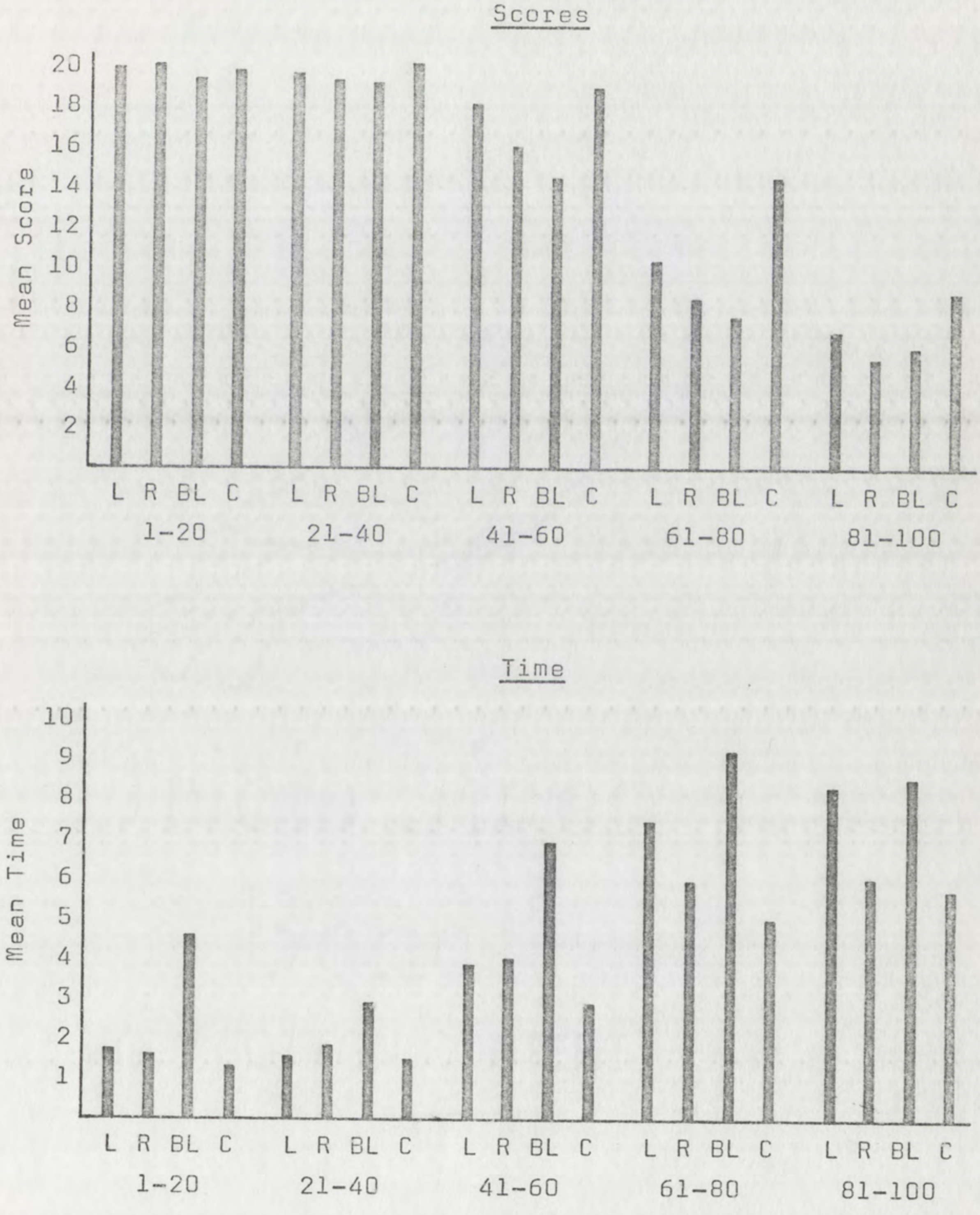



Figure 6. Mean Test Scores and Mean Test Time for Control and Experimental Groups on the Columbia Mental Maturity Scale Items 1-20, 21-40, 41-60, 61-80, and 81-100.

tasks are comparatively more difficult for left hemisphere lesion subjects.

The latter observation gains considerable support from the performances of the left and right hemisphere lesion subjects on the CMMS, which requires visual input ability. The right hemisphere lesion group obtained significantly lower scores than the control group on items 41-60, 61-80, and 81-100, while the left hemisphere lesion group obtained significantly lower scores than the controls on items 61-80 only.

Left Hemisphere and Bilateral Lesion Subjects

The left hemisphere and bilateral lesion subjects did not differ significantly on auditory and visual input task scores on the GFT and the TT. However, certain inferences can be drawn from the data.

On the GFT auditory battery, the left hemisphere lesion group differed significantly from the control and right hemisphere lesion groups, whereas the bilateral lesion group differed significantly from the control group only. The auditory input tasks on the GFT were apparently more difficult for the left hemisphere lesion group than for the bilateral lesion group.

On the visual battery of the GFT, however, the relationship between these two groups was reversed from that on the auditory battery. The bilateral lesion group differed significantly from the control and right hemisphere lesion groups, while the left hemisphere lesion group differed from the control group only.

Similar relationships occurred on the auditory and visual batteries of the TT. On the auditory battery of the TT, the left hemisphere lesion group obtained significantly lower scores than the control and right hemisphere lesion groups, whereas the bilateral lesion group differed from the control group only.

On the visual battery of the TT, the bilateral lesion group obtained significantly lower scores than the right hemisphere lesion group, and the control group. The scores of the left hemisphere lesion group did not differ significantly from the control group or the right hemisphere lesion group on the visual battery of the TT.

The relative amounts of time required by the left hemisphere and bilateral lesion groups reveal rather consistent inverse relationships to the scores obtained by each of the groups. As scores increased, the amount of time required to complete the tasks decreased, or as scores decreased, the amount of time required to complete the tasks increased.

On the GFT auditory battery, the left hemisphere lesion group required significantly more time than the control and right hemisphere lesion groups. The bilateral lesion group also required a significantly greater amount of time than the right hemisphere lesion group and the controls.

On the visual battery of the GFT, however, the left hemisphere lesion group did not differ significantly from the right hemisphere lesion group or the controls. On the same battery, the bilateral lesion group required a significantly greater amount of time than the left hemisphere lesion group, the right hemisphere lesion group, and the control group.

Significant differences between the bilateral group and the left hemisphere lesion group were also shown to exist on the CMMS. On items 21-40, the bilateral lesion group required significantly more time than the left hemisphere lesion group. On items 41-60, the bilateral lesion group obtained significantly lower scores and required more time than the left hemisphere lesion group. These differences provide considerable support to observations of difficulties experienced by the bilateral lesion group on the visual batteries of the GFT and the TT.

Left Hemisphere Lesion and Control Subjects

The left hemisphere lesion group did differ from the control group on some measures of visual input ability (GFT, "c" $< 0.05$; TT time, "c" $< 0.01$; CMMS, 61-80, "c" $< 0.05$). A more consistent finding was seen on the auditory input tasks of the GFT and the TT, where differences between left hemisphere lesion subjects and controls were significant beyond the 0.01 level of confidence for scores and task time. This suggests that, although subjects with left hemisphere lesions may experience some difficulty with visual input tasks, primary difficulty arises with tasks requiring auditory input abilities.

Right Hemisphere Lesion and Control Subjects

There were no significant differences between the right hemisphere lesion subjects and controls on the GFT and the TT. The only significant differences observed between these groups were on the CMMS. The right hemisphere lesion group obtained scores which were significantly lower than the control group on three blocks of items: items 41-60, 61-80, and 81-100.

Right Hemisphere and Bilateral Lesion Subjects

The most significant differences between right hemisphere and bilateral lesion subjects were found on tasks requiring visual input ability. These differences were at the 0.01 level on the GFT visual input scores, GFT visual time, and the TT visual time. Differences on the TT visual input scores were at the 0.05 level of confidence. On the CMMS, however, there were no significant differences between these groups on scores, but the bilateral lesion group did require a significantly greater amount of time on items 41-60. The right hemisphere and bilateral lesion subjects tended to experience similar degrees of difficulty on all other tasks on the CMMS which, in turn, suggests similar degrees of difficulty with visual input on this test.

Differences between right hemisphere and bilateral lesion subjects on auditory input tasks were significant only on the variable of time for the GFT and the TT. In both instances, the bilateral lesion group required a significantly greater amount of time than the right hemisphere lesion group.

Bilateral Lesion and Control Subjects

The bilateral lesion subjects differed significantly from the controls by obtaining lower scores and requiring more time on all tasks. All differences on auditory and visual input tasks were at the 0.01 level of confidence with the exception of scores on the TT auditory battery and time on CMMS items 1-20, which were significant at the 0.05 level of confidence.

The results of this study demonstrate that differences do exist with respect to auditory versus visual input ability between subjects with right hemisphere, left hemisphere, and bilateral lesions of the brain, on comparable auditory and visual input tasks. The most apparent differences exist between the left hemisphere and bilateral lesion groups. Although right hemisphere lesion subjects demonstrated a tendency toward lower scores on visual input tasks than on auditory input tasks, these findings were inconclusive on the GFT and the TT. Considerable evidence of difficulties on visual input tasks was demonstrated by right hemisphere lesion subjects on the CMMS.

# CHAPTER IV

# DISCUSSION

## Pertinence of Findings

The hemispheric location of cerebral lesions has been shown to affect the auditory and visual input modalities differentially, depending upon whether the lesion is contained within the left cerebral hemisphere, the right cerebral hemisphere, or within both cerebral hemispheres. In the light of these findings, certain suggestions are indicated, both for future research and for speech clinicians dealing with adult disorders of language resulting from brain injury.

Research directed toward the investigation of communication abilities in brain-injured adults should specify the location of brain injury in the description of experimental subjects. Furthermore, the results of such research should be related to the location of brain injury. With a lack of consideration for this variable, results may be confounded due to the differential effects of location of cerebral lesions on auditory and visual input abilities.

The relative auditory and visual input abilities of brain-injured adults should also be of interest to the speech clinician. Successful rehabilitation of speech and language is largely dependent upon the speech clinician's knowledge of the client's specific abilities or disabilities. Findings of the present study related to auditory and visual input ability, and to the variable of time, tend to suggest two basic applications for speech and language therapy. Therapy for left hemisphere lesion clients should be centered on activities utilizing visual input tasks, whereas therapy for bilateral or right hemisphere lesion clients should be centered on auditory input tasks. Secondly, clients with left hemisphere lesions may require a considerable amount of time to respond to auditory input tasks, and bilateral lesion clients may require a considerable amount of time to respond to both auditory and visual input tasks during the initial phases of therapy. The goals of therapy, then, would include attempts to improve the input abilities of both the auditory and visual modalities and would also be directed toward decreasing response latency on auditory and visual input tasks.

The tests used in this project deserve attention. Both the GFT and the TT were shown to demonstrate differences between the four groups of subjects. Even though all differences between groups were not statistically significant, profiles of test results for the groups on each test reveal rather interesting relationships.

A reversal of relationships between the bilateral and left hemisphere lesion groups on auditory and visual tasks was discussed earlier. In addition, it is of interest to note that the bilateral and right hemisphere lesion groups exhibited a parallel relationship between auditory and visual input tasks. The right hemisphere lesion group performed considerably better on both auditory and visual input tasks, yet the relationships between scores for both groups tended to be proportionally lower on visual input tasks than on auditory input tasks.

The bilateral lesion group's scores were significantly lower than those of the controls on visual input tasks, while the scores of the right hemisphere lesion subjects were not. It is difficult to determine on the basis of the present analyses whether the latter finding was a function of the tasks, a function of the right hemisphere lesion subjects included in this sample, or if the performances were representative of a right hemisphere lesion population. The performances of right hemisphere lesion subjects may, therefore, deserve further attention to clarify the relationships between their respective auditory and visual input abilities.

In general, the GFT and the TT do appear to be tests worthy of clinical application. On the basis of observations made throughout the testing of subjects, findings on the GFT and the TT tended to compliment findings on the PICA. While subjects with minimal auditory or visual input difficulties tended to obtain maximum scores on subtests VI, X, VIII, and XI of the PICA, it was not unusual for the same subjects to experience a considerable amount of difficulty on the GFT and the TT.

Reverse relationships between test findings were often apparent for subjects with severe communication involvement. On the GFT and the TT, these subjects (in most cases, bilateral and left hemisphere lesion subjects) tended to demonstrate inconsistent relationships between auditory and visual input abilities. A few bilateral lesion subjects with severe communication involvement obtained higher scores on visual input tasks than on auditory tasks, while a few subjects with left hemisphere lesions obtained higher scores on auditory input tasks than on visual input tasks. The profiles of the test results on the PICA for the more severely involved subjects, on the other hand, usually showed rather obvious differences between bilateral and left hemisphere lesion subjects on auditory and visual input tasks similar to those shown in Appendix H. On the basis of group comparisons, however, findings related to auditory and visual input ability on the GFT and the TT are in agreement with those of the PICA. Bilateral lesion subjects experience comparatively greater difficulty on visual input tasks than on auditory input tasks, while left hemisphere lesion subjects experience comparatively greater difficulty on auditory input tasks than on visual input tasks.

Findings related to the CMMS are in agreement with those of Boone (1959) and Shontz (1957). The scores obtained between right and left hemisphere lesion subjects did not differ significantly. These findings are true not only for total scores, the criterion used in the studies mentioned above, but also for scores obtained and amounts of time used on each block of 20 items. Of particular interest, however, is the finding that the CMMS scores of the right hemisphere lesion group were significantly lower than those of the controls on three blocks of the items (41-60, 61-80, and 81-100), while the left hemisphere lesion subjects differed significantly from the controls on only one block of item scores (61-80). This tends to indicate that even though the CMMS scores show no significant differences between the performances of right and left hemisphere lesion subjects, comparisons with the performances of subjects with no brain injury may provide useful clinical information. This also tends to indicate that the establishment of norms for brain-injured and non-brain-injured adults may prove to be a worthy project.

Use of the CMMS with bilaterally injured subjects has also provided interesting results. Not only were the bilateral group's scores significantly lower than the controls and left hemisphere lesion subjects (L x BL, items 41-60; C x BL, items 41-60 and 61-80), but the amounts of time required by the bilateral lesion group were significantly greater than that of the controls on items 1-80. They also required significantly more time than the left hemisphere lesion group (items 21-40 and 61-80) and significantly more time than the right hemisphere lesion group (items 41-60). Of particular interest is the finding that the bilateral lesion group required less time to complete items 21-40 rather than items 1-20, as might have been expected. The relationships between groups on each of the blocks of items and between blocks of items for each group would appear to deserve closer attention. The present project suggests that, even though certain intergroup differences were significant, the variable of time may provide a great deal of clinical information once the relationships of groups are more clearly defined.

The PPVT failed to show any significant intergroup differences on obtained scores. However, similar to the CMMS, the bilateral lesion group required a significantly greater amount of time than the controls to complete each of the three blocks of items (1-50, 51-100, and 101-150).

This finding tends to strengthen an argument that more attention should be given to the dimension of time when intergroup or inter-individual differences are being sought, whether for research or for clinical purposes.

A comparison of the GFT, the TT, the CMMS, and the PPVT as auditory and visual input tasks tends to point out the GFT and the TT as being the more favorable. First of all, the parallel construction and procedures used with the GFT and the TT provide for more meaningful comparisons between auditory and visual input abilities than are possible with the CMMS and the PPVT as used in the present study. The latter tests have been standardized on two different age ranges; hence, there was a tendency for the PPVT to be more strongly correlated with the educational level of the subjects than the CMMS. Secondly, since there is a tendency for positive correlations between scores and educational level, it may be more difficult to attribute low scores to a lack of input ability. There were no significant correlations between scores obtained on the GFT and the TT and the educational level of subjects. Another point worthy of consideration is that for both the auditory and visual batteries of the GFT and the TT, the examiner was bound to a set amount of time in presenting stimuli to the subject. As presently used, the examiner tended to have more control over the timing of stimulus presentations on the PPVT, whereas the subject was in complete control for the presentation of stimuli on the CMMS. In essence, both the PPVT and the CMMS provide valuable information as single measures, but group comparisons between the two measures would appear to be less meaningful than similar comparisons on the GFT and the TT.

## Relationship of Findings to Pertinent Literature

It will be recalled that there was a reversal of relationships between the left hemisphere and bilateral lesion groups on auditory and visual task scores. Auditory tasks were comparatively more difficult for left hemisphere lesion subjects, while visual tasks were comparatively more difficult for bilateral lesion subjects. This finding is in agreement with Porch (1967, Vol. II) who has observed that this reversal of relationships on auditory and visual task scores is the most consistent difference between subjects with left hemisphere damage and subjects with bilateral damage.

The differences between the left hemisphere lesion subjects and bilateral subjects on auditory and visual task scores were not found to be statistically significant on the GFT, the TT, or on PICA subtests VI, VIII, X, and XI. These differences, however, are of clinical significance when one observes the PICA profiles (Appendix H; Porch, 1967, Vol. II, p. 84). Similarly, the differences between left hemisphere and bilateral lesion subjects shown in Figures 3 and 4 may also be of clinical, if not statistical, significance.

It is somewhat more difficult to compare the results of the present study to those of Stark (1961) due to differences in the nature of tasks employed for each respective study. Essentially, however, Stark found that left hemisphere lesion subjects obtained significantly more errors than right hemisphere lesion subjects in response to auditory stimuli, while right hemisphere lesion subjects obtained significantly more errors than the left hemisphere lesion subjects in response to visual stimuli. Findings of the present study related to comparisons of left and right hemisphere lesion subjects on auditory stimuli are in agreement with those of Stark. The left hemisphere lesion subjects obtained significantly lower scores than the right hemisphere lesion subjects. Reverse relationships between the groups on visual stimuli were not found in the present study on the GFT and the TT.

The discrepancy in findings between groups on the visual input tasks may, however, be related to the nature of responses required of the subjects. In response to the visual stimuli, Stark's subjects were required to produce a graphic response, i.e., closure of an incomplete figure. All of Stark's subjects were right handed; hence, difficulties on graphic responses due to motor deficit were ruled out. Difficulties experienced by the right hemisphere lesion group were attributed to a deficit "in visual-spatial learning and retention" ability (Stark, 1961, p. 285).

In the light of available evidence, it would appear that the inaccurate graphic responses of the right hemisphere lesion group may not have been due to poor visual-spatial learning and retention ability. Benton (1967) indicates that grossly defective copying performance has been observed in 11 per cent of his right hemisphere lesion cases, but in none of his left hemisphere lesion cases. Furthermore, he states that:

> Many patients with right hemisphere disease show qualitatively peculiar graphic constructions that reflect a neglect of the left half of space. Others may show the so-called "closing-in" phenomenon, in which the patient fails to distinguish the model presented to him from his own construction . . . . I found that the right hemisphere group tended to make relatively more distortion and omission errors, while the left hemisphere group tended to make relatively more displacement errors of a minor nature (pp. 160-161).

In essence, there is evidence that subjects with right hemisphere lesions commonly experience comparatively more difficulty on certain types of graphic responses than do left hemisphere lesion subjects. The differences between right and left hemisphere lesion subjects in Stark's research, then, might have been expected, but not necessarily due to visual-spatial learning and retention ability.

The type of response required of the subjects on the major tasks included in this study (the GFT and the TT) was simply to point to the appropriate objects. The same response was used on both auditory and visual input tasks. When this technique was used, analysis of the obtained results revealed no significant differences between the right and left hemisphere lesion groups on visual input tasks of the GFT and the TT.

The only task requiring visual input ability on which the right hemisphere lesion group demonstrated apparent significant difficulty was the CMMS. Benton states that neglect of the contralateral half of space is a "right hemisphere" phenomenon (1967, p. 160). As mentioned earlier, the length of stimulus cards on the CMMS is 19 inches with as many as five figures on a card. Neglect of the left half of these cards may provide a partial explanation for the comparatively lower scores of the right hemisphere lesion group on this test. However, it is felt that such an explanation is inadequate due to the precautions taken during the administration of this test.

Porch states that ". . . in general the bilaterally damaged patient sample does less well on all subtests [of the PICA] than a unilaterally damaged patient sample.

Instead of showing the projected course of improvement . . . [bilaterally damaged patients] . . . demonstrate probable downward progression [on PICA profiles] as the patient loses cerebral efficiency" (Porch, Manual II, p. 81). Auditory input tends to be less affected than certain other abilities when cerebral damage is present bilaterally. In brief, not only do bilaterally damaged patient samples obtain lower scores than unilaterally damaged patient samples, but also, rather than showing improvement over time, bilaterally damaged patients tend to decrease in communication abilities.

Findings of this study are in agreement with Porch's observations. Bilaterally injured subjects tended to obtain lower scores and require more time than unilaterally damaged subjects except on certain auditory tasks (L > BL on GFT and TT auditory scores). Also, correlational statistical methods showed that unilaterally damaged patients obtain higher scores and require less time to do so as the number of weeks post-onset increases. The bilaterally injured patient, on the other hand, obtained lower scores and required increasing amounts of time to complete the various tasks as weeks post-onset increased. These findings tend to indicate that long-term prognosis for improvement in language abilities for patients who have diffuse or bilateral vascular lesions is unfavorable.

# CHAPTER V

# SUMMARY AND CONCLUSIONS

## Summary

Recent literature in the area of brain damage research has suggested that the auditory and visual input abilities of adults may be affected differentially by brain damage, depending upon the location of the damage. Presently available information has failed to specify adequately the relationships between the location of brain damage and the relative auditory-visual input ability of brain-injured adults.

The present study was designed to compare the relative performance within each experimental group, and to explore the relationships among experimental groups on parallel auditory and visual input tasks.

The procedures employed were as follows: (1) selection and development of comparable input tasks for each of two modalities, auditory and visual; (2) standardization of procedures for the administration and scoring of all tests used; (3) selection of subjects in a manner which would provide maximal control of variables considered critical to the outcome of the study; (4) examination of the relationships among subject variables and obtained test results; and (5) analysis of the differential effects of site of lesion upon the respective auditory and visual input abilities of the selected subjects.

Two tests, the Geometric Figures Test (GFT) and the Token Test (TT) were constructed. Each was composed of a battery which employed auditory input of stimuli and a battery which employed the visual input of stimuli. Both tests were constructed so that the criterion tasks (pointing to figures) were the same for the auditory and the visual batteries, but the mode of stimuli presentations were different. For the auditory batteries, instructions were given verbally, whereas for the visual batteries, instructions were given visually.

Standardized testing procedures were established for the GFT and the TT, and put into a test format which specified instructions for the placement and presentation of test materials and for specific testing procedures.

A multidimensional method of scoring, adapted from the Porch Index of Communicative Ability was used for the scoring of all responses on the GFT and the TT. This method of scoring was chosen over plus-minus scoring because of its sensitivity to differences in types of observed responses, and because of its previously proven level of reliability. In addition, the amount of time necessary to complete each respective task was recorded to the nearest minute.

Four groups of subjects (15 per group) were included in the study: (1) subjects with injury confined to the left cerebral hemisphere; (2) subjects with injury confined to the right cerebral hemisphere; (3) subjects with bilateral cerebral injury; and (4) subjects in whom cerebral injury was ruled out. None of the subjects had peripheral auditory or visual defects which seriously interfered with testing procedures. There were no significant differences between groups on the variables of age, educational level, and number of weeks between onset of injury and testing. Communication abilities of the subjects were quantified using the Porch Index of Communicative Ability.

Since the GFT and the TT, as used in the present study, were previously unproven tests, stability of test scores was investigated by means of a test-retest study which was conducted using a sample of ten subjects. Stability coefficients for the GFT ranged from 0.89 to 0.99 on the eight subtests, while stability coefficients for the TT ranged from 0.97 to 0.99 on its eight subtests.

An investigation of subject variables and test scores on the GFT and the TT was conducted using correlational statistical methods. There was found to be a significant negative correlation between age and test scores on the visual batteries of both tests. For the bilateral lesion group, significant correlations were found between the amount of time necessary to complete certain test batteries and the number of weeks between onset and testing. A rationale for these findings was proposed. There were no significant correlations between test scores and educational level.

In addition to the GFT and the TT, the Peabody Picture Vocabulary Test (PPVT) and the Columbia Mental Maturity Scale (CMMS) were administered to each subject. The entire battery of tests was administered to each subject during three sessions, and the test results were analyzed using one-way analyses of variance as the basic statistical procedure.

Results

The major findings of this study were as follows:

(a) Left hemisphere lesion subjects experienced comparatively greater difficulty on tasks requiring auditory input than on tasks requiring visual input on the GFT and the TT. In comparison with control subjects, the scores of left hemisphere lesion subjects were lower on both auditory and visual input tasks. On the CMMS, left hemisphere lesion subjects' scores were lower than those of the control group on items 61-80.

(b) Right hemisphere lesion subjects experienced comparatively greater difficulty on tasks requiring visual input than on tasks requiring auditory input on the GFT and the TT. In comparison to control subjects, differences on the GFT and the TT were not statistically significant. On the CMMS, however, right hemisphere lesion subjects obtained scores on items 41-60, 61-80, and 81-100 which were significantly lower than the scores obtained by the control subjects.

(c) Bilateral lesion subjects experienced comparatively greater difficulty on tasks requiring visual input than on tasks requiring auditory input on the GFT and the TT. In comparison with control subjects, the scores of bilateral lesion subjects were significantly lower on both auditory and visual input tasks. On the CMMS, the bilateral lesion subjects obtained scores which were significantly lower than those of the controls on items 41-60 and 61-80. They also required significantly more time than the controls on items 1-20, 21-40, 41-60, and 61-80 of the CMMS. On the PPVT, the bilateral lesion group required significantly more time than the controls on all three blocks of items: items 1-50, 51-100, and 101-150.

(d) A comparison of left and right hemisphere lesion subjects on the GFT and the TT revealed that left hemisphere lesion subjects obtained significantly lower scores and required more time on auditory input tasks, while on visual input tasks, no significant differences were found between these two groups on scores or on time.

(e) A comparison of left hemisphere and bilateral lesion subjects revealed no significant differences on scores for auditory and visual input tasks on the GFT and the TT. Although the differences were not statistically significant, they are of interest because of a reversal of relationships between the groups on auditory and visual task scores and task time. That is, on auditory input tasks, the left hemisphere lesion group obtained lower scores and required more time than the bilateral lesion group, while on visual input tasks, the bilateral lesion group obtained lower scores and required more time than the left hemisphere lesion group. On the CMMS, the bilateral group obtained significantly lower scores than the left hemisphere lesion group on items 41-60 and required significantly more time than the left hemisphere lesion group on items 21-40 and 41-60.

(f) A comparison of right hemisphere and bilateral lesion subjects revealed inconsistent differences on scores and time on the auditory batteries of the GFT and the TT, while on the visual batteries of these two tests, significant differences existed on both scores and on time. The bilateral group obtained lower scores and required a greater amount of time.

## Conclusions

Several conclusions appear warranted by the data obtained from this research and by observations made throughout the testing of subjects:

1. Auditory and visual input abilities of brain-injured adults will differ depending upon whether the lesion is to the right cerebral hemisphere, the left cerebral hemisphere, or to both cerebral hemispheres.

   a. Left hemisphere lesions tend to result in rather notable decreases in auditory input ability, while visual input ability is most often affected to a substantially lesser degree.

   b. Right hemisphere lesions tend to result in a slight decrease of visual input ability, while auditory input ability remains comparatively less affected.

   c. Bilateral hemisphere lesions tend to result in rather notable decreases in both auditory and visual input. Auditory input ability tends to be somewhat less affected than visual input ability. Furthermore, these abilities may decrease with the passage of time rather than improve when the lesion(s) is vascular in origin.

2. Response latency would appear to be a sensitive indicator of population differences, particularly when attempting to differentiate unilateral from bilateral cerebral lesion cases. Bilateral lesion cases tend to be considerably more latent in their responses to various types of stimuli.

3. The Geometric Figures Test and the Token Test appear capable of detecting certain population differences among brain-injured adults. Two considerations may have contributed a great deal to the apparent successes of these tests: (1) rather rigid standardization of testing procedures; and (2) the use of a scoring system that is descriptive of observable subject behaviors, yet quantifies these behaviors.

4. The results contained herein should be particularly helpful clinically when rehabilitative goals are being established for individual clients. Information regarding the auditory and visual modality abilities of various brain-injured populations also lends itself to determining approaches to treatment which might be most effective. The relationships between the various input abilities, treatment approaches, and the progress of clients in language rehabilitation require more extensive investigation.

5. It may be of interest and importance to submit similar populations to other types of auditory and/or

visual input tasks, tasks which differ in terms of difficulty and in terms of administrative procedures in order that input problems within populations might be better defined.

6. Throughout the testing of subjects, certain non-language behaviors were observed:

a. Subjects with lesions of the left cerebral hemisphere were often quite severely limited in most input and output language abilities. There appeared to be a tendency toward being highly interested in all procedures, a high degree of motivation, and most of these subjects were generally "good natured."

b. Subjects with lesions of the right cerebral hemisphere most often demonstrated minimal deficits in language abilities. Many of these subjects tended to verbalize a questioning attitude toward procedures. It was not unusual for these subjects to verbalize a great deal of concern for their post-traumatic physical state and, in general, to exhibit what appeared to be a rather depressed psychological state.

c. Subjects with lesions of both cerebral hemispheres, like subjects with lesions of the left cerebral hemisphere, were usually quite severely limited in most input and output language abilities. Unlike subjects with lesions of the left cerebral hemisphere, however, bilateral lesion subjects tended to be generally unresponsive to procedures, and it was not unusual to observe inappropriate laughing and/or crying among these subjects.

Several of these observations are not new and may be related to the extent and location of cerebral lesions. They may also be directly related to subjects' post-traumatic language abilities. However, a need for a better understanding of the observed behaviors and their relationships to cerebral lesions and language abilities is indicated.

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# APPENDIX A

## Geometric Figures Test (GFT)
## Auditory and Visual Batteries

## PRELIMINARY AUDITORY AND VISUAL DISCRIMINATION TEST

<u>Pretest</u>: Place response cards 1 and 2 before the subject with card 2 closer and within 12 inches of the subject. The stimuli have been randomly numbered and are to be presented in their given order. Twenty performances are required of the subject so that each of the stimulus items may be presented both auditorily and visually.

<u>Instructions</u>: CAN YOU SEE ALL OF THESE CARDS? (Gesture.) I WILL EITHER NAME ONE OF THEM OR SHOW YOU ONE OF THEM. AS I DO THIS, TOUCH THE ONE IN FRONT OF YOU THAT MATCHES IT. ARE YOU READY?

<u>Repeat if</u>:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

<u>Cue</u>: AS I NAME (OR SHOW) A CARD OR FIGURE, YOU SHOW ME ONE JUST LIKE IT BY TOUCHING IT (demonstrate, using a previous stimulus).

<u>Order of Presentation</u>: (Note: Time for each presentation is 2 seconds)

| Visual | Auditory |
|---|---|
| 1. red card | 2. "black triangle" |
| 3. black square | 4. "black cross" |
| 5. the X | 6. "yellow card" |
| 7. black circle | 8. "black card" |
| 9. green card | 10. "blue card" |
| 11. black cross | 12. "black X" |
| 13. yellow card | 14. "green card" |
| 15. black triangle | 16. "red card" |
| 17. black card | 18. "black circle" |
| 19. blue card | 20. "black square" |

Remove response cards 1 and 2.

## GEOMETRIC FIGURES TEST: PART I (Auditory)

Test 1: Place response cards 3 and 4 before the subject with card 4 closer and within 12 inches of the subject. The stimuli are randomly numbered and are to be presented in their given order. Ten responses are required.

Instructions: THIS IS TEST 1. I AM GOING TO NAME EACH OF THESE CARDS (Gesture). AS I DO SO, TOUCH THE ONE I HAVE NAMED. ARE YOU READY?

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I NAME THE FIGURE, YOU SHOW ME WHICH ONE WAS NAMED BY TOUCHING IT (demonstrate, using a previous stimulus).

Order of Presentation: (Time for each presentation is 2 seconds.)

Say:

1. "blue triangle, on black"
2. "red X, on green"
3. "green circle, on yellow"
4. "yellow square, on green"
5. "black square, on blue"
6. "red triangle, on black"
7. "blue circle, on red"
8. "black X, on yellow"
9. "yellow cross, on red"
10. "green cross, on blue"

Remove response cards 3 and 4.

GEOMETRIC FIGURES TEST: PART I (Auditory) Cont'd.

_Test_ _2_: Place response cards 5 and 6 before the subject with card 6 closer and within 12 inches of the subject. The stimuli are randomly numbered and are to be presented in their given order. Ten responses are required.

_Instructions_: THIS IS TEST 2. WE WILL DO THE SAME THINGS AS ON THE LAST TEST. ARE YOU READY?

_Repeat_ _if_:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

_Cue_: AS I NAME THE FIGURES, YOU SHOW ME WHICH ONE WAS NAMED BY TOUCHING IT (demonstrate, using a previous stimulus).

_Order_ _of_ _Presentation_: (Time for each presentation is 2 seconds.)

Say:

1. "blue square, on green"
2. "black circle, on red"
3. "red cross, on yellow"
4. "yellow triangle, on black"
5. "blue square, on yellow"
6. "red cross, on blue"
7. "green X, on red"
8. "yellow triangle, on green"
9. "black circle, on blue"
10. "green X, on black"

Remove response cards 5 and 6.

GEOMETRIC FIGURES TEST: PART I (Auditory) Cont'd.

Test 3: Place response cards 7 and 8 before the subject with card 8 closer and within 12 inches of the subject. The stimuli are randomly numbered and are to be presented in their given order. Ten responses are required.

Instructions: THIS IS TEST 3. ARE YOU READY?

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I NAME THE FIGURES, YOU SHOW ME WHICH ONE WAS NAMED BY TOUCHING IT (demonstrate, using a previous stimulus).

Order of Presentation: (Time for each presentation is 2 seconds.)

Say:

1. "green circle, on red cross"
2. "yellow square, on green X"
3. "blue triangle, on red X"
4. "red triangle, on blue X"
5. "red circle, on green cross"
6. "blue square, on yellow cross"
7. "blue circle, on black cross"
8. "green triangle, on black square"
9. "black triangle, on yellow square"
10. "yellow circle, on black X"

Remove response cards 7 and 8.

GEOMETRIC FIGURES TEST: PART I (Auditory) Cont'd.

Test 4: Place response cards 9 and 10 before the subject with card 10 closer and within 12 inches of the subject. The stimuli are randomly numbered and are to be presented in their given order. Ten responses are required.

Instructions: THIS IS TEST 4. ARE YOU READY?

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I NAME THE FIGURES AND CARD, YOU SHOW ME WHICH WAS NAMED BY TOUCHING IT (demonstrate, using a previous stimulus).

Order of Presentation: (Time for each presentation is 3 seconds.)

Say:

1. "green square, blue cross, on yellow card"
2. "black square, yellow cross, on green card"
3. "yellow circle, green cross, on black card"
4. "blue triangle, black X, on red card"
5. "red triangle, yellow square, on blue card"
6. "blue circle, red cross, on black card"
7. "red circle, blue X, on yellow card"
8. "black triangle, yellow X, on red card"
9. "yellow triangle, red square, on green card"
10. "black circle, green X, on blue card"

Remove response cards 9 and 10.

GEOMETRIC FIGURES TEST: PART II (Visual)

Test 1: Place response cards 3 and 4 before the subject with card 4 closer and within 12 inches of the subject. Stimulus cards are randomly numbered and are to be presented in their given order. The order is the same as in the auditory test. Ten responses are required.

Instructions: THIS IS A DIFFERENT TEST. I AM GOING TO SHOW YOU OBJECTS JUST LIKE THOSE IN FRONT OF YOU. WHEN I SHOW YOU THE OBJECT, TOUCH THE ONE IN FRONT OF YOU THAT MATCHES IT. ARE YOU READY? WATCH CAREFULLY.

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I SHOW YOU ONE OF THE FIGURES, TOUCH THE ONE THAT LOOKS LIKE IT (demonstrate, relating a previously used stimulus to one of the figures before the subject).

Order of Presentation: (Time for each presentation is 2 seconds.)

1. blue triangle, on black
2. red X, on green
3. green circle, on yellow
4. yellow square, on green
5. black square, on blue
6. red triangle, on black
7. blue circle, on red
8. black X, on yellow
9. yellow cross, on red
10. green cross, on blue

Remove response cards 3 and 4.

GEOMETRIC FIGURES TEST: PART II (Visual) Cont'd.

Test 2: Place response cards 5 and 6 before the subject with card 6 closer and within 12 inches of the subject. Stimulus cards are randomly numbered and are to be presented in their given order. The ordering is the same as in the auditory test. Ten responses are required.

Instructions: THIS IS TEST 2. ARE YOU READY? WATCH CAREFULLY.

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I SHOW YOU ONE OF THE FIGURES, TOUCH THE ONE THAT LOOKS LIKE IT (demonstrate, relating a previously used stimulus to one of the figures before the subject).

Order of Presentation: (Time for each presentation is 2 seconds.)

1. blue square, on green
2. black circle, on red
3. red cross, on yellow
4. yellow triangle, on black
5. blue square, on yellow
6. red cross, on blue
7. green X, on red
8. yellow triangle, on green
9. black circle, on blue
10. green X, on black

Remove response cards 5 and 6.

GEOMETRIC FIGURES TEST: PART II (Visual) Cont'd.

Test 3: Place response cards 7 and 8 before the subject with card 8 closer and within 12 inches of the subject. Stimulus cards are randomly numbered and are to be presented in their given order. The ordering is the same as in the auditory test. Ten responses are required.

Instructions: THIS IS TEST 3. ARE YOU READY? WATCH CAREFULLY.

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I SHOW YOU ONE OF THE FIGURES, TOUCH THE ONE THAT LOOKS LIKE IT (demonstrate, relating a previously used stimulus to one of the figures before the subject).

Order of Presentation: (Time for each presentation is 2 seconds.)

1. green circle, on red cross
2. yellow square, on green X
3. blue triangle, on red X
4. red triangle, on blue X
5. red circle, on green cross
6. blue square, on yellow cross
7. blue circle, on black cross
8. green triangle, on black square
9. black triangle, on yellow square
10. yellow circle, on black X

Remove response cards 7 and 8.

GEOMETRIC FIGURES TEST: PART II (Visual) Cont'd.

<u>Test 4</u>: Place response cards 9 and 10 before the subject with card 10 closer and within 12 inches of the subject. Stimulus cards are randomly numbered and are to be presented in their given order. The ordering is the same as in the auditory test. Ten responses are required.

<u>Instructions</u>: THIS IS TEST 4. ARE YOU READY? WATCH CAREFULLY.

<u>Repeat if</u>:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

<u>Cue</u>: AS I SHOW YOU THE FIGURES, TOUCH THE ONE THAT LOOKS LIKE IT (demonstrate, relating a previously used stimulus to one of the figures before the subject).

<u>Order of Presentation</u>: (Time for each presentation is 3 seconds.)

1. green square, blue cross, on yellow card
2. black square, yellow cross, on green card
3. yellow circle, green cross, on black card
4. blue triangle, black X, on red card
5. red triangle, yellow square, on blue card
6. blue circle, red cross, on black card
7. red circle, blue X, on yellow card
8. black triangle, yellow X, on red card
9. yellow triangle, red square, on green card
10. black circle, green X, on blue card

Remove response cards 9 and 10.

# APPENDIX B

## Multidimensional Scoring System for GFT and TT

MULTIDIMENSIONAL SCORING SYSTEM* USED WITH GEOMETRIC FIGURES TEST AND TOKEN TEST

| Score | Category | Response Characteristics |
|---|---|---|
| 15 | COMPLETE | Accurate, responsive, complete, prompt, efficient |
| 14 | DISTORTED | Accurate, responsive, complete, prompt, distorted (awkwardness or physical involvement, etc.) |
| 13 | COMPLETE-DELAYED | Accurate, responsive, complete, delayed |
| 12 | INCOMPLETE | Accurate, responsive, incomplete, (correct color and form, but incorrect size), prompt |
| 11 | INCOMPLETE-DELAYED | Accurate, responsive, incomplete, delayed |
| 10 | CORRECTED | Accurate, self-corrected |
| 9 | REPEATED | Accurate, after instructions are repeated |
| 8 | CUED | Accurate, after cue is given |
| 7 | RELATED | Inaccurate, almost accurate (correct form, incorrect color) |
| 6 | ERROR | Inaccurate attempt at task item |
| 5 | INTELLIGIBLE | Comprehensible (perseveration or rejection of the task) |
| 4 | UNINTELLIGIBLE | Incomprehensible but differentiated (e.g., random, unrelated pointing to items) |
| 3 | MINIMAL | Incomprehensible and undifferentiated (e.g., random perseverative responses) |
| 2 | ATTENTION | No response but subject attends to examiner |
| 1 | NO RESPONSE | No response, no awareness of task |

* Adapted from Porch, 1967, Vol. I, p. 12.

# APPENDIX C

## Sample Score Sheet
## for GFT and TT

SAMPLE SCORE SHEET FOR AUDITORY AND VISUAL BATTERIES
OF GEOMETRIC FIGURES TEST AND TOKEN TEST

Name ______________________________ Subject No. __________

Date _________ By _____ Time ____ to ____ Total Time _____

Test (circle one) ____GFT____; ____TT____

Test Situation: ________________________________________

| Time | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test | Pre-V | | Pre-A | | A 1 | | A 2 | | A 3 | | A 4 | | V 1 | | V 2 | | V 3 | | V 4 | |
| Scores | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Item 1 | | | | | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | |
| Mean Score | | | | | | | | | | | | | | | | | | | | |
| Minutes | | | | | | | | | | | | | | | | | | | | |

Response Levels: Auditory __________ Visual __________

Mean Subtest Time: ________________; __________________

Comments: ____________________________________________

# APPENDIX D

## Token Test (TT)
## Auditory and Visual Batteries

## THE TOKEN TEST: PART I (Auditory)

Test 1: Place the card containing only the large rectangles and large circles before the subject. The card must be within easy reach of the subject. Ten responses are required.

Instructions: THIS IS A DIFFERENT TEST, BUT WE WILL DO THE SAME THINGS AS ON THE LAST TEST. ARE YOU READY?

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I NAME ONE OF THE OBJECTS, YOU SHOW ME WHICH ONE WAS NAMED BY TOUCHING IT (demonstrate, using a previous stimulus).

Order of Presentation: (Time for each presentation is 2 seconds.)

Say:

1. "Touch the red rectangle."
2. "Touch the white circle."
3. "Touch the white rectangle."
4. "Touch the yellow circle."
5. "Touch the green circle."
6. "Touch the red circle."
7. "Touch the blue circle."
8. "Touch the yellow rectangle."
9. "Touch the green rectangle."
10. "Touch the blue rectangle."

Remove the card containing only the large rectangles and large circles.

THE TOKEN TEST: PART I (Auditory) Cont'd.

Test 2: Place the card containing all 20 tokens before the subject. The card must be within easy reach of the subject. Ten responses are required.

Instructions: THIS IS TEST 2. ARE YOU READY?

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I NAME ONE OF THE OBJECTS, YOU SHOW ME THE ONE THAT WAS NAMED BY TOUCHING IT (demonstrate, using a previous stimulus).

Order of Presentation: (Time for each presentation is 2 seconds.)

Say:

1. "Touch the large yellow rectangle."
2. "Touch the large green rectangle."
3. "Touch the large blue circle."
4. "Touch the small green rectangle."
5. "Touch the small yellow rectangle."
6. "Touch the small blue circle."
7. "Touch the large green circle."
8. "Touch the small white rectangle."
9. "Touch the large white circle."
10. "Touch the large red rectangle."

Remove the card containing all 20 tokens.

THE TOKEN TEST: PART I (Auditory) Cont'd.

Test 3: Place the card containing only the large rectangles and large circles before the subject. The card must be within easy reach of the subject. Ten responses are required.

Instructions: THIS IS TEST 3. ARE YOU READY?

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I NAME THE OBJECTS, YOU SHOW ME WHICH OBJECTS WERE NAMED BY TOUCHING THEM (demonstrate, using a previous stimulus).

Order of Presentation: (Time for each presentation is 3 seconds.)

Say:

1. "Touch the yellow rectangle and the blue rectangle."
2. "Touch the red circle and the red rectangle."
3. "Touch the white rectangle and the blue circle."
4. "Touch the green circle and the yellow circle."
5. "Touch the green rectangle and the white circle."
6. "Touch the white circle and the green rectangle."
7. "Touch the red circle and the blue circle."
8. "Touch the red rectangle and the yellow rectangle."
9. "Touch the blue rectangle and the green circle."
10. "Touch the white rectangle and the yellow circle."

Remove the card containing only the large rectangles and large circles.

Test 4: Place the card containing all tokens before the subject. The card must be within easy reach of the subject. Ten responses are required.

Instructions: THIS IS TEST 4. ARE YOU READY?

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I NAME THE OBJECTS, YOU SHOW ME WHICH OBJECTS I HAVE NAMED BY TOUCHING THEM (demonstrate, using a previous stimulus).

Order of Presentation: (Time for each presentation is 4 seconds.)

Say:

1. "Touch the small blue rectangle and the small white rectangle."
2. "Touch the large white rectangle and the large white circle."
3. "Touch the large green circle and the small green rectangle."
4. "Touch the small red circle and the large green rectangle."
5. "Touch the small red rectangle and the small white circle."
6. "Touch the small blue circle and the large blue rectangle."
7. "Touch the small yellow circle and the large red rectangle."
8. "Touch the large yellow rectangle and the small green circle."
9. "Touch the large red circle and the small yellow rectangle."
10. "Touch the large yellow circle and the large blue circle."

Remove the card containing all tokens.

## THE TOKEN TEST: PART II (Visual)

Test 1: Place the card containing only the large rectangles and large circles before the subject. Each stimulus is presented in a two-step sequence. First, the reverse side of the stimulus card is shown for approximately one second. Second, the card is turned over, thus exposing the given token to the subject. The card must be within easy reach of the subject. Ten responses are required.

Instructions: THIS IS A DIFFERENT TEST. I AM GOING TO SHOW YOU OBJECTS JUST LIKE THOSE IN FRONT OF YOU. WHEN I SHOW YOU THE OBJECT, TOUCH THE ONE IN FRONT OF YOU THAT MATCHES IT. ARE YOU READY? WATCH CAREFULLY.

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I SHOW YOU ONE OF THE OBJECTS, TOUCH THE ONE THAT LOOKS LIKE IT (demonstrate, relating a previously used stimulus to one of the tokens before the subject).

Order of Presentation: (Time for each presentation is 2 seconds.)

1. red rectangle
2. white circle
3. white rectangle
4. yellow circle
5. green circle
6. red circle
7. blue circle
8. green rectangle
9. yellow rectangle
10. blue rectangle

Remove the card containing only the large rectangles and large circles.

THE TOKEN TEST: PART II (Visual) Cont'd.

Test 2: Place the card containing all 20 tokens before the subject. The card must be within easy reach of the subject. Ten responses are required.

Instructions: THIS IS TEST 2. ARE YOU READY? WATCH CAREFULLY.

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I SHOW YOU ONE OF THE OBJECTS, TOUCH THE ONE THAT LOOKS LIKE IT (demonstrate, relating a previously used stimulus to one of the tokens before the subject).

Order of Presentation: (Time for each presentation is 2 seconds.)

1. large yellow rectangle
2. large green rectangle
3. large blue circle
4. small green rectangle
5. small yellow rectangle
6. small blue circle
7. large green circle
8. small white rectangle
9. large white circle
10. large red circle

Remove the card containing all 20 tokens.

THE TOKEN TEST: PART II (Visual) Cont'd.

Test 3: Place the card containing only the large rectangles and large circles before the subject. The card must be within easy reach of the subject. Ten responses are required.

Instructions: THIS IS TEST 3. ARE YOU READY? WATCH CAREFULLY.

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I SHOW YOU ONE OF THE OBJECTS, TOUCH THE ONE THAT LOOKS LIKE IT (demonstrate, relating a previously used stimulus to one of the tokens before the subject).

Order of Presentation: (Time for each presentation is 3 seconds.)

1. yellow rectangle and blue rectangle
2. red circle and green rectangle
3. white rectangle and blue circle
4. green circle and yellow circle
5. green rectangle and white circle
6. white circle and red rectangle
7. red circle and blue circle
8. red rectangle and yellow rectangle
9. blue rectangle and green circle
10. white rectangle and yellow circle

Remove the card containing only the large rectangles and large circles.

THE TOKEN TEST: PART II (Visual) Cont'd.

Test 4: Place the card containing all 20 tokens before the subject. The card must be within easy reach of the subject. Ten responses are required.

Instructions: THIS IS TEST 4. ARE YOU READY? WATCH CAREFULLY.

Repeat if:
1. the subject requests a repetition
2. the subject gives no response for 30 seconds
3. the subject's responses are inappropriate, indicating that he has not understood the instructions.

Cue: AS I SHOW YOU ONE OF THE OBJECTS, TOUCH THE ONE THAT LOOKS LIKE IT (demonstrate, relating a previously used stimulus to one of the tokens before the subject).

Order of Presentation: (Time for each presentation is 4 seconds.)

1. small blue rectangle and small white rectangle
2. large white rectangle and large white circle
3. large green circle and small green rectangle
5. small red rectangle and small white circle
6. small blue circle and large blue rectangle
7. small yellow circle and large red rectangle
8. large yellow rectangle and small green circle
9. large red circle and small yellow rectangle
10. large yellow circle and large blue circle

Remove the card containing all 20 tokens.

# APPENDIX E

## Subject Information

SUMMARY OF SUBJECT INFORMATION FOR THE 60 SUBJECTS INCLUDED IN THIS STUDY

The variables presented below include: location of injury (LI); age; sex; educational level in years; handedness; occupational level divided into the five categories of unskilled, semi-skilled, skilled, professional, and unemployed; etiologies of vascular, trauma, neoplasm, and degenerative; number of weeks between onset and testing (WPO); those subjects used in the GFT and TT test-retest study ($N_1$=10); those subjects used in the PICA scorer agreement study ($N_2$=10); and the total number correct on the Peabody Picture Vocabulary Test (PPVT) and the Columbia Mental Maturity Scale (CMMS).

| No. | S | LI | Age | Sex | Educ. | Hand. | Occ. | Etiol. | WPO | $N_1$=10 | $N_2$=10 | PPVT | CMMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | W.A. | L | 34 | M | 16 | R | Pf | V | 15 | | X | 62 | 68 |
| 2 | T.C. | L | 32 | F | 16 | R | Pf | V | 30 | | X | 102 | 76 |
| 3 | S.L. | L | 47 | M | 8 | R | Ss | V | 174 | X | X | 75 | 67 |
| 4 | M.M. | L | 54 | M | 16 | R | Pf | V | 52 | | | 137 | 69 |
| 5 | J.J. | L | 49 | F | 12 | R | Ue | V | 104 | | | 131 | 75 |
| 6 | M.A. | L | 62 | F | 8 | R | Us | V | 67 | X | | 63 | 70 |
| 7 | G.M. | L | 63 | M | 7 | R | Ss | V | 113 | | | 113 | 78 |
| 8 | R.K. | L | 58 | F | 12 | R | Us | V | 49 | X | | 106 | 83 |
| 9 | J.B. | L | 43 | M | 12 | R | Sk | V | 124 | | X | 108 | 81 |
| 10 | F.B. | L | 24 | M | 10 | R | Ue | V | 8 | | | 91 | 71 |
| 11 | L.D. | L | 66 | F | 16 | R | Pf | V | 10 | | | 132 | 82 |
| 12 | M.M. | L | 52 | M | 13 | R | Ss | V | 1 | | | 145 | 84 |
| 13 | H.B. | L | 63 | M | 12 | R | Ss | V | 81 | | | 124 | 74 |
| 14 | J.R. | L | 45 | F | 8 | R | Us | V | 38 | | | 86 | 77 |
| 15 | R.S. | L | 66 | F | 10 | R | Ss | V | 42 | | | 78 | 69 |
| 16 | L.C. | R | 43 | M | 13 | R | Sk | N | 4 | | X | 129 | 71 |
| 17 | J.P. | R | 19 | M | 12 | L | Ss | T | 38 | | X | 115 | 67 |
| 18 | M.L. | R | 49 | F | 12 | R | Us | V | 42 | X | | 119 | 61 |
| 19 | M.G. | R | 58 | F | 9 | R | Us | V | 17 | | | 112 | 63 |
| 20 | W.S. | R | 34 | F | 12 | R | Us | V | 38 | X | | 115 | 58 |
| 21 | A.C. | R | 57 | F | 13 | R | Ss | V | 102 | | | 143 | 85 |

| No. | S | LI | Age | Sex | Educ. | Hand. | Occ. | Etiol. | WPO | $N_1$=10 | $N_2$=10 | PPVT | CMMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | A.C. | R | 57 | F | 13 | R | Ss | V | 102 | | | 143 | 85 |
| 22 | J.T. | R | 52 | F | 16 | R | Sk | V | 84 | | | 135 | 75 |
| 23 | J.S. | R | 60 | M | 7 | R | Us | V | 8 | | | 77 | 72 |
| 24 | L.B. | R | 73 | M | 4 | R | Us | V | 10 | X | | 65 | 68 |
| 25 | M.B. | R | 74 | F | 8 | R | Us | V | 40 | | | 125 | 69 |
| 26 | E.C. | R | 73 | F | 16 | L | Sk | V | 85 | | | 139 | 82 |
| 27 | O.I. | R | 56 | M | 7 | R | Us | V | 48 | | | 113 | 51 |
| 28 | C.M. | R | 52 | M | 10 | R | Ss | V | 2 | | | 116 | 67 |
| 29 | J.S. | R | 55 | M | 8 | R | Us | N | 47 | | | 88 | 78 |
| 30 | O.B. | R | 63 | M | 8 | R | Us | V | 19 | | | 94 | 77 |
| 31 | F.L. | BL | 52 | M | 8 | R | Us | V | 2 | | | 103 | 60 |
| 32 | A.M. | BL | 53 | M | 6 | R | Us | V | 37 | X | | 72 | 54 |
| 33 | M.O. | BL | 57 | F | 14 | R | Sk | V | 140 | | | 73 | 63 |
| 34 | J.S. | BL | 54 | M | 6 | R | Us | V | 52 | | | 66 | 58 |
| 35 | J.R. | BL | 19 | M | 13 | R | Us | T | 61 | X | | 106 | 73 |
| 36 | P.M. | BL | 62 | M | 8 | R | Sk | V | 6 | | | 125 | 59 |
| 37 | C.B. | BL | 46 | M | 14 | R | Sk | V | 4 | | X | 113 | 69 |
| 38 | J.C. | BL | 49 | M | 16 | R | Pf | D | 52 | | X | 135 | 76 |
| 39 | A.O. | BL | 68 | M | 14 | R | Sk | V | 49 | | | 113 | 75 |
| 40 | E.Y. | BL | 67 | M | 8 | R | Ss | V | 196 | | | 94 | 74 |
| 41 | J.S. | BL | 29 | M | 7 | R | Us | N | 43 | | | 96 | 75 |
| 42 | P.C. | BL | 73 | F | 7 | R | Us | V | 7 | | | 86 | 57 |
| 43 | H.F. | BL | 47 | M | 12 | R | Sk | T | 3 | | X | 133 | 78 |
| 44 | R.A. | BL | 82 | M | 8 | R | Us | V | 1 | | | 43 | 56 |
| 45 | E.S. | BL | 51 | M | 4 | R | Ss | T | 25 | | | 102 | 77 |
| 46 | T.B. | C | 22 | M | 12 | R | Ss | | | | | 119 | 87 |
| 47 | A.F. | C | 33 | M | 12 | R | Us | | | | | 105 | 88 |
| 48 | A.V. | C | 48 | M | 10 | R | Ss | | | | | 113 | 82 |
| 49 | K.H. | C | 46 | M | 7 | R | Us | | | X | | 120 | 71 |
| 50 | E.B. | C | 67 | F | 13 | R | Ss | | | | | 129 | 96 |
| 51 | A.V. | C | 37 | M | 3 | R | Us | | | | | 98 | 87 |
| 52 | F.S. | C | 37 | M | 12 | R | Ss | | | | | 118 | 78 |
| 53 | D.G. | C | 48 | M | 8 | R | Ss | | | | | 93 | 79 |

| No. | S | LI | Age | Sex | Educ. | Hand. | Occ. | Etiol. | WPO | $N_1=10$ | $N_2=10$ | PPVT | CMMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 54 | F.M. | C | 24 | M | 14 | R | Ss | | | | | 126 | 91 |
| 55 | P.S. | C | 48 | M | 8 | R | Us | | | | | 92 | 78 |
| 56 | J.G. | C | 43 | M | 18 | R | Pf | | | | | 130 | 84 |
| 57 | A.C. | C | 46 | M | 10 | R | Ss | | | | | 125 | 72 |
| 58 | C.C. | C | 54 | M | 14 | R | Sk | | | | | 98 | 76 |
| 59 | G.C. | C | 46 | M | 7 | R | Us | | | | | 81 | 73 |
| 60 | S.W. | C | 63 | F | 11 | R | Ss | | | X | | 140 | 91 |

MEANS, STANDARD DEVIATIONS, AND RANGES FOR EACH OF THE EXPERIMENTAL GROUPS ON THE VARIABLES OF AGE, EDUCATIONAL LEVEL, AND NUMBER OF WEEKS POST-ONSET (WPO)

| Experimental Groups | Age | | | Educational Level | | | WPO | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | Range | Mean | S.D. | Range | Mean | S.D. | Range |
| Left | 50.53 | 13.13 | 24-66 | 11.73 | 3.21 | 7-16 | 60.53 | 49.94 | 1-174 |
| Right | 54.53 | 14.74 | 19-74 | 10.33 | 3.45 | 4-16 | 38.93 | 31.10 | 2-102 |
| Bilateral | 53.93 | 16.00 | 19-82 | 9.66 | 3.75 | 4-16 | 45.20 | 55.33 | 1-196 |
| Control | 44.13 | 12.40 | 22-67 | 10.60 | 3.66 | 3-18 | | | |

DISTRIBUTION OF SUBJECTS BY AGE
AND LOCATION OF INJURY

| Age | Left | Right | Bilateral | Control | Total |
|---|---|---|---|---|---|
| 16-25 | 1 | 1 | 1 | 2 | 5 |
| 26-35 | 2 | 1 | 1 | 1 | 5 |
| 36-45 | 2 | 1 | 0 | 3 | 6 |
| 46-55 | 4 | 4 | 7 | 7 | 22 |
| 56-65 | 4 | 5 | 2 | 1 | 12 |
| 66-75 | 2 | 3 | 3 | 1 | 9 |
| 76-85 | 0 | 0 | 1 | 0 | 1 |
| TOTAL | 15 | 15 | 15 | 15 | 60 |

DISTRIBUTION OF SUBJECTS BY EDUCATION
AND LOCATION OF INJURY

| Education | Left | Right | Bilateral | Control | Total |
|---|---|---|---|---|---|
| 1-3 | 0 | 0 | 0 | 1 | 1 |
| 4-6 | 0 | 1 | 3 | 0 | 4 |
| 7-9 | 4 | 6 | 6 | 4 | 20 |
| 10-12 | 6 | 4 | 1 | 6 | 17 |
| 13-16 | 5 | 4 | 5 | 3 | 17 |
| 17-18 | 0 | 0 | 0 | 1 | 1 |
| TOTAL | 15 | 15 | 15 | 15 | 60 |

DISTRIBUTION OF SUBJECTS BY WEEKS POST-ONSET AND LOCATION OF INJURY

| WPO | Left | Right | Bilateral | Total |
|---|---|---|---|---|
| 1-2 | 1 | 1 | 2 | 4 |
| 3-4 | 0 | 1 | 2 | 3 |
| 5-6 | 0 | 0 | 1 | 1 |
| 7-10 | 2 | 2 | 1 | 5 |
| 11-15 | 1 | 0 | 0 | 1 |
| 16-20 | 0 | 2 | 0 | 2 |
| 21-30 | 1 | 0 | 1 | 2 |
| 31-40 | 1 | 3 | 1 | 5 |
| 41-50 | 2 | 3 | 2 | 7 |
| 51-60 | 1 | 0 | 2 | 3 |
| 61-80 | 1 | 0 | 1 | 2 |
| 81-100 | 1 | 2 | 0 | 3 |
| 101-120 | 2 | 1 | 0 | 3 |
| 121-140 | 1 | 0 | 1 | 2 |
| 141-180 | 1 | 0 | 0 | 1 |
| 181-200 | 0 | 0 | 1 | 1 |
| TOTAL | 15 | 15 | 15 | 45 |

# APPENDIX F

## Geometric Figures Test
## Correlation Matrix of Results
## from Test-Retest Series

CORRELATION MATRIX OF RELATIONSHIPS BETWEEN RESULTS OBTAINED FROM TEST-RETEST SERIES OF THE GEOMETRIC FIGURES TEST (N = 10)*

| Retest | Initial Test | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_{\overline{X}}$ | $A_t$ | $V_1$ | $V_2$ | $V_3$ | $V_4$ | $V_{\overline{X}}$ | $V_t$ |
| $A_1$ | .99 | .96 | .96 | .96 | .99 | -.75 | .88 | .83 | .69 | .45 | .76 | -.71 |
| $A_2$ | .98 | .99 | .94 | .95 | .98 | -.80 | .92 | .84 | .72 | .45 | .79 | -.79 |
| $A_3$ | .94 | .96 | .98 | .94 | .97 | -.89 | .77 | .66 | .58 | .34 | .65 | -.63 |
| $A_4$ | .94 | .93 | .96 | .99 | .96 | -.74 | .77 | .70 | .60 | .39 | .66 | -.67 |
| $A_{\overline{X}}$ | .98 | .97 | .98 | .98 | .99 | -.81 | .87 | .79 | .67 | .42 | .74 | -.70 |
| $A_t$ | -.81 | -.91 | -.88 | -.79 | -.84 | .99 | -.72 | -.57 | -.61 | -.40 | -.67 | .70 |
| $V_1$ | .73 | .80 | .71 | .62 | .73 | -.79 | .97 | .90 | .89 | .69 | .93 | -.89 |
| $V_2$ | .64 | .68 | .48 | .60 | .61 | -.44 | .77 | .88 | .79 | .70 | .81 | -.79 |
| $V_3$ | .78 | .81 | .74 | .70 | .77 | -.73 | .93 | .93 | .93 | .67 | .93 | -.92 |
| $V_4$ | .38 | .40 | .35 | .30 | .36 | -.43 | .63 | .63 | .89 | .97 | .88 | -.77 |
| $V_{\overline{X}}$ | .74 | .76 | .65 | .64 | .71 | -.66 | .92 | .94 | .96 | .80 | .97 | -.92 |
| $V_t$ | -.65 | -.73 | -.65 | -.61 | -.67 | .75 | -.87 | -.86 | -.94 | -.77 | -.93 | .99 |

$A_{1-4}$ = The four auditory subtests

$A_{\overline{X}}$ = The mean of the four auditory subtests

$A_t$ = Total time necessary to complete the four auditory subtests

$V_{1-4}$ = The four visual subtests

$V_{\overline{X}}$ = The mean of the four visual subtests

$V_t$ = Total time necessary to complete the four visual subtests

* $r_{.95}$ (2,8) = .632

* $r_{.99}$ (2,8) = .765

# APPENDIX G

## Token Test
## Correlation Matrix of Results from Test-Retest Series

CORRELATION MATRIX OF RELATIONSHIPS BETWEEN RESULTS OBTAINED FROM TEST-RETEST SERIES OF THE TOKEN TEST (N = 10)*

| Retest | Initial Test | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_{\overline{X}}$ | $A_t$ | $V_1$ | $V_2$ | $V_3$ | $V_4$ | $V_{\overline{X}}$ | $V_t$ |
| $A_1$ | .99 | .83 | .86 | .83 | .89 | -.58 | .94 | .97 | .79 | .78 | .68 | -.86 |
| $A_2$ | .85 | .99 | .97 | .92 | .98 | -.55 | .84 | .79 | .62 | .55 | .37 | -.81 |
| $A_3$ | .86 | .98 | .99 | .94 | .99 | -.60 | .85 | .85 | .70 | .62 | .41 | -.91 |
| $A_4$ | .84 | .92 | .95 | .99 | .98 | -.79 | .74 | .82 | .80 | .71 | .61 | -.92 |
| $A_{\overline{X}}$ | .90 | .97 | .98 | .97 | .99 | -.66 | .86 | .88 | .75 | .68 | .52 | -.91 |
| $A_t$ | -.63 | -.55 | -.66 | -.83 | -.70 | .99 | -.39 | -.61 | -.81 | -.70 | -.81 | .77 |
| $V_1$ | .97 | .89 | .90 | .85 | .92 | -.57 | .97 | .97 | .76 | .70 | .51 | -.88 |
| $V_2$ | .94 | .79 | .78 | .77 | .83 | -.58 | .90 | .97 | .80 | .83 | .70 | -.81 |
| $V_3$ | .74 | .65 | .69 | .81 | .75 | -.85 | .62 | .76 | .98 | .86 | .73 | -.85 |
| $V_4$ | .77 | .59 | .64 | .69 | .68 | -.65 | .67 | .83 | .88 | .99 | .76 | -.81 |
| $V_{\overline{X}}$ | .89 | .76 | .79 | .84 | .84 | -.75 | .81 | .93 | .96 | .95 | .75 | -.91 |
| $V_t$ | -.83 | -.78 | -.84 | -.87 | -.86 | .78 | -.76 | -.89 | -.86 | -.82 | -.56 | .99 |

$A_{1-4}$ = The four auditory subtests

$A_{\overline{X}}$ = The mean of the four auditory subtests

$A_t$ = Total time necessary to complete the four auditory subtests

$V_{1-4}$ = The four visual subtests

$V_{\overline{X}}$ = The mean of the four visual subtests

$V_t$ = Total time necessary to complete the four visual subtests

* $r_{.95}$ (2,8) = .632

* $r_{.99}$ (2,8) = .765

# APPENDIX H

## Supplementary Tests
## PICA, PPVT, and CMMS

## PORCH INDEX OF COMMUNICATIVE ABILITY

Quantification of subjects' communicative ability was accomplished with the PICA. Subtest means for the four groups show the relationships between the groups on each of the 18 subtests.

The control group, while scoring higher than the other groups, obtained lower scores than might have been expected. Certain control subjects had relatively little education and, therefore, had considerable difficulty with some of the reading and writing tasks.

The right hemisphere lesion group approximated the control group on most subtests. These relationships might be expected since language involvement is seldom associated with right hemisphere lesions. However, it would appear that the lesions do have an overall effect which depresses the test performances of subjects with right hemisphere lesions.

The left hemisphere and bilateral lesion groups approximated one another quite closely, and were considerably depressed in comparison to the right hemisphere lesion and control groups on the majority of subtests, findings which are expected in consideration of the relationship between language functions and the left cerebral hemisphere.

The greatest differences between the left and bilateral lesion groups were found to be on graphic subtests E and F, and on gestural tasks V, VIII, and XI, which involve visual input ability. Similar relationships can be seen between these groups in profiles presented in Volume II of the PICA manuals (Porch, 1967, p. 84). A comparison of the profiles for the left and bilateral lesion groups of the present study with those presented by Porch reveals that both of the former groups performed comparatively higher on all subtests than what might be expected of larger, more representative samples. This observation was not considered to be of major importance, however, since the basic differences between groups in both studies are highly similar.

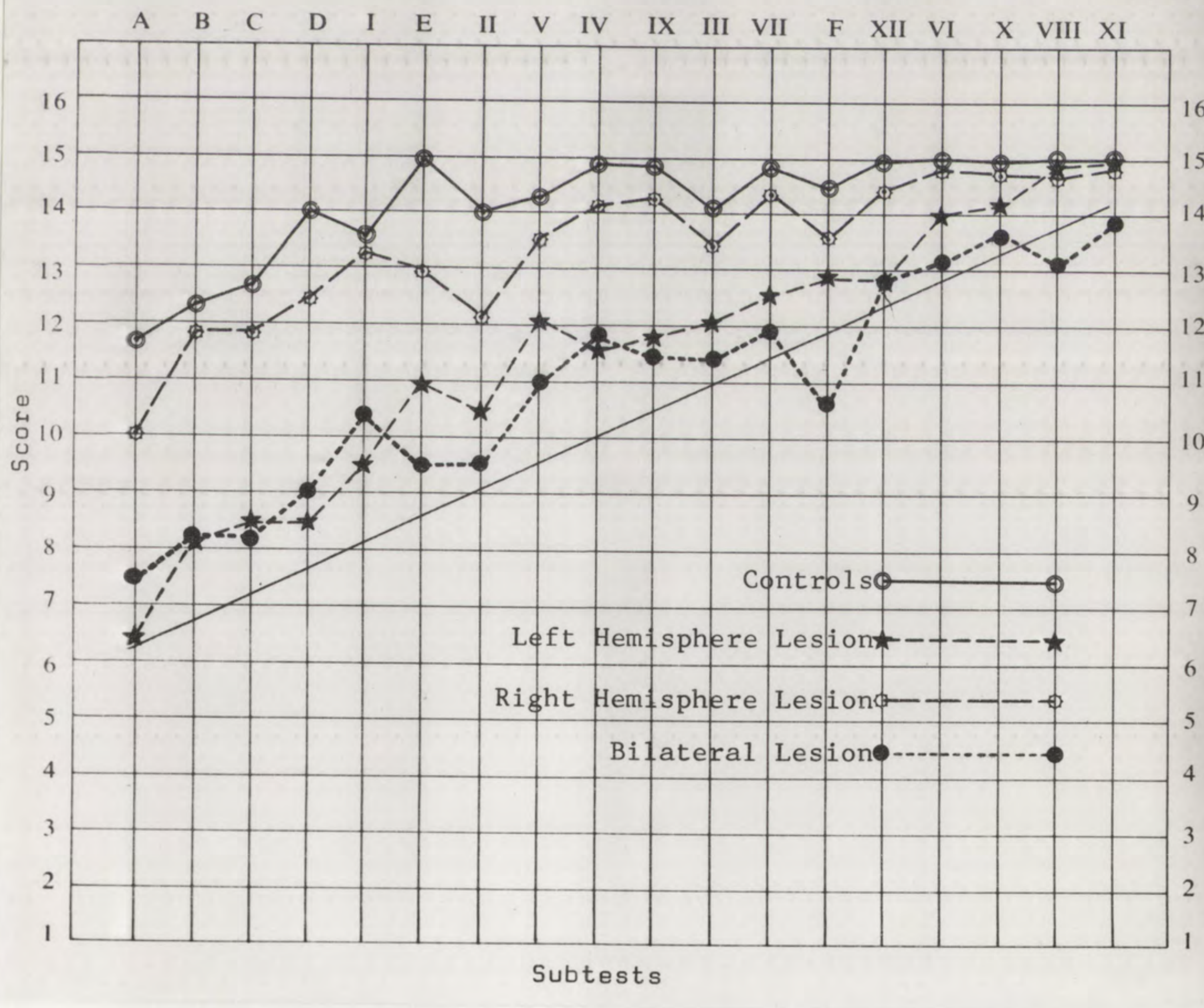
OVERALL SCORES ON PORCH INDEX OF COMMUNICATIVE ABILITY FOR EXPERIMENTAL AND CONTROL GROUPS

| Subject Number* | Group | | | |
|---|---|---|---|---|
| | Left | Right | Bilateral | Control |
| 1 | 8.31 | 13.98 | 13.23 | 14.58 |
| 2 | 9.37 | 13.80 | 9.97 | 13.69 |
| 3 | 12.06 | 14.74 | 5.83 | 13.94 |
| 4 | 11.81 | 14.19 | 7.25 | 14.63 |
| 5 | 13.46 | 13.54 | 12.89 | 14.66 |
| 6 | 7.53 | 14.59 | 12.57 | 12.75 |
| 7 | 11.39 | 14.19 | 12.53 | 14.78 |
| 8 | 11.89 | 12.06 | 12.57 | 13.90 |
| 9 | 13.10 | 12.42 | 12.25 | 14.63 |
| 10 | 11.97 | 12.69 | 7.43 | 14.07 |
| 11 | 13.33 | 14.16 | 13.00 | 14.31 |
| 12 | 12.38 | 13.91 | 12.74 | 14.29 |
| 13 | 10.72 | 13.33 | 13.98 | 12.89 |
| 14 | 12.66 | 12.50 | 5.76 | 12.76 |
| 15 | 12.78 | 11.91 | 12.58 | 14.78 |
| Mean | 11.52 | 13.47 | 10.97 | 14.04 |
| S.D. | 1.80 | 0.92 | 2.90 | 0.72 |

* Subjects by group are in the same order as they appear in Appendix E.

RANKED RESPONSE SUMMARY OF THE THREE EXPERIMENTAL GROUPS AND THE CONTROL GROUP ON THE PORCH INDEX OF COMMUNICATIVE ABILITY

| | | | | |
|---|---|---|---|---|
| Control: | Overall 14.04; | Gestural 14.54; | Verbal 14.58; | Graphic 13.05 |
| Right: | Overall 13.47; | Gestural 14.07; | Verbal 14.06; | Graphic 12.02 |
| Left: | Overall 11.52; | Gestural 13.21; | Verbal 11.42; | Graphic 9.25 |
| Bilateral: | Overall 10.97; | Gestural 12.25; | Verbal 11.67; | Graphic 8.96 |



## PEABODY PICTURE VOCABULARY TEST

From group data for items 1-50, 51-100, and 101-150 on the Peabody Picture Vocabulary Test, it can be seen that for all groups there was a decrease in scores and an increase in time for each successive block of 50 items. The bilateral lesion group was consistently lower in obtained scores and required more time for each block of 50 items than any of the other three groups.

It is of interest to note that all groups maintained the same relative positions with respect to obtained scores. There was only one exception; on items 101-150, the control group's scores fell below those of the left and right hemisphere lesion groups. Although there were no significant differences between groups on educational level, the findings relative to items 101-150 may be related to the fact that the range of educational levels for the control group extended to a lower level than for the experimental groups. That is, those controls with the lowest educational levels may have reached their peak abilities on items 51-100 of the PPVT, and therefore caused a lowering of the group mean on items 101-150.

An analysis of variance on the three blocks of scores obtained by the groups and an analysis of variance on time for the three blocks on the PPVT were computed. The differences between the groups on obtained scores were not significant. However, the difference between groups on time was significant beyond the .01 level for each of the three blocks: 1-50, 51-100, and 101-150.

The "c" statistic shows that, as with certain other measures, the bilateral group required a significantly greater amount of time than the control subjects.

MEANS, STANDARD DEVIATIONS, AND RANGES OF TEST SCORES AND TEST TIMES FOR ITEMS 1-50, 51-100, AND 101-150 OF THE PPVT FOR CONTROL AND EXPERIMENTAL GROUPS

| Group | Scores | | | Time in Minutes | | |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Range | Mean | S.D. | Range |
| **1-50** | | | | | | |
| Left | 46.6 | 6.06 | 32-50 | 5.86 | 1.99 | 4-10 |
| Right | 47.2 | 4.86 | 34-50 | 5.53 | 1.99 | 2-10 |
| Bilateral | 44.4 | 9.32 | 17-50 | 8.33 | 5.27 | 3-25 |
| Control | 49.6 | .62 | 48-50 | 3.46 | 1.12 | 2-5 |
| **51-100** | | | | | | |
| Left | 34.9 | 12.12 | 17-49 | 9.27 | 3.86 | 4-16 |
| Right | 39.3 | 10.52 | 17-50 | 7.80 | 2.73 | 5-13 |
| Bilateral | 33.2 | 12.20 | 10-48 | 11.40 | 5.42 | 5-23 |
| Control | 41.0 | 8.90 | 20-50 | 5.93 | 2.19 | 3-11 |
| **101-150** | | | | | | |
| Left | 22.0 | 12.37 | 4-47 | 11.13 | 3.31 | 5-19 |
| Right | 25.9 | 9.57 | 13-43 | 10.00 | 3.63 | 6-22 |
| Bilateral | 19.7 | 8.23 | 9-37 | 13.20 | 4.14 | 8-20 |
| Control | 21.8 | 8.81 | 7-40 | 8.93 | 2.40 | 5-13 |

ANALYSIS OF VARIANCE ON TEST SCORES AND TEST TIMES
FOR PPVT ITEMS 1-50, 51-100, AND 101-150
FOR CONTROL AND EXPERIMENTAL GROUPS

| Items | Source | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|---|
| | | | Scores | | |
| 1-50 | Treatments | 3 | 211.5 | 70.51 | 1.91 |
| | Within | 56 | 2067.5 | 36.92 | |
| | Total | 59 | 2279.0 | | |
| 51-100 | Treatments | 3 | 601.5 | 200.50 | 1.65 |
| | Within | 56 | 6797.5 | 121.40 | |
| | Total | 59 | 7399.0 | | |
| 101-150 | Treatments | 3 | 301.7 | 100.60 | 1.03 |
| | Within | 56 | 5462.3 | 97.54 | |
| | Total | 59 | 5764.0 | | |
| | | | Time in Minutes | | |
| 1-50 | Treatments | 3 | 179.1 | 59.69 | 6.45** |
| | Within | 56 | 518.5 | 9.26 | |
| | Total | 59 | 697.6 | | |
| 51-100 | Treatments | 3 | 240.5 | 80.18 | 5.67** |
| | Within | 56 | 791.9 | 14.14 | |
| | Total | 59 | 1032.4 | | |
| 101-150 | Treatments | 3 | 149.9 | 49.97 | 4.25** |
| | Within | 56 | 659.1 | 11.77 | |
| | Total | 59 | 809.0 | | |

** Significant beyond the .01 level of confidence

"c" STATISTIC ON TIMES FOR PPVT ITEMS
1-50, 51-100, AND 101-150 FOR
CONTROL AND EXPERIMENTAL GROUPS

| Groups | 1-50<br>"c" | 51-100<br>"c" | 101-150<br>"c" |
|---|---|---|---|
| L x R | .30 | 1.07 | .92 |
| L x BL | 2.22 | 1.55 | 1.70 |
| L x C | 2.16 | 2.43 | 1.06 |
| R x C | 1.86 | 1.36 | .87 |
| R x BL | 2.52 | 2.62 | 2.60 |
| C x BL | 4.37** | 3.98** | 3.47** |

** Significant beyond the .01 level of confidence

## COLUMBIA MENTAL MATURITY SCALE

As can be seen from group data for five blocks of items on the Columbia Mental Maturity Scale (items 1-20, 21-40, 41-60, 61-80, and 81-100), the bilateral lesion group obtained the lowest mean score and required the greatest amount of time to complete the items on all five blocks. Of particular interest, the left hemisphere lesion group obtained higher scores than the right hemisphere lesion group on all blocks of items except 1-20, a finding that is in agreement with other tasks requiring visual input presented above.

Also of interest is the observation that on auditory input tasks, the left hemisphere and bilateral lesion groups obtained similar scores and required similar amounts of time to complete the tasks. On visual input tests, however, the left hemisphere lesion group obtained higher scores than the bilateral lesion group and required considerably less time to do so.

The analysis of variance on scores for each block of CMMS items shows that the groups differed significantly on all but the first block, items 1-20. The differences between groups on items 21-40 and 81-100 were beyond the .05 level, while differences on items 41-60 and 61-80 were significant beyond the .01 level.

In the analysis of variance on times for each of the five blocks of the CMMS, the groups were shown to differ significantly on all but the last block of items, items 81-100. The differences between groups were beyond the .05 level for items 1-20, and beyond the .01 level for items 21-40, 41-60, and 61-80.

A summary of the "c" statistic on scores for CMMS items 21-40, 41-60, 61-80, and 81-100 shows that there were no significant differences between the groups on scores for items 21-40 of the CMMS. On items 41-60, the bilateral lesion group obtained scores which were significantly lower than the left hemisphere lesion group and the control group beyond the .01 level. The right hemisphere lesion group also differed from the control group, but beyond the .05 level of confidence only.

On items 61-80, the difference between the left hemisphere lesion group and controls was significant beyond the .05 level, while the right hemisphere lesion group differed from the controls beyond the .01 level. The bilateral lesion group also obtained scores which were significantly lower than those of the controls beyond the .01 level.

On items 81-100, only the right hemisphere lesion and control groups differed significantly. This difference is beyond the .05 level.

A summary of the "c" statistic on time for CMMS items 1-20, 21-40, 41-60, and 61-80 shows that the bilateral lesion group required a significantly greater amount of time than the control group on these four blocks of items. These differences were beyond the .05 level for items 1-20, and beyond the .01 level for items 21-40, 41-60, and 61-80.

The bilateral lesion group also required a significantly greater amount of time than the left hemisphere lesion group on items 21-40 ("c" $<$ .05) and items 41-60 ("c" $<$ .01). Similarly, the differences between the bilateral and right hemisphere lesion groups were beyond the .01 level of confidence for items 41-60.

MEANS, STANDARD DEVIATIONS, AND RANGES OF TEST SCORES AND TEST TIMES FOR CONTROL AND EXPERIMENTAL GROUPS ON ITEMS 1-20, 21-40, 41-60, 61-80, AND 81-100 OF THE CMMS

| Group | Scores Mean | Scores S.D. | Scores Range | Time in Minutes Mean | Time in Minutes S.D. | Time in Minutes Range |
|---|---|---|---|---|---|---|
| | | | 1-20 | | | |
| Left | 19.93 | .26 | 19-20 | 1.93 | 1.16 | 1-5 |
| Right | 20.00 | --- | --- | 1.80 | 1.08 | 1-5 |
| Bilateral | 19.46 | 1.30 | 15-20 | 4.73 | 5.99 | 1-23 |
| Control | 19.80 | .56 | 18-20 | 1.53 | .74 | 1-3 |
| | | | 21-40 | | | |
| Left | 19.86 | .35 | 19-20 | 1.80 | 1.01 | 1-5 |
| Right | 19.40 | .73 | 18-20 | 2.00 | .75 | 1-4 |
| Bilateral | 19.33 | 1.11 | 16-20 | 3.13 | 1.72 | 2-7 |
| Control | 20.00 | --- | --- | 1.73 | .80 | 1-4 |
| | | | 41-60 | | | |
| Left | 18.13 | 1.68 | 15-20 | 4.06 | 1.39 | 2-7 |
| Right | 16.00 | 3.68 | 7-20 | 4.26 | 1.83 | 2-8 |
| Bilateral | 14.20 | 3.86 | 8-20 | 7.13 | 3.50 | 2-15 |
| Control | 19.26 | .96 | 17-20 | 3.13 | 1.19 | 2-5 |
| | | | 61-80 | | | |
| Left | 10.20 | 4.24 | 3-17 | 7.86 | 3.02 | 4-13 |
| Right | 8.46 | 3.96 | 2-16 | 6.13 | 1.99 | 4-11 |
| Bilateral | 7.53 | 3.94 | 1-13 | 9.40 | 5.47 | 4-22 |
| Control | 14.46 | 3.16 | 10-20 | 5.13 | 2.06 | 2-9 |

MEANS, STANDARD DEVIATIONS, AND RANGES OF TEST SCORES AND TEST TIMES FOR CONTROL AND EXPERIMENTAL GROUPS ON ITEMS 1-20, 21-40, 41-60, 61-80, AND 81-100 OF THE CMMS, CONT'D

| Group | 81-100 | | | | | |
|---|---|---|---|---|---|---|
| | Scores | | | Time in Minutes | | |
| | Mean | S.D. | Range | Mean | S.D. | Range |
| Left | 6.80 | 2.24 | 3-11 | 8.53 | 4.14 | 4-18 |
| Right | 5.73 | 2.15 | 2-9 | 6.33 | 2.71 | 3-13 |
| Bilateral | 6.40 | 2.35 | 3-12 | 8.80 | 7.16 | 3-32 |
| Control | 8.66 | 4.20 | 3-16 | 6.00 | 2.10 | 3-9 |

ANALYSIS OF VARIANCE ON TEST SCORES FOR CMMS
ITEMS 1-20, 21-40, 41-60, 61-80, AND 81-100
FOR CONTROL AND EXPERIMENTAL GROUPS

| Items | Source | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|---|
| 1-20 | Treatments | 3 | 2.6 | .84 | 1.63* |
| | Within | 56 | 29.0 | .52 | |
| | Total | 59 | 31.6 | | |
| 21-40 | Treatments | 3 | 4.9 | 1.66 | 3.49* |
| | Within | 56 | 26.7 | .47 | |
| | Total | 59 | 31.6 | | |
| 41-60 | Treatments | 3 | 228.3 | 76.11 | 9.45** |
| | Within | 56 | 451.1 | 8.05 | |
| | Total | 59 | 679.4 | | |
| 61-80 | Treatments | 3 | 424.7 | 141.60 | 9.56** |
| | Within | 56 | 829.6 | 14.81 | |
| | Total | 59 | 1254.3 | | |
| 81-100 | Treatments | 3 | 71.1 | 23.71 | 2.88* |
| | Within | 56 | 460.3 | 8.22 | |
| | Total | 59 | 531.4 | | |

* Significant beyond the .05 level of confidence

** Significant beyond the .01 level of confidence

ANALYSIS OF VARIANCE FOR TEST TIMES ON CMMS
ITEMS 1-20, 21-40, 41-60, 61-80, AND 81-100
FOR CONTROL AND EXPERIMENTAL GROUPS

| Items | Source | df | Sum of Squares | Mean Square | F |
|---|---|---|---|---|---|
| 1-20 | Treatments | 3 | 101.0 | 33.67 | 3.45* |
| | Within | 56 | 546.0 | 9.75 | |
| | Total | 59 | 647.0 | | |
| 21-40 | Treatments | 3 | 19.3 | 6.42 | 4.92** |
| | Within | 56 | 73.1 | 1.30 | |
| | Total | 59 | 92.4 | | |
| 41-60 | Treatments | 3 | 134.3 | 44.77 | 9.45** |
| | Within | 56 | 265.3 | 4.74 | |
| | Total | 59 | 399.6 | | |
| 61-80 | Treatments | 3 | 160.1 | 53.38 | 4.51** |
| | Within | 56 | 662.8 | 11.84 | |
| | Total | 59 | 822.9 | | |
| 81-100 | Treatments | 3 | 95.1 | 31.71 | 1.58 |
| | Within | 56 | 1123.9 | 20.06 | |
| | Total | 59 | 1219.0 | | |

* Significant beyond the .05 level of confidence

** Significant beyond the .01 level of confidence

"c" STATISTIC ON SCORES FOR CMMS ITEMS 21-40, 41-60, 61-80, AND 81-100 FOR CONTROL AND EXPERIMENTAL GROUPS

| Groups | 21-40 "c" | 41-60 "c" | 61-80 "c" | 81-100 "c" |
|---|---|---|---|---|
| L x R | 1.85 | 2.06 | 1.24 | 1.02 |
| L x BL | 2.13 | 3.79** | 1.90 | .38 |
| L x C | .53 | 1.09 | 3.03* | 1.78 |
| R x C | 2.38 | 3.14* | 4.26** | 2.79* |
| R x BL | .28 | 1.74 | .66 | .64 |
| C x BL | 2.66 | 4.89** | 4.93** | 2.16 |

* Significant beyond the .05 level of confidence

** Significant beyond the .01 level of confidence

"c" STATISTIC ON TIMES FOR CMMS ITEMS
1-20, 21-40, 41-60, AND 61-80 FOR
CONTROL AND EXPERIMENTAL GROUPS

| Groups | 1-20 "c" | 21-40 "c" | 41-60 "c" | 61-80 "c" |
|---|---|---|---|---|
| L x R | .12 | .48 | .24 | 1.38 |
| L x BL | 2.45 | 3.19* | 3.85** | 1.22 |
| L x C | .35 | .17 | 1.18 | 2.18 |
| R x C | .24 | .64 | 1.43 | .80 |
| R x BL | 2.57 | 2.71 | 3.60** | 2.60 |
| C x BL | 2.80* | 3.35** | 5.03** | 3.39** |

* Significant beyond the .05 level of confidence

** Significant beyond the .01 level of confidence