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A Comparison of Aphasic and Non-Brain Injured Adults on a Dichotic CV-Syllable Listening Task

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Master of Science in Communicative Disorders

A COMPARISON OF APHASIC AND NON-BRAIN INJURED ADULTS ON A DICHOTIC CV-SYLLABLE LISTENING TASK

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A COMPARISON OF APHASIC AND NON-BRAIN INJURED ADULTS ON A DICHOTIC CV-SYLLABLE LISTENING TASK

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B.S., Western Michigan University, 1971

THESIS

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ABSTRACT OF THESIS

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Normal listeners traditionally show a right ear preference for dichotically presented speech stimuli, and a left ear preference for dichotically presented non-speech stimuli. Although some inter-subject variability is observed within and between groups of non-brain damaged subjects, the performance of the group as a whole is rather predictable and homogeneous. However, results from experiments in which brain damaged subjects have been studied have been less straightforward. Although left brain damaged subjects have consistently shown a bilateral deficit in reporting dichotic speech stimuli, a great deal of variability in performance is observed within the groups. Further study of brain damaged individuals, in an attempt to account for this variability, might provide information toward a more thorough understanding of auditory processing. The method of data analysis applied in these studies might also be an important factor in answering this question. Accordingly, the purpose of this investigation was to compare the performance of a group of aphasic individuals

with a group of normal, control subjects, on a dichotic CV-syllable listening task. In addition, two methods of data analysis, the traditional R-L method and the Percent-of-Errors (POE) method, were evaluated.

In comparing the aphasic with the non-aphasic group, the aphasics showed a bilateral deficit in reporting the dichotic CV-syllables. In addition, the non-aphasic group showed a significant right ear advantage for the CV-syllables, while the aphasic group showed a non-significant right ear advantage for the stimuli. However, in view of the fact that six of the aphasics showed a right ear advantage and five showed a left ear advantage for the dichotic CVs, the two aphasic subgroups were analyzed separately. On the basis of single correct item analysis, the superior ear within each aphasic subgroup was found to perform better than the respective ear within the control group. Finally, R-L and POE methods of data analysis were found to correlate very highly.

These results were interpreted in view of a functional model which assumed more efficient contralateral auditory pathways, and the presence of bilateral auditory processors and a unilateral speech processor. In accordance with this model, the bilaterally depressed ear scores of the aphasic group exhibited in response to the dichotic stimuli were explained by the presence of a lesion in the dominate left hemisphere, interfering with the processing of auditory signals from both ears. Secondly, the right ear advantage for the dichotic syllables within the control group was felt to reflect the greater efficiency of contralateral auditory pathways, as well as the specialized function of the left hemisphere in processing speech. The right ear advantage found within one aphasic subgroup was explained by a lesion interfering with the corpus callosal tract after entering the left hemisphere; the left ear advantage exhibited by the other aphasic subgroup was explained by a lesion in the area of the auditory processor of the left hemisphere. Finally, only one method of data analysis, either R-L or POE, seems necessary since both measures relate the same information about an individual's performance on a dichotic listening task.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

TABLE PAGE

CHAPTER I

REVIEW OF THE LITERATURE, SUMMARY, AND STATEMENT OF THE PROBLEM

Review of the Literature

Studies concerned with the localization of speech and language functions in specific areas of the brain, and with the lateralization of speech and language functions to either the left or right hemisphere, have been ongoing for over a century. These investigations have been prompted by two major concerns: one, to gain a more thorough understanding of the organization and processing of speech and language within the central auditory nervous system, and secondly, to understand better the deterioration of speech and language functions as a result of brain damage.

In 1861, Broca became the first proponent of a localization theory when he hypothesized that speech was asymmetrically represented in the third frontal convolution of the left hemisphere, now referred to as Broca's area. Based upon post-mortem examinations of two patients, he reported that damage to this area of the brain resulted in aphemia, later renamed aphasia by Trousseau (Schuell, Jenkins, & Jimenez-Pabon, 1964; Giannitrapani, 1967). Broca's attempt to localize speech in a specific area of the left hemisphere stimulated the interest of a number of investigators. The following review includes highlights of these studies.

In 1874, Wernicke localized speech in an area between Heschl's gyrus and the angular gyrus in the left hemisphere, now called Wernicke's area (Schuell et al., 1964; Geschwind, 1972). In 1959, Penfield and Roberts supported Broca's and Wernicke's findings by using electrical stimulation to map the speech areas in exposed brains during surgery. In addition, they revealed a third possible speech area--the supplementary motor speech area. Electrical stimulation of any of these three areas of the brain resulted in an "aphasic type" response (cited in Masland, 1969). Wada and Rasmussen (1960) later introduced a third method useful in studying the brain's processing of speech. They found that cerebral dominance for speech could be predicted by injecting sodium amytal into the left or right carotid artery. Deterioration of speech, with contralateral hemiparesis was noted with injections affecting the dominant speech hemisphere, while contralateral hemiparesis with no effect on speech was noted with injections affecting the non-dominant hemisphere. This method, confirmed in surgery, was found to be 98 percent accurate in predicting cerebral dominance for speech (Branch, Milner, & Rasmussen, 1964).

The belief that the brain is functionally asymmetrical has been supported repeatedly through post-mortem examination, electrical stimulation, and sodium amytal injections. Evidence now exists which suggests that the brain is anatomically asymmetrical as well. Geschwind and Levitsky (1968) reported that an area on the upper surface of the temporal lobe, called the planum temporale--an extension of Wernicke's area--was larger on the left side of the brain in 65 percent of the 100 subjects studied, and larger on the right side in 11 percent of the 100 subjects.

Dichotic Listening in Normals

During the past few decades, a much safer and more controllable procedure was developed which has contributed additional information about the brain's processing of auditory signals. In an experiment dealing with memory span, Broadbent (1954) introduced dichotic listening tasks in which different pairs of digits were simultaneously presented to both ears. He noted that simultaneous stimulation of both ears resulted in confusion, but it was Kimura (1961b) who recognized the significance of his finding and began to use dichotic listening tasks to assess cerebral dominance for speech.

In experiments using pairs of dichotic digits, Kimura found that the digits were more accurately perceived in the right ear than in the left ear. This right ear advantage was attributed to a unilateral speech processor in the left hemisphere, and to the greater efficiency of contralateral pathways between the ear and the auditory cortex (Kimura, 1961a). Her reasoning was further supported by anatomical evidence showing that most cochlear nerve fibers decussate in the brain stem (Noback & Demarest, 1972).

Following Kimura's use of dichotic listening tasks in studying cerebral dominance for speech, several other experimenters confirmed her findings and sought to gain further understanding of this asymmetrical processing of speech by manipulating the test conditions and the acoustic parameters of the dichotic stimuli. The major findings of these investigations may be summarized as follows:

1. Under dichotic stimulation, there is a right ear advantage for speech stimuli, reflecting processing in the left hemisphere, and a left ear advantage for non-speech stimuli, reflecting processing in the right hemisphere.
    a. Speech stimuli used in dichotic listening experiments:
        (1) Digits (Bryden, 1963; Kimura, 1961a; Satz, Achenbach, Pattishall, & Fennell, 1965).
        (2) Nonsense syllables (Berlin, Lowe-Bell, Jannetta, & Kline, 1972; Wilson, Dirks, & Carterette, 1968).

(3) Monosyllabic words (Curry, 1967).

(4) Bisyllabic words (Bartz, Satz, Fennell, & Lally, 1967).

(5) Spondee words (Dirks, 1964).

(6) Sentences (Pisoni, Jarvella, & Tikofsky, 1970).

(7) Vowels (Shankweiler & Studdert-Kennedy, 1966; Weiss & House, 1973).

(8) Backwards-speech sounds (Kimura & Folb, 1968).

b. Non-speech stimuli used in dichotic listening experiments:

(1) Music (Kimura, 1964; Shankweiler, 1966).

(2) Environmental sounds (Curry, 1967).

(3) Sonar sounds (Chaney & Webster, 1966).

2. Based largely on clinical observations of children following brain damage, and on results from dichotic listening experiments, the lateralization by age five theory has received wide support (Berlin, Hughes, Lowe-Bell, & Berlin, 1973a; Krashen & Harshman, 1972). Further evidence suggests that cerebral dominance is established in females slightly earlier than in males, a finding consistent with earlier language development in females; however, no sex differences have been noted in later years (Carr, 1969; Kimura, 1963; Nagafuchi, 1970).

3. Although no direct relationship has been found between handedness and hemispheric dominance for speech, reversals are more frequent among left-handers. Using sodium amytal injections, 90 percent of the right-handed subjects and 66 percent of the left-handed subjects were found to be left hemispheric dominant for speech; using a dichotic listening task, 88.5 percent of the right-handers and 73.2 percent of the left-handers were found to be left hemispheric dominant for speech (Branch et al., 1964; Satz et al., 1965). Other investigators have reported smaller between ear differences among left-handers than among right-handers on dichotic listening tasks. They hypothesized that right-handers have a more specialized speech hemisphere than left-handers, or that left-handers have a greater hemispheric equipotentiality for speech (Curry, 1967).
4. The asymmetry found on dichotic listening tasks was not due to an attentional bias or to greater trace decay of the stored stimuli, usually the left ear stimuli, as the right ear superiority was retained even when order of report was controlled (Bryden, 1963; Cooper, Achenbach, Satz, & Levy, 1967; Gerber & Goldman, 1971; Inglis, 1962; Oxbury, Oxbury, & Gardiner, 1967).
5. The right ear superiority was upheld even when dichotic CV-syllables presented to the right ear were 10 dB less

intense than those presented to the left ear (Stafford, 1971; Thompson, Stafford, Cullen, Hughes, Lowe-Bell, & Berlin, 1972).

6. With a lag time of 30-60 msec, the left ear overcame the right ear superiority on dichotic CV listening tasks, but with lag times greater than 250 msec, both stimuli were perceived accurately (Berlin, et al, 1972). Experimenters hypothesized that the lagging message interrupted processing of the leading message in competition for the single speech processor in the left hemisphere (Berlin, Lowe-Bell, Cullen, Thompson, & Loovis, 1973b; Studdert-Kennedy, Shankweiler, & Schulman, 1970). The lag effect was used to explain the superior intelligibility of voiceless CVs in voiced-voiceless pairings, whether delivered to the right or left ear (Lowe, Cullen, Berlin, Thompson, & Willett, 1970).

7. The right-left ear difference on dichotic listening tasks was maximized when onsets of the stimuli were precisely aligned (Hannah, Thompson, Cullen, Hughes, & Berlin, 1971), when the stimuli were presented at 50 dB SPL (Thompson & Hughes, 1972), when the stimuli were presented in a background of noise (Weiss & House, 1973; Wilson et al., 1968), and when the amount of stimuli was increased (Bryden, 1962; Satz et al., 1965).

8. The right ear superiority for CV-syllables was not demonstrated when the CVs were presented through a 3000 Hz filter, or when the CVs were presented at a signal-to-noise ratio of 18 dB (Berlin, 1973).

Other investigators have recently studied the effect of the method of analysis on results obtained in dichotic listening tasks in an effort to account for the large differences in scores obtained among individuals and among the types of speech stimuli used. At times this variability has been said to reflect differences in the degree of lateralization, and at other times, to differences in the difficulty of the dichotic stimuli used (Studdert-Kennedy & Shankweiler, 1970). Recently, Harshman and Krashen (1972) attributed this difference to the method of analysis used in dichotic listening experiments. In the traditional or R-L method of scoring, the percentage of correct left ear responses is subtracted from the percentage of correct right ear responses. This score is said to reflect the degree of lateralization of the dichotic stimuli, departure from zero indicating an increase in the degree of lateralization. Experimenters using this technique of analysis have found the greatest degree of lateralization for nonsense syllables, a lesser degree for digits, and very little for vowels (Shankweiller & Studdert-Kennedy, 1966). Harshman and Krashen (1972) criticize this method of analysis as follows:

> Although this technique provides a straightforward index of surface response asymmetry, it does not give an adequate measure of underlying brain asymmetry--of the degree of lateralization of the perceptual functions invoked by the stimuli. This is because the R-L score is sensitive not only to changes in the underlying degree of lateralization but also to changes in overall (non-lateralized) perceptual accuracy, and to changes in the amount of guessing used by subjects (p. 4).

They argue that the absolute difference in accuracy between ears is not important, but that the difference between ears is. They suggest a method of analysis referred to as Percent-of-Errors (POE), in which the number of left ear errors is divided by the total number of errors. They contend that POE is not affected by the difficulty of the stimuli, or by the amount of guessing, as is the R-L method. They concluded that the POE method of analysis more accurately reflected the degree of lateralization, regardless of the type of stimuli used or the age of the subjects. With this method, scores deviating from 50 percent indicate an increase in the degree of lateralization of the stimuli.

Dichotic Listening in Brain Damaged Subjects

Information gained from dichotic listening experiments with non-brain injured subjects cannot be generalized to pathological groups--the two groups must first be studied separately. Until recently, auditory perception in brain damaged subjects has been evaluated through the use of tests of receptive abilities such as the Token

Test, the Porch Index of Communicative Ability (PICA), and the Staggered Spondaic Word Test (SSW).

The Token Test, developed by De Renzi and Vignolo (1962), has been used to evaluate an individual's auditory receptive abilities by requiring him to follow a series of non-redundant commands. A direct relationship was found between the number of errors on the Token Test and severity of aphasia (Wertz, Keith, & Custer, 1971). The PICA, developed by Porch (1971), enables one to make inferences about input and integrative abilities by quantifying an individual's performance in three modalities--verbal, gestural, and graphic. The overall PICA score reflects severity of involvement in comparison with other aphasics. Wertz et al. (1971) found that performance on the Token Test was significantly related to the PICA gestural score and to auditory subtests VI and X.

The SSW Test was devised by Katz (1968) as a test of central auditory dysfunction. The test, based on the competing message technique, involves the presentation of different spondaic words to each ear in a partially overlapping manner. The subject's responses are corrected for word discrimination ability, and then scored according to the norms standardized on a large sample of normal and brain injured subjects. A moderate to severe impairment is said to be indicative of central auditory dysfunction. Information gained from analyzing the pattern and accuracy of the subject's responses is used to localize the lesion both intra- and inter-hemispherically. For further details on the administration and interpretation of the SSW Test, see Katz (1968, 1970).

In addition, a limited number of investigators have attempted to learn more about auditory processing in brain injured subjects through dichotic listening experiments. The following is a summary of their major findings:

1. In a dichotic digit listening experiment using 33 left temporal lobectomees and 18 right temporal lobectomees with histories of epileptic seizures from infancy, Kimura (1961a) found that:
   a. Pre-operatively, both lesion groups showed a right ear advantage for digits regardless of side or site of lesion.
   b. The ear contralateral to the lesion performed poorly under dichotic stimulation.
   c. Damage to the left temporal lobe resulted in an overall decrease in performance on dichotic tasks; damage to the right temporal lobe did not.
2. Shankweiler (1966) compared 21 left temporal lobe patients with 24 right temporal lobe patients, having epilepsy from infancy, on a dichotic digits and a melody recognition task. The findings were:
   a. Left temporal lobe patients showed a right ear

advantage for dichotically presented digits, and a left ear advantage for melody recognition

b. Right temporal lobe patients showed a right ear advantage for dichotic digits, and a left ear advantage for melodies if Heschl's gyrus was spared in surgery, but a right ear advantage for melodies if Heschl's gyrus was damaged.

3. Pettit (1969) studied 25 aphasics with histories of trauma and cerebro-vascular accident (CVA), in an attempt to determine which hemisphere assumed the dominant role in language processing after brain damage. The results were as follows:

   a. The aphasic group showed a left ear superiority on both dichotic speech and non-speech tasks.

   b. On re-test following a two-month interval, the left ear superiority increased, with no significant change in right ear scores.

   On the basis of these results he concluded that:

   a. There is "a change in cerebral dominance from the left to the right hemisphere after cerebral injury.

   b. As language recovery improves, there is some evidence to indicate that cerebral dominance becomes more firmly established in the right hemisphere.

   c. Findings indicate that no such shift occurs in the processing of non-verbal stimuli" (p. xiii).

4. Schulhoff and Goodglass (1969) compared the perception of dichotically presented digits, tonal sequences, and clicks in 10 normals, 10 left brain damaged aphasics, and 10 right brain damaged individual, with the following results:
   a. Normals showed the expected right ear advantage for digits and the left ear advantage for tonal sequences, with no asymmetry of response found for clicks.
   b. Left brain damaged subjects showed a bilateral deficit in addition to a slight right ear advantage for digits, a large left ear advantage for tonal sequences, and a left ear advantage for clicks.
   c. Right brain damaged subjects showed a large right ear advantage for digits, a bilateral deficit in addition to a slight left ear advantage for tonal sequences, and a right ear advantage for clicks.
5. Sparks, Goodglass, & Nickel (1970) used dichotically presented animal names and digits to assess cerebral dominance for speech in 28 left brain damaged aphasics and 20 right brain damaged non-aphasics with histories of trauma or CVA. They reported the following:
   a. The right brain damaged group performed better overall than the left brain damaged group.
   b. The "lesion effect," poor performance in the ear

contralateral to the lesion, was found for both groups, although the right brain damaged group showed larger between ear differences than the left hemispheric group.

c. Ipsilateral extinction was seen in some left brain damaged subjects felt to have deep lesions of the anterior commissure and corpus callosum due to CVAs; ipsilateral extinction was rarely seen in the right hemispheric lesion group, or in the left hemispheric group with surgical etiology.

6. Dobie and Simmons (1971) presented the CVs pa, ta, and ka dichotically to 33 normals and 10 patients with unilateral cerebral lesion (6 non-dominant lesions and 4 dominant lesions). Subjects attended to one ear in which the intensity of the signal was attenuated, while the intensity of the signal in the unattended ear remained constant at 75 dB SPL. The following results were reported:

a. Of the six patients with non-dominant cerebral lesions, four showed a large advantage in the ear contralateral to the intact dominant hemisphere; of the four aphasics, one performed superiorally in the ear contralateral to the lesion, and one showed a large preference for the ear ipsilateral to the lesion, while the remainder of the subjects performed like normals.

b. Normals reported the input to either ear accurately until the amplitude of the unattended ear exceeded that of the attended ear by 15 dB, while 6 of the 10 patients reported the input accurately at differences ranging from 48 to 110 dB; the remainder of the patients performed like normals.

7. In a dichotic CV listening task, Berlin et al. (1972) reported that two left temporal lobectomees and two right temporal lobectomees performed as follows:

   a. Monotically, patients reported stimuli with 100 percent accuracy.

   b. Pre-operatively, subjects obtained decreased scores in the ear contralateral to the lesion; post-operatively, subjects showed an additional decrease in the contralateral ear score, and enhanced scores in the ipsilateral ear.

   c. The patients showed no lag effect.

Summary

Dichotic listening experiments have been conducted repeatedly using individuals with normal central auditory functioning. On the basis of these investigations, it is now possible to predict with a degree of certainty, that a group of normal subjects will show a right ear advantage for dichotically presented speech stimuli, and a left ear advantage for dichotically presented non-speech stimuli.

These results have been attributed to the greater efficiency of the contralateral pathways between the ear and the auditory cortex, and to the specialized function of each cerebral hemisphere.

A few experimenters have conducted dichotic listening studies with brain damaged individuals in an effort to learn more about auditory processing in pathologicals as well as in normals. Results from these studies indicate that brain injured subjects are less predictable and less homogeneous than normals. Although a bilateral deficit in response to dichotically presented speech stimuli is consistently reported for a group of left brain damaged subjects, some researchers report a right ear advantage for the group, while others report a left ear advantage for the group. Another consistent finding of these studies is the wide inter-subject variability observed within groups of left brain damaged subjects. However, many investigators merely report the results in terms of group scores, rather than trying to account for this inter-subject variability. Instead of ignoring this wide range of performance found among brain damaged individuals, researchers should attempt to identify factors which might account for the variability in an attempt to learn more about speech perception in abnormals as well as in normals.

The method of data analysis used in dichotic listening tasks might also be extremely important. Depending on the procedure used, valuable information might be obscured or emphasized. Therefore, data should be analyzed in a number of ways in an effort to identify the most appropriate method of analysis for a particular population.

Statement of the Problem

The objective of this study was to examine the performance of aphasics, both in comparison to non-brain injured subjects and to other aphasics, on a CV-syllable dichotic listening task. In addition, different methods of data analysis were studied in an attempt to identify the method that provided the most information regarding individual performance on the dichotic listening task.

More specifically, this investigation was directed toward the following questions:

1. How does the performance of aphasics on a dichotic CV-syllable listening task compare to that of non-brain damaged individuals?
2. How do individual aphasics compare to each other on a dichotic CV listening task?
3. Which method of analysis, R-L or POE, provides the most information about dichotic performance in aphasics as compared to non-brain damaged subjects?
4. How does the performance of an aphasic on a

dichotic listening task relate to his performance on the Token Test, the PICA, and the SSW Test?

CHAPTER II

PROCEDURE

Subjects

The experimental subjects were selected from among the aphasics seen in the Speech Pathology Service at the Veterans Hospital in Albuquerque, New Mexico, on the basis of availability and ability to do the task. The aphasic group consisted of 10 males and 1 female ranging in age from 24 to 66 years, with a mean age of 48.73 years. Educational levels ranged from 5 to 17 years with a mean of 11.09 years. Two of the 11 subjects were left-handed. However, since all subjects were aphasic as a result of a left hemispheric lesion, it seemed reasonable to assume that they were left hemispheric dominant for speech and language functions. In addition, 4 subjects were bilingual, learning English and a second language simultaneously or at an early age. All subjects were aphasic due to left hemispheric damage with the following etiologies: 6 thrombo-embolic, 3 trauma, 1 hemorrhage, and 1 arterio-venous malformation (AVM). Months post onset at the time of the study ranged from 1 to 45 months, with a mean of 17.82 months. Information on each subject is summarized in Appendix A.

Because of the resultant heterogeneous group of aphasics, the experimental and control groups were matched as closely as possible on an individual basis. All control subjects were obtained from the Orthopedic Ward and the Escort Service at the Veterans Hospital, and had no history of brain damage or head trauma. In addition, they were required to score within normal limits on Part V of the Token Test, in accordance with the norms published by Wertz et al. (1971). The control group consisted of 10 males and 1 female ranging in age from 27 to 64 years, with a mean age of 49.73 years. Educational levels ranged from 6 to 21 years with a mean level of 11.36 years. One of the subjects was left-handed and another was ambidextrous. In addition, 4 of the subjects were bilingual, learning English and their second language simultaneously or at an early age. Specific information on each control subject is summarized in Appendix B.

All subjects were required to meet the following criteria for inclusion in the study:

1. Normal and symmetrical hearing in accordance with the following:
   a. Hearing thresholds on pure tone audimetry of less than or equal to 30 dB HTL (ANSI, 1969) in the 250-3000 Hz frequency range.
   b. Not more than 10 dB difference between ears at any frequency in the 250-3000 Hz range.

2. Not more than 1 error per ear on a CV-syllable discrimination test presented monaurally.

Test Stimuli

The test stimuli for this study consisted of a tape recording of dichotically presented CV-syllables. The tape was constructed at the Kresge Hearing Research Laboratory of the South by randomly pairing two different syllables from the following: PA, BA, TA, DA, KA, GA. Each of the resultant 30 test items consisted of two different syllables presented simultaneously, one to each ear (see Appendix C). A 1000 Hz tone preceded the stimuli for calibration at the earphones. In addition, to ensure that the signals were being delivered to the intended ear, the following phrases were presented prior to the dichotic stimuli: "This is Channel I, point to the ear in which you hear me; this is Channel II, point to the ear in which you hear me." For additional information on the construction of the tape, see Stafford (1971).

A discrimination test tape, comprised of the six different CV-syllables dubbed in a random order for presentation at the right ear, and in a different order for presentation at the left ear, was constructed from the dichotic test tape just described (see Appendix D).

Instrumentation

All test stimuli were played on a dual channel Sony TC-366 tape recorder, one signal being delivered through Channel I, and the other signal through Channel II of a Grason Stadler 1701 audiometer. The signals were then delivered through acoustically balanced TDH-39 earphones with MX 41-AR cushions, while the subject was seated in a double room, double walled IAC booth.

Prior to the presentation of the test stimuli, the equipment was calibrated at each earphone using a Bruel and Kjaer artificial ear and sound level meter, Type 2203. A 1000 Hz tone at the beginning of the test tape was routinely peaked at zero on the VU meter of the audiometer, and then calibrated to 75 dB SPL at each earphone by adjusting the appropriate attenuator on the audiometer.

Test Protocol

Information on each aphasic subject was obtained from his personal file in the Speech Pathology Service at the Veterans Hospital, and recorded on a form similar to the one shown in Appendix E. Control subjects personally provided the material necessary for completion of the information sheet (see Appendix F) before being administered Part V of the Token Test. Current Token Test, PICA, and SSW Test scores on each aphasic subject were obtained within one week of the administration of the dichotic listening task.

Following pure tone audiometry, each subject listened to the discrimination test presented monaurally at 75 dB SPL. All control subjects recorded their responses on multiple-choice answer sheets. However, with the aphasic subjects, it was necessary to screen for the most appropriate response mode by having them respond to the tester's verbal examples of the stimulus items. As a result, six aphasics recorded their answers on the multiple-choice answer sheets, four repeated the stimuli while the tester recorded the responses, and one pointed to his answers on a large response card containing the six CV-syllables, while the tester recorded the responses. There was no reason to believe that the method of response would differentially affect the results since Berlin et al. (1973a) and Wilson et al. (1968) found no statistical differences between oral and written methods of response. Furthermore, in some cases it was necessary to play the discrimination test tape twice before the subject became accustomed to the task and could respond appropriately. Before presenting the dichotic test stimuli, the instructions shown in Appendix G were read to each subject, ensuring that he thoroughly understood the task before proceeding. All subjects were allowed as much time as necessary to respond to each dichotic presentation.

To counterbalance for effects by earphones, the 30 test items were presented with Channel I of the tape being delivered to the right ear and Channel II to the left ear. The earphones were then reversed, and the 30 items were presented again. To control for effects by order of presentation, all odd numbered subjects began the task with Channel I being presented to the right ear, while all even numbered subjects began the task with Channel II being presented to the right ear. In addition, to ensure that one standard method was used with all subjects, a check list of procedures was carefully followed (see Appendix H).

Data Reduction and Analysis

Upon completion of the task, the two dichotic presentations of 30 items each were combined and scored to determine the total number of correct right ear and left ear responses for each subject.

The Student t-statistic was employed to test differences between ears within each group, and to compare performances of the aphasic group with the non-brain injured group. Pearson product-moment correlations were computed for R-L and POE scores to assess the relationship between these two methods of analysis. Finally, a multiple regression technique was carried out in an attempt to obtain exploratory information regarding the amount of common variance accounted for by the PICA, the Token Test, and the SSW Test in predicting dichotic performance.

CHAPTER III

RESULTS AND DISCUSSION

Results

Right Versus Left Ear Scores

Total correct ear scores and absolute between ear difference scores for each subject are shown in Appendix I. Right ear scores plotted against left ear scores for each individual are combined in Figure 1 for a comparison of aphasic and non-aphasic subjects' performances on the dichotic CV listening task. As can be seen in the figure, six aphasics showed a right ear advantage and five showed a left ear advantage for the CV-syllables; nine non-aphasics showed a right ear advantage, one showed a left ear advantage, and another showed no ear preference for the CVs.

Table 1 shows the mean correct right ear scores and the mean correct left ear scores obtained by the aphasic and non-aphasic groups. In submitting these scores to a t-test, the right ear advantage within the aphasic group failed to reach significance, while the right ear advantage within the non-aphasic group was found to be significant.

In comparing the aphasic with the non-aphasic group,

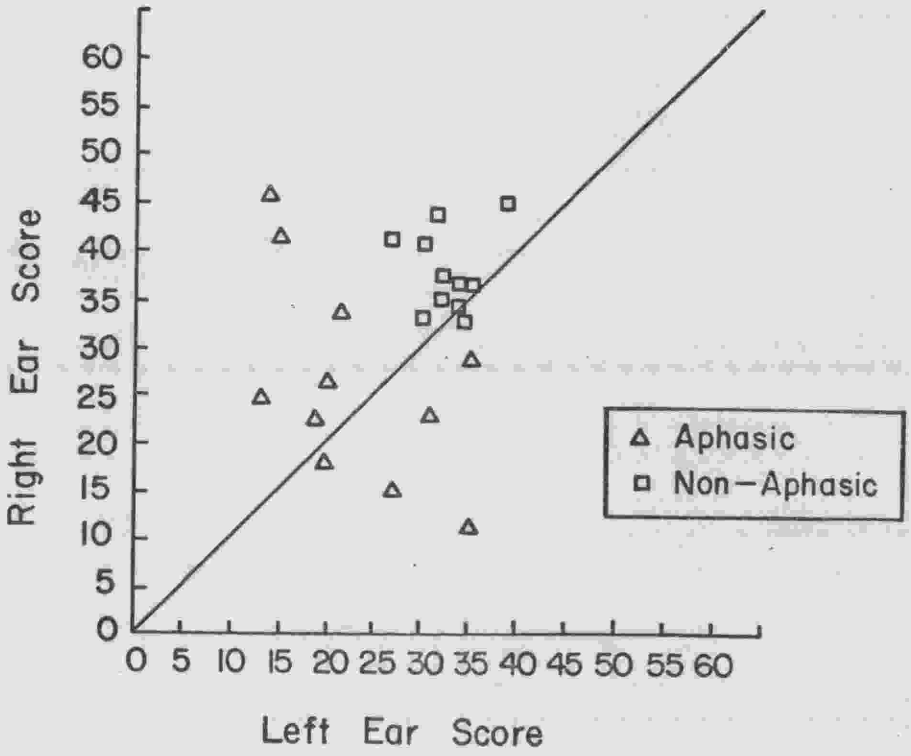

Figure 1. The Total Number of Correct Responses for the Right Ear Plotted against the Total Number of Correct Responses for the Left Ear for Individual Aphasic and Non-aphasic Subjects.

TABLE 1

A COMPARISON OF THE MEAN NUMBER OF CORRECT RIGHT EAR RESPONSES AND THE MEAN NUMBER OF CORRECT LEFT EAR RESPONSES AND STANDARD DEVIATIONS WITHIN THE APHASIC AND NON-APHASIC GROUPS

		Correct Right Ear Responses	Correct Left Ear Responses	t
Aphasic Group	$\bar{X}$=	26.64	22.73	.9650 (NS)
	SD=	10.25	7.69	
Non-aphasic Group	$\bar{X}$=	37.91	32.27	
	SD=	4.06	2.99	3.5386**

**Significant at the .01 level

the data in Table 2 indicate that left hemispheric damage results in a bilateral deficit on the dichotic CV listening task. Mean correct right ear, left ear, and total accuracy scores for the aphasic group are significantly depressed in comparison with the non-aphasic group. In addition, the aphasic group showed a significantly larger absolute between ear difference score than the non-aphasic group.

An additional finding of this study was the division of the aphasic group into two subgroups--a right ear advantage group and a left ear advantage group. In view of this difference, the two subgroups of aphasics were analyzed separately. As can be seen in Table 3, the difference between ears for the right ear advantage group of aphasics is significant, while the difference between ears for the left ear advantage group is not.

TABLE 2

A COMPARISON OF THE MEAN CORRECT SCORES AND STANDARD DEVIATIONS BETWEEN THE APHASIC AND NON-APHASIC GROUPS ON THE DICHOTIC CV LISTENING TASK

		Aphasic Group	Non-aphasic Group	t
Right ear	$\bar{X}$=	26.64	37.91	3.2352**
	SD=	10.25	4.06	
Left Ear	$\bar{X}$=	22.73	32.27	3.6597**
	SD=	7.69	2.99	
Total Right +	$\bar{X}$=	49.37	70.18	6.5769***
Left Ear	SD=	8.65	5.04	
Absolute Between Ear Dif-	$\bar{X}$=	13.36	5.82	2.2417*
ferences	SD=	9.49	4.82	

*Significant at the .05 level
**Significant at the .01 level
***Significant at the .001 level

TABLE 3

A COMPARISON OF THE MEAN NUMBER OF CORRECT RIGHT EAR RESPONSES AND THE MEAN NUMBER OF CORRECT LEFT EAR RESPONSES AND STANDARD DEVIATIONS WITHIN EACH APHASIC SUBGROUP

		Right Ear	Left Ear	t
Right Ear	$\bar{X}$=	32.83	17.00	3.8445*
Advantage Group	SD=	8.67	3.11	
Left Ear	$\bar{X}$=	19.20	29.60	2.4649 (NS)
Advantage Group	SD=	6.27	5.64	

*Significant at the .05 level

A summary of the mean performance scores for the two subgroups of aphasics is presented in Table 4. By examining the data, it can be noted that the two aphasic groups differ very little in terms of overall accuracy, as is indicated by comparing the mean total number of right ear plus left ear responses for the two groups.

TABLE 4

A COMPARISON OF THE MEAN CORRECT SCORES AND STANDARD DEVIATIONS BETWEEN THE TWO APHASIC SUBGROUPS ON THE DICHOTIC CV LISTENING TASK

		Right Ear Advantage Group	Left Ear Advantage Group	t
Right Ear	$\bar{X}$=	32.83	19.20	2.7338*
	SD=	8.67	6.27	
Left Ear	$\bar{X}$=	17.00	29.60	4.0058*
	SD=	3.11	5.64	
Total Right + Left Ear	$\bar{X}$=	49.83	48.80	.1757(NS)
	SD=	8.07	9.26	
Absolute Between Ear Difference	$\bar{X}$=	15.83	10.40	.9175(NS)
	SD=	10.22	7.53	

*Significant at the .05 level

In comparing the mean number of correct right ear responses for the right ear advantage group, with the mean number of correct left ear responses for the left ear advantage group, no significant difference was found (t=.6743), nor was a significant difference found when the other two ear scores were compared (t=.6410). In other words, the two aphasic groups performed very much alike on the dichotic listening task, except that in one group, the right ear performed better, while in the other group, the left ear performed better.

R-L Versus POE Scores

Raw scores were converted into R-L and POE scores for each subject according to the procedure discussed earlier (see Appendix J). In comparing the R-L and POE scores within the aphasic and non-aphasic groups, as well as within the two aphasic subgroups, the scores were found to correlate at the .01 level (r=.99). In addition, as can be noted from observing the mean R-L and POE scores presented in Table 5, neither score differentiated between the aphasic and non-aphasic groups.

TABLE 5

A COMPARISON OF THE MEAN R-L AND POE SCORES AND STANDARD DEVIATION BETWEEN THE APHASIC AND NON-APHASIC GROUPS

		Aphasic Group	Non-aphasic Group	t
R-L	$\bar{X}$=	6.52	9.39	.3269(NS)
	SD=	26.53	8.39	
POE	$\bar{X}$=	53.29	55.89	.6208(NS)
	SD=	12.15	5.25	

However, as could be expected, both the R-L and POE scores differentiate between the two aphasic subgroups. This comparison is presented in Table 6.

TABLE 6

A COMPARISON OF THE MEAN R-L AND POE SCORES AND STANDARD DEVIATIONS BETWEEN THE TWO SUBGROUPS OF APHASICS

		Right Ear Advantage Group	Left Ear Advantage Group	t
R-L	$\bar{X}$=	26.39	-17.33	4.4306***
	SD=	17.03	12.54	
POE	$\bar{X}$=	62.12	42.69	4.1642***
	SD=	8.86	4.94	

***Significant at the .001 level

PICA, Token Test, and SSW Test Results

PICA, Token Test, and SSW Test scores for individual aphasics are listed in Appendix K. Group performance on the PICA, in terms of the overall scores, and the graphic, verbal, and gestural subtest scores is presented in Table 7.

In comparing the aphasics showing a right ear advantage on the dichotic listening task, with those showing a left ear advantage, no significant difference was found between the performance of the two subgroups on any of the 18 PICA subtests.

Table 8 lists the mean error scores for the aphasic

TABLE 7

A SUMMARY OF THE MEAN CORRECT PERCENTAGE SCORES AND STANDARD DEVIATIONS OF THE APHASIC GROUP'S PERFORMANCE ON THE PICA

	Overall	Gestural	Verbal	Graphic
$\bar{X}$=	71.18	69.82	65.82	73.55
SD=	12.96	18.35	12.58	14.96

TABLE 8

A SUMMARY OF THE MEAN NUMBER OF ERRORS AND STANDARD DEVIATIONS OBTAINED BY THE APHASIC GROUP ON THE TOKEN TEST

	I	II	III	IV	V	Total
$\bar{X}$=	1.36	1.55	4.09	4.55	11.73	23.36
SD=	1.37	1.78	2.91	3.20	4.43	12.37

group on the five subtests of the Token Test. Although the two subgroups of aphasics did not perform significantly different on the Token Test, it is interesting to note that the right ear advantage group performed better on each Token subtest except on Part V. Figure 2 graphically represents the difference in performance between the two groups of aphasics on the Token Test.

Table 9 presents a summary of the aphasic group

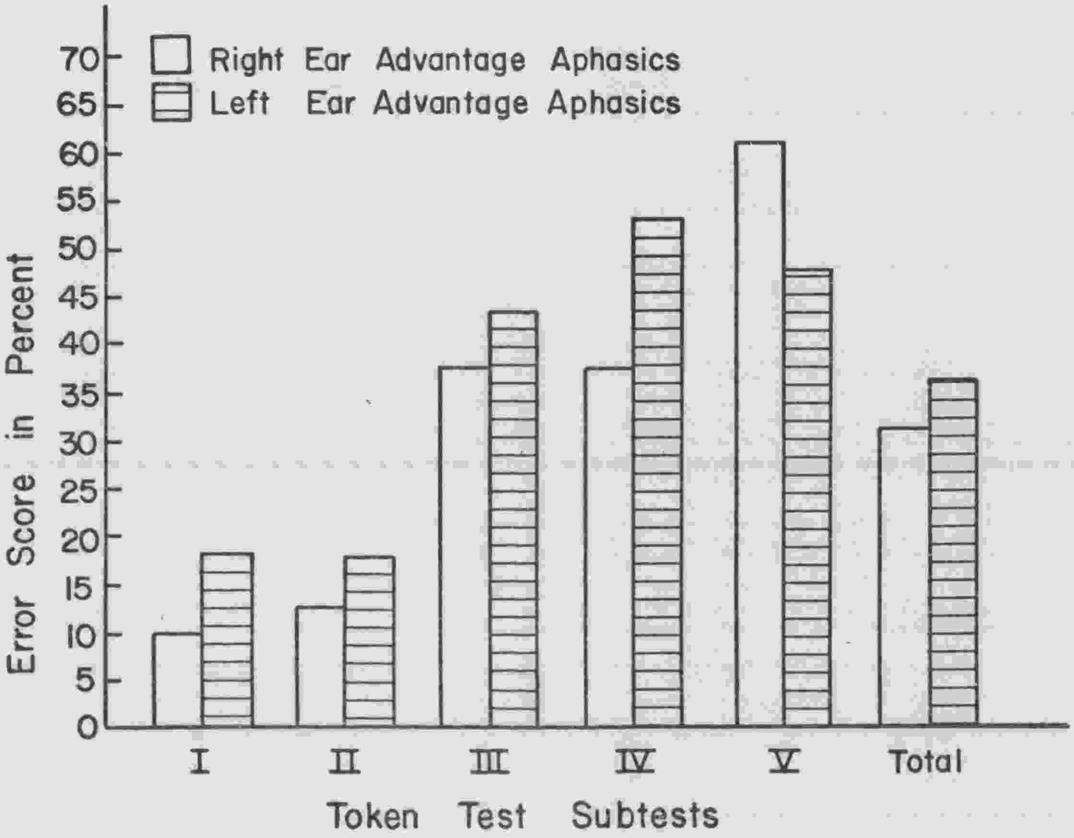

Figure 2. A Comparison of the Errors Exhibited by the Two Aphasic Subgroups on the Subtests of the Token Test.

performance on the SSW Test. Again, the aphasic subgroups performed somewhat different on the test, but the differences failed to reach significance. The performance of each aphasic subgroup on the SSW Test is graphed in Figure 3.

TABLE 9

A SUMMARY OF THE MEAN PERCENTAGE ERROR SCORES AND STANDARD DEVIATIONS OBTAINED BY THE APHASIC GROUP ON THE FOUR CONDITIONS OF THE C-SSW

	RNC	RC	LC	LNC
$\bar{X}$=	20.09	37.36	28.27	14.64
SD=	21.38	31.37	16.23	12.98

Because the SSW Test also utilizes a competing message technique, results from this test were compared on an individual basis with results from the dichotic listening task. As suggested by Katz (1973), performance on the SSW Test was scored using a combination of the most severe total, ear, and condition scores (TEC). Moderate to severe impairment was considered to be indicative of central auditory involvement. As was found with the dichotic CV task, some aphasics showed a right ear advantage while others showed a left ear advantage on the

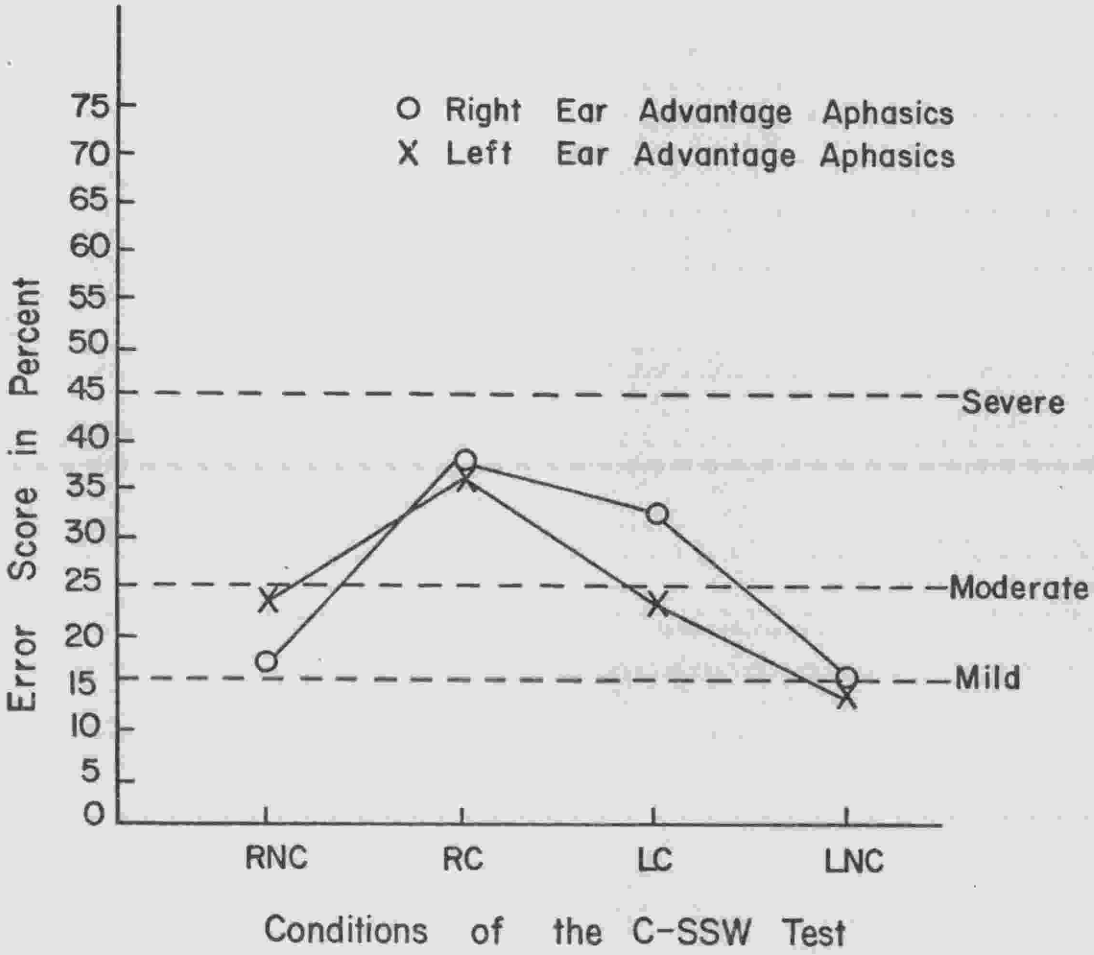

Figure 3. A Comparison of the Two Aphasic Subgroups on the Four Conditions of the C-SSW Test.

SSW Test. Appendix L provides a comparison of the results obtained from the SSW Test, with results obtained from the dichotic CV task for each aphasic. The SSW Test results agree with the dichotic test results in four cases and disagree in three cases. Of the remaining aphasics, three obtained normal scores and one showed a bilateral deficit on the SSW Test.

Finally, in a multiple regression analysis run on the aphasic group with POE as the dependent variable, 93 percent of the common variance was accounted for by scores obtained on the PICA verbal, PICA gestural, Token Test Total, and PICA graphic subtests, and by etiology, in that order. With the total correct responses as the dependent variable, 72 percent of the variance was accounted for by POE, PICA gestural, and Token Test scores. However, no single variable was found to be a good predictor for either the POE or the total correct response score.

In running the multiple regression analysis on all subjects, a relationship was suggested between Part V of the Token Test and dichotic performance. Handedness and bilingualism were not good predictors of dichotic performance, while age and education showed a mild relationship with dichotic performance.

Discussion

The first objective of this study was to compare the performances of a group of non-brain damaged individuals with a group of aphasics on a dichotic CV listening task. As has been found repeatedly in previous studies, a group of non-brain damaged adults showed a small, but statistically significant right ear advantage for dichotically presented CV-syllables. The group of aphasics showed a non-significant right ear advantage for the dichotic stimuli. This result is similar to that reported by Schulhoff and Goodglass (1969). Although both the aphasic and non-aphasic groups showed a right ear advantage for the stimuli, examination of the data shows that the two groups did not perform alike on the dichotic listening task. The aphasic group showed a bilateral deficit in response to the dichotic items in comparison with the non-aphasic group's performance, as reflected by the depressed mean correct ear scores for the aphasic group. This finding has been reported consistently in studies where left-hemispheric lesioned patients were studied (Berlin et al., 1972; Kimura, 1961a; Schulhoff & Goodglass, 1969). Sparks et al. (1970) logically explained that left hemispheric damage results in an impairment of the auditory signals from both ears as both signals undergo final processing together in the left hemisphere.

It was interesting to note that the two groups differed significantly if accuracy of report was compared, but did not differ significantly if the R-L or POE scores of the two groups were compared. If POE and R-L scores truly reflect the degree of lateralization of dichotically presented stimuli, and if the total number of correct responses is an indicator of accuracy of report, the data seem to indicate that the aphasic and non-aphasic groups differ only in terms of accuracy, rather than in the underlying degree of hemispheric lateralization of the stimuli.

To test this hypothesis, the data were re-analyzed on the basis of single correct responses. Studdert-Kennedy and Shankweiler (1970) pointed out that an ear advantage cannot be detected on trials where both items are correctly or incorrectly perceived. Analysis of trials in which only one syllable is correctly perceived focuses attention only on those items which show an ear preference, while equating all subjects at a 50 percent level of accuracy. This would seemingly allow for a more accurate comparison of the underlying laterality effect of the two groups. Accordingly, the data were re-analyzed using only single correct items. Individual scores are listed in Appendix M, while the group data are summarized in Table 10.

As can be noted from Table 10, the two groups now differ significantly only in the number of double correct and double incorrect responses, while the mean correct ear scores are indistinguishable between the two groups. Therefore, when only single correct responses are analyzed, the aphasic and non-aphasic groups do not differ in the degree of ear asymmetry on the dichotic listening task, but do differ significantly in accuracy of response.

TABLE 10

A COMPARISON OF MEAN CORRECT EAR SCORES AND STANDARD DEVIATIONS BETWEEN THE APHASIC AND NON-APHASIC GROUPS IN ANALYZING SINGLE CORRECT RESPONSES

		Non-aphasic Group	Aphasic Group	t
Right Ear	$\bar{X}$=	22.64	21.46	.3668(NS)
	SD=	3.08	9.71	
Left Ear	$\bar{X}$=	17.00	17.55	.2104(NS)
	SD=	3.13	7.56	
Total Right + Left Ear	$\bar{X}$=	39.64	39.00	.2537(NS)
	SD=	3.65	7.03	
Double Incorrect	$\bar{X}$=	5.09	15.82	4.7351***
	SD=	2.88	6.56	
Double Correct	$\bar{X}$=	15.27	5.18	5.8102***
	SD=	3.33	4.37	

***Significant at the .001 level

However, analysis entirely on a group basis seems to be misleading in view of the inter-subject variability seen within groups, especially within the aphasic group.

The group of non-brain damaged subjects appears to be relatively predictable in terms of their overall dichotic performance. However, as can be seen from observing individual performances, not all subjects showed a right ear advantage for the dichotically presented speech stimuli. Two of the eleven control subjects showed either no ear preference, or showed a left ear preference for the dichotic stimuli. Nonetheless, the group is quite homogeneous in its performance, as can be noted from the clustering of performances among the control group graphed in Figure 1 and from the relatively small standard deviation scores. Furthermore, Ryan and McNeil (1973) recently reported a relatively high degree of test-retest reliability for a group of normal subjects on a dichotic CV listening task, despite some intra- and inter-subject variability.

Although there is some individual variability within the non-aphasic control group, the aphasic group appears to be much less predictable and more heterogeneous. This point is again made clear by observing the scattered range of performance of the aphasic group in Figure 1. Only six of the eleven aphasics actually showed a right ear advantage for the CVs, while the other five aphasics showed a left ear advantage. As was pointed out earlier, in examining the data in Table 4, the two aphasic subgroups are not merely representative of slight variations in responses, but reflect a true dichotomy in performance. Although the two groups perform with the same degree of accuracy, one group shows a right ear advantage, and the other shows a left ear advantage for the dichotic stimuli.

This finding is not unique to the present study. Schulhoff and Goodglass (1969) also reported a non-significant right ear advantage for a group of ten aphasics, although six of the subjects actually showed a left ear advantage for the dichotic speech stimuli. On the other hand, Sparks et al. (1970) reported a left ear advantage for a group of aphasics, but also found a great deal of variability within the group. Fifteen of the aphasics showed a right ear advantage for digits while 13 showed a left ear advantage; 7 showed a right ear advantage for words, 18 showed a left ear advantage, and 1 showed no ear preference.

In view of the heterogeneity of performance within the aphasic group, attempts to discuss the aphasics as a single group may be extremely misleading. Therefore, the two aphasic subgroups were compared on the basis of single correct item analysis. The data are presented in Table 11.

Regardless of whether single correct items or all items are analyzed, the outcome is the same when the two subgroups are compared. The two groups do not differ in accuracy of report but differ only in ear preference. When the premorbid right ear advantage is considered, it

TABLE 11

A COMPARISON OF MEAN CORRECT SCORES AND STANDARD DEVIATIONS FOR THE TWO SUBGROUPS OF APHASICS, BASED ON AN ANALYSIS OF SINGLE CORRECT RESPONSES

		Right Ear Advantage Group	Left Ear Advantage Group	t
Right Ear	$\bar{X}$ =	29.00	12.40	5.2865**
	SD=	6.63	2.06	
Left Ear	$\bar{X}$=	13.17	22.80	2.4311(NS)
	SD=	5.55	6.18	
Total Right + Left Ear	$\bar{X}$=	42.17	35.20	1.7379(NS)
	SD=	6.72	5.31	
Double Incorrect	$\bar{X}$=	14.00	18.00	.9570(NS)
	SD=	6.25	6.13	
Double Correct	$\bar{X}$=	3.83	6.80	1.0621(NS)
	SD=	3.85	4.40	

**Significant at the .01 level

is not surprising that the difference between ear scores for the left ear advantage group fails to reach significance, while the difference between ear scores reaches significance for the right ear advantage group. To show a left ear advantage, the left ear's performance must first override this premorbid right ear advantage. Therefore, the improvement in the left ear performance is greater than is suggested by the mean number of correct right and left ear scores. Although it is difficult to test this hypothesis empirically, the left ear advantage aphasic group appears to be a distinct group, separate from the right ear advantage aphasics.

A more enlightening result of the single correct response analysis was noted in comparing the performance of the two aphasic subgroups with that of the control group. It was found that the right ear advantage aphasic group actually obtained a higher mean correct right ear score, but a lower mean correct left ear score than the control group. This finding may be interpreted as indicating that the right ear has undergone some release from competition for the single speech processor as the result of brain damage. The right ear signal is seemingly processed with little interference, while the left ear signal seems to be placed under added interference.

In examining the left ear advantage group, the opposite conditions exist. This aphasic subgroup obtained a higher mean correct left ear score, but a lower mean correct right ear score than the control group. It appears here that the left ear signal is now released from the normal amount of competition for the unilateral speech processor, while the right ear signal is subjected to a greater amount of interference. The relationship between right and left ear scores within the three groups is shown in Figure 4.

In view of these findings, the difference in performance of the aphasics on the dichotic CV listening

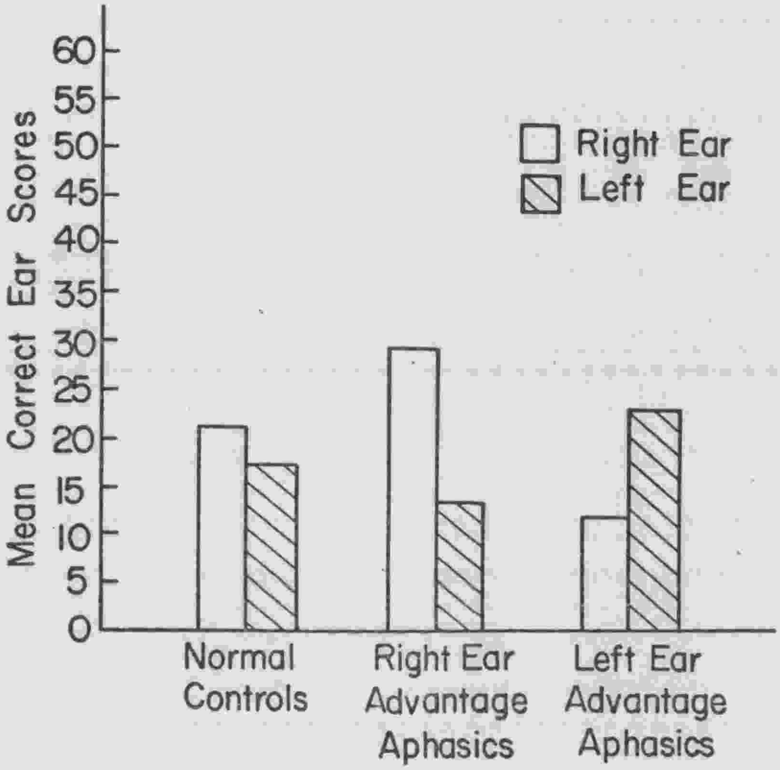

Figure 4. A Comparison of the Mean Correct Right and Left Ear Scores of the Three Groups on the Basis of Single Correct Item Analysis.

task could best be explained in terms of a model similar to that presented by Sparks et al. (1970). The model is based on the assumption that auditory signals undergo similar processing in bilateral auditory processors, while further analysis of both signals is carried out in a unilateral, left hemispheric speech processor. This information, in addition to evidence in support of the more efficient contralateral pathways between the ear and the auditory cortex resulted in the formulation of the model shown schematically in Figure 5. The model is not meant to imply that these areas, or even the functions of these areas, are well defined and localized. The model serves merely to attempt to identify the level at which the processing of an auditory signal is interfered with following brain damage.

In applying the results of this study to the model just described, a bilateral deficit on the dichotic listening task by aphasics is explained by the presence of a lesion in the dominant left hemisphere, where the auditory signals from both ears converge for final processing. Superimposed on this bilateral deficit is an additional right ear deficit in one aphasic subgroup and an additional left ear deficit in the other aphasic subgroup.

In order to explain the findings for the right ear advantage aphasic group on the basis of the model just presented, the left hemispheric lesion must be situated

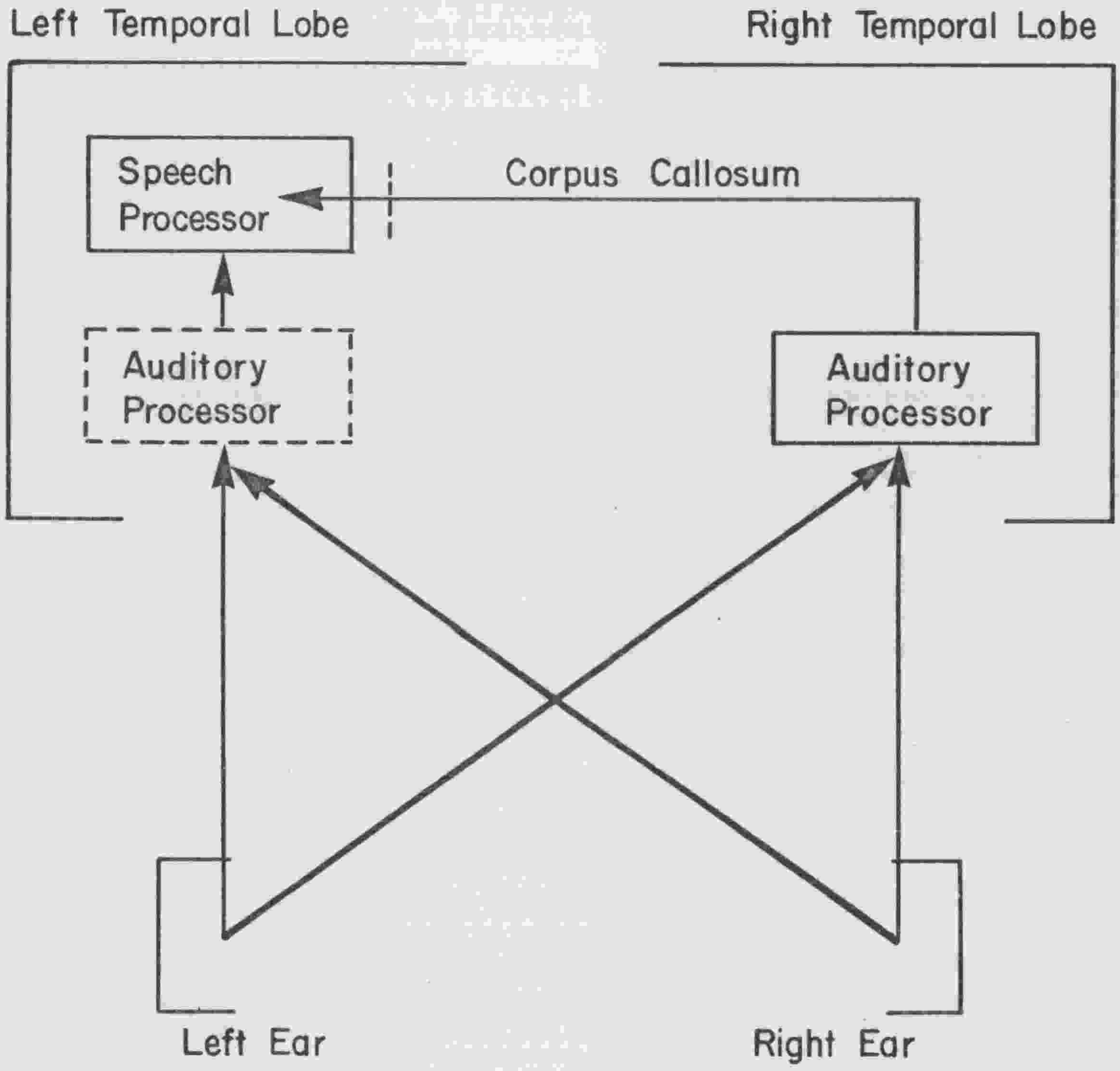

Figure 5. A Schematic Representation of a Functional Model Used to Explain the Processing of Dichotic Speech Stimuli.

in an area which would interfere with processing of the left ear signal, while allowing the right ear signal better access to the processor. To explain this finding, it would be necessary for the lesion to involve the corpus callosum tract in the left temporo-parietal lobe area. The lesion is designated by a short, dashed line along the corpus callosum in Figure 5.

In order to explain the findings for the left ear advantage subgroup, the left hemispheric lesion must be located in a position which would interfere with processing of the right ear signal, while allowing the left ear signal better access to the speech processor. It appears that the lesion would have to be located in the area of the auditory processor of the left hemisphere, which is enclosed by the dashed lines in Figure 5.

This explanation is in agreement with the hypothesis first presented by Sparks et al. (1970). This hypothesis is also consistent with findings reported by Milner, Taylor, and Sperry (1968) in a study of seven patients with sections of the cerebral commissures, including the corpus callosum. In response to pairs of dichotically presented digits, the patients showed a large difference in performance between ears. In addition, the right ear of the patient group performed slightly better than the right ear of the normal group, while the left ear performed very poorly in comparison with the control group.

Speaks, Rubens, Podreza, and Kuhl (1973) recently presented further information in support of this model. They found that three aphasics showing a right ear advantage for CV-syllables had left hemispheric lesions in the area where the corpus callosal fibers enter the left hemisphere, while three other aphasics showing a left ear advantage for the CV-syllables had lesions in the posterior, superior temporal lobe area.

An additional observation from studies using patients with left hemispheric lesions has been that only aphasics with lesions due to CVAs have shown a right ear advantage for speech stimuli, while left hemispherectomees have consistently shown a left ear advantage for the stimuli. The right ear advantage observed among some CVA cases is hypothesized to be the result of deep lesions involving the corpus callosal fibers. This is rarely the case with surgical patients, whose lesions are generally less diffuse. Although intra-hemispheric lesion data were not available on the eleven aphasics used in this study, it seemed logical to hypothesize that trauma cases, in whom lesions would most probably be more superficial than lesions due to CVAs, would perform like surgical cases in showing a left ear advantage for dichotic speech stimuli. This hypothesis was supported by the results of this study. Aphasic subjects with histories of CVAs were found within both the right ear advantage subgroup and within the left ear advantage subgroup, while the three trauma cases all fell within the left ear advantage subgroup.

In summary, analysis of only single correct items equated the control group and the two aphasic subgroups at a 50 percent accuracy level, so that the underlying ear asymmetry could be compared across the three groups. The results are in support of the hypothesis that left hemispheric lesioned subjects showing a right ear preference for dichotic CV-syllables have a lesion along the corpus callosal tract in the left hemisphere; subjects showing a left ear preference for the CVs have a lesion in the area of the auditory processor of the left hemisphere.

Another objective of this study was to compare the R-L and POE methods of data analysis. As was discussed earlier, the R-L and POE scores were found to correlate highly, and therefore, seem to be affected by the same factors. Harshman and Krashen's argument that the R-L score is affected by accuracy and guessing while the POE score reflects only the degree of lateralization is not supported in this study. On the contrary, the results of this study seem to indicate that both the R-L and POE scores reflect hemispheric lateralization of the dichotic stimuli, without being affected by accuracy of response. Since no new information is contributed by computing both R-L and POE scores, only one of the two scoring methods would seem necessary.

The final objective of this investigation was to explore possible relationships existing between the performance of aphasics on the dichotic listening task and their performance on the PICA, the Token Test, and the SSW Test. Although each measure seems to be effective in identifying speech and language dysfunctions due to brain damage, no measure alone was shown to be a good predictor of dichotic performance. However, all tests taken together were a good predictor of this performance. This finding should not be interpreted to mean that no relationships exist among these measures, but more logically, may be due to the small number of aphasic subjects studied. The latter seems to be indicated in view of the differences in performance of the two aphasic subgroups on the Token Test and the SSW Test, although these differences were not statistically significant.

On the other hand, an alternative explanation is that the tests merely assess performance at different functional levels. This might explain the disagreement found in three cases between the dichotic listening task and the SSW Test. The listener's task of identifying precisely aligned CV-syllables, differing only in initial consonants, may reasonably be quite a different task from identifying partially overlapping, familiar spondaic words.

Limitations of the Study

Aphasics for this study were chosen on the basis of availability and ability to do the task. Therefore, the resultant group is a biased sample and is not representative of the entire population of aphasics, especially in terms of severity of involvement. In addition, the small number of subjects in each group may have affected the data analysis in testing the relationship between dichotic performance and performance on the PICA, Token Test, and SSW Test.

Finally, in view of the many variables which have been found to influence dichotic performance, comparison of results across studies should be carried out cautiously. In addition to procedural differences, differences in the stimuli used might also be a factor. For example, CV-syllables and digits may be processed somewhat differently in view of the differences in the acoustic and linguistic features of the two stimulus items.

Future Experiments

Future experiments with aphasic subjects should be based on a larger and more homogeneous group than in the present study. In view of the indications that etiology and site of lesion may affect dichotic performance, experimenters should carefully describe their subjects in terms of etiology and site of lesion as well as in severity, and months post onset of aphasia. Additional studies are necessary to assess the relationship between these factors and dichotic performance.

In observing the performances of the aphasic and non-aphasic groups in the present study, it was noted that the two groups appeared to differ in latency of response to the dichotic stimuli. This observation warrants further investigation and may contribute additional information about speech perception processes in normals and in brain damaged subjects.

Finally, a comparison of a group of right ear advantage aphasics and left ear advantage aphasics, in terms of prognosis and recovery may provide useful information in hypothesizing about the importance of certain areas in the speech perceptual process. In addition, such an investigation might also provide valuable clinical information.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Summary

A dichotic CV-syllable listening task was administered to a group of eleven non-brain damaged adults and to a group of eleven adult aphasics. The total number of correct right ear responses and the total number of correct left ear responses, out of a possible 60 items per each ear, were computed for each individual. The mean scores for each group were then submitted to a series of t-tests to determine whether differences between groups were significant. In addition to a comparison of the R-L and POE methods of data analysis, dichotic performance of the aphasic group was compared with its performance on the PICA, Token Test, and SSW Test. The results of this study may be summarized as follows:

1. The group of non-brain injured adults showed a right ear advantage for dichotically presented CV-syllables.
2. In comparison with the control group, the aphasic group showed a bilateral deficit in response to the dichotic CV-syllables.

3. Although the aphasic group showed a slight right ear advantage for the dichotic CV-syllables, only six of the aphasics showed a right ear preference for the stimuli, while the remaining five aphasics showed a left ear preference for the stimuli.
4. The two subgroups of aphasics, a right ear advantage group and a left ear advantage group, performed significantly different on the dichotic listening task.
5. When a single correct method of analysis was used, the superior ear within each aphasic subgroup was found to perform better than the respective ear within the control group.
6. The R-L and POE scores correlated highly in reflecting the degree of lateralization of the dichotic stimuli.
7. Although the PICA, Token Test, and SSW Test results also reflected an impairment in functioning within the aphasic group, no single test served as a good predictor of dichotic performance.

Conclusions

The results of this study were analyzed in terms of a functional model which assumes more efficient contralateral auditory projections to the cerebral hemispheres, and the presence of bilateral auditory processors and a unilateral speech processor. In view of this model, the right ear advantage for dichotic speech stimuli within the control group was interpreted as reflecting the greater efficiency of the contralateral auditory pathways, and the specialized function of the left hemisphere in processing speech. The bilateral deficit in dichotic performance of the aphasic group was accounted for by the presence of a lesion within the dominant left hemisphere, where the auditory signals from both ears converge for final processing. In order to explain the performances of the two aphasic subgroups in terms of the model discussed, the right ear advantage shown by one aphasic subgroup was explained by a lesion interfering with the corpus callosal pathways coming from the right hemisphere; the left ear advantage observed within the other subgroup was explained by a lesion in the area of the auditory processor of the left hemisphere.

In analyzing the R-L and POE scoring methods, both measures seemed to be unaffected by accuracy of response while reflecting the degree of underlying lateralization of dichotic stimuli. Since the two scores correlated very highly and appeared to be affected by the same factors, only one method of analysis seems necessary. However, in view of the finding that neither the R-L nor POE scores differentiated between the aphasic and non-aphasic groups, a method of data analysis which reflects accuracy of response also seems warranted. While R-L and POE scores appear to be good indicators of the degree of lateralization of dichotic stimuli, accuracy of response appears to be best reflected by an analysis of raw scores or double correct and double incorrect items.

Unfortunately, no conclusions could be drawn from a comparison of PICA, Token Test, and SSW Test performances and dichotic listening task performances. Although some differences were noted in the performances of the two aphasic subgroups on the Token Test and the SSW Test, these differences were not significant. This finding was felt to be due to the small number of aphasics studied, or to the possibility that each test assessed an individual's performance at a different functional level.

APPENDICES

APPENDIX A

EXPERIMENTAL GROUP SUMMARY

Subject	Sex	Age	Education	Handedness	Language	MPO	Etiology
1	M	49	15	R	Bilingual	16	Thrombo-embolic
2	M	24	10	L	Bilingual	45	AVM
3	M	66	16	L	English	1	Hemorrhage
4	M	50	6	R	English	1	Thrombo-embolic
5	M	64	12	R	English	1	Thrombo-embolic
6	M	50	8	R	Bilingual	13	Thrombo-embolic
7	M	46	9	R	English	45	Trauma
8	M	41	12	R	English	34	Trauma
9	F	53	12	R	English	10	Trauma
10	M	47	17	R	English	25	Thrombo-embolic
11	M	46	5	R	Bilingual	5	Thrombo-embolic

APPENDIX B

CONTROL GROUP SUMMARY

Subject	Sex	Age	Education	Handedness	Language
1	M	58	12	R	Bilingual
2	M	27	9	R	Bilingual
3	F	46	12	L	English
4	M	43	12	R	English
5	M	53	6	Ambidex.	English
6	M	64	13	R	English
7	M	58	9	R	English
8	M	63	14	R	English
9	M	41	21	R	English
10	M	53	10	R	Bilingual
11	M	41	7	R	Bilingual

APPENDIX C

DICHOTIC CV TEST STIMULI

	Channel I	Channel II
1.	DA	TA
2.	BA	PA
3.	GA	TA
4.	TA	KA
5.	TA	BA
6.	GA	KA
7.	KA	TA
8.	DA	GA
9.	PA	DA
10.	KA	GA
11.	KA	DA
12.	GA	BA
13.	BA	GA
14.	BA	TA
15.	DA	BA
16.	BA	KA
17.	PA	GA
18.	GA	PA
19.	PA	TA
20.	TA	DA
21.	DA	PA
22.	DA	PA
23.	KA	BA
24.	PA	KA
25.	PA	BA
26.	GA	DA
27.	DA	KA
28.	BA	DA
29.	TA	GA
30.	TA	PA

APPENDIX D

SPEECH DISCRIMINATION TEST STIMULI

CV SYLLABLES			
RIGHT EAR		LEFT EAR	
1.	BA	1.	GA
2.	PA	2.	KA
3.	GA	3.	TA
4.	DA	4.	PA
5.	KA	5.	DA
6.	TA	6.	BA

APPENDIX E

APHASIC INFORMATION SHEET

NAME________________________ DATE________________________

DATE OF BIRTH________________ EDUCATION__________________

OCCUPATION____

WHICH HAND DO YOU WRITE WITH?____________________________

EAT WITH?____________________________

THROW A BALL WITH?____________________________

ARE YOU A NATIVE SPEAKER OF ENGLISH?______________________

HAVE YOU HAD ANY PREVIOUS EXPERIENCE IN LISTENING TO DICHOTICALLY PRESENTED MESSAGES?____________________

SITE OF LESION

MONTHS POST ONSET

ETIOLOGY

SEVERITY (PICA SCORES)

	SCORE	PERCENTILE
OVERALL	______________	______________
GESTURAL	______________	______________
VERBAL	______________	______________
GRAPHIC	______________	______________

TOKEN TEST SCORES

SSW TEST SCORES

APPENDIX F

NON-APHASIC INFORMATION SHEET

NAME________________________ DATE________________________

DATE OF BIRTH______________ EDUCATION____________________

OCCUPATION____

WHICH HAND DO YOU WRITE WITH?____________________________

EAT WITH?____________________________

THROW A BALL WITH?____________________________

ARE YOU A NATIVE SPEAKER OF ENGLISH?____________________

HAVE YOU HAD ANY PREVIOUS EXPERIENCE IN LISTENING TO

DICHOTICALLY PRESENTED MESSAGES?____________________

HAVE YOU HAD BRAIN DAMAGE OR HEAD TRAUMA AT ANY TIME?_____

____

TOKEN TEST SCORE

APPENDIX G

SUBJECTS' TEST INSTRUCTIONS

The tapes you are about to hear consist of 60 pairs of nonsense syllables from the group BA, DA, GA, PA, TA, KA. From now on there will always be two syllables given at the same time--one to the right ear and a <u>different</u> one to the left ear.

Please look at your answer sheet and notice the numbers from 1 through 30 on page 1, and 1 through 30 on page 2. To the right of each number are the six syllables. <u>Please mark two different answers on the sheet</u> immediately following the presentation of each of the items.

Remember, you must mark <u>two</u> answers for each pair even if you think you hear only one syllable. You must guess at the other syllable if necessary.

Any questions?

APPENDIX H

PROCEDURAL CHECK LIST

I. Calibration of equipment
   A. Turn on audiometer
      1. Channel I and II phones
      2. Continuous switching mode
      3. Oscillator to speech
      4. Channel I and II continuous on
      5. Tape A--Channel I--right ear
      6. Tape B--Channel II--left ear
   B. Turn on tape recorder
      1. Speed at $7\frac{1}{2}$
      2. Thread CV tape & turn to calibration tone
      3. Peak 1000 Hz tone at 0 on VU meter for Channel I with Tape A adjustment
      4. Peak 1000 Hz tone at 0 on VU meter for Channel II with Tape B adjustment
   C. Turn on sound level meter (SLM)
      1. External filter
      2. 70 dB range
      3. 1000 Hz frequency range
      4. Right earphone on 6 cc coupler
      5. 500 grams pressure
      6. Adjust Channel I attenuator on audiometer to read 75 dB SPL on SLM
      7. Left earphone on 6 cc coupler
      8. 500 grams pressure
      9. Adjust Channel II attenuator on audiometer to read 75 dB SPL on SLM

II. Complete subject information sheet
   A. Aphasic information from files
   B. Control information provided by subject

III. Administer Part V of the Token Test to control subjects
   A. Position large circles and rectangles
      1. Circles--white, blue, yellow, green, red
      2. Rectangles--white, blue, yellow, green, red
   B. Read and score 21 test items

IV. Pure tone audiometry
   A. Channel I--tone
      1. Right ear
      2. Left ear
   B. Oscillator to 250 Hz-3000 Hz
   C. Check thresholds

APPENDIX H (continued)

PROCEDURAL CHECK LIST

V. Screen for response mode in aphasics
   A. Written
   B. Gestural
   C. Verbal

VI. CV discrimination test
   A. Oscillator to speech
   B. Channel I continuous on
   C. Channel I--Tape A
   D. Attenuator to 75 dB SPL
   E. CV task
      1. Instructions and answer sheets
      2. Right ear
      3. Left ear
   F. Score

VII. Dichotic CV-syllable listening task
   A. Channel I & II continuous on
   B. Tape A--Channel I--right ear
   C. Tape B--Channel II--left ear
   D. Channel I & II attenuators at 75 dB SPL
   E. Control for order of presentation
      1. Odd numbered subjects--Channel I, right ear; Channel II, left ear
      2. Even numbered subjects--Channel I, left ear; Channel II, right ear
   H. Control for effect by earphones
      1. Present 30 test items
      2. Reverse earphones and again present 30 test items
   F. Administer instructions and answer sheets
   G. Present the dichotic listening task

VIII. Score responses and record data

IX. Administer or obtain from the files, PICA, Token, and SSW test scores on each aphasic, administered within one week of the dichotic listening task

APPENDIX I

RAW SCORES FOR INDIVIDUAL APHASIC AND NON-APHASIC SUBJECTS

Group	Subject	Right Ear Correct	Left Ear Correct	Total Correct	Absolute Difference Between Ears
Aphasic	1	42	15	57	27
	2	46	14	60	32
	3	25	13	38	12
	4	34	21	55	13
	5	23	19	42	4
	6	27	20	47	7
	7	18	20	38	2
	8	29	35	64	6
	9	23	31	54	8
	10	15	27	42	12
	11	11	35	46	24
Non-aphasic	1	35	32	67	3
	2	44	31	75	13
	3	41	30	71	11
	4	37	35	72	2
	5	34	34	68	0
	6	33	30	63	3
	7	33	34	67	1
	8	37	32	69	5
	9	45	38	83	7
	10	41	26	67	15
	11	37	33	70	4

APPENDIX J

R-L AND POE SCORES FOR INDIVIDUAL APHASIC AND NON-APHASIC SUBJECTS

Group	Subject	R-L	POE
Aphasic	1	45.00	71.42
	2	53.33	76.66
	3	20.00	57.31
	4	21.66	60.00
	5	6.67	52.56
	6	11.67	54.79
	7	- 3.33	48.78
	8	-10.00	44.64
	9	-13.33	43.93
	10	-20.00	42.30
	11	-40.00	33.78
Non-aphasic	1	5.00	52.83
	2	21.67	64.44
	3	18.33	61.22
	4	3.33	52.08
	5	0.00	50.00
	6	5.00	52.63
	7	- 1.66	49.05
	8	8.33	54.90
	9	11.67	59.45
	10	25.00	64.15
	11	6.66	54.00

APPENDIX K

PERFORMANCE OF INDIVIDUAL APHASICS ON THE PICA, TOKEN TEST, AND SSW TEST

PICA

Subject	Overall	Gestural	Verbal	Graphic
1	84	88	70	85
2	80	85	79	78
3	73	65	51	86
4	69	52	64	78
5	53	64	59	34
6	74	60	65	81
7	70	66	61	75
8	41	32	43	57
9	89	95	78	89
10	75	94	64	72
11	75	67	90	74

APPENDIX K (Continued)

PERFORMANCE OF INDIVIDUAL APHASICS ON THE PICA, TOKEN TEST, AND SSW TEST

	Token Test Errors					
Subject	I	II	III	IV	V	Total
1	2	0	1	2	10	15
2	0	0	4	2	7	13
3	0	0	0	2	12	14
4	0	2	7	6	14	29
5	0	0	2	1	13	16
6	4	6	9	10	21	50
7	2	3	7	7	16	35
8	2	2	4	5	10	24
9	0	0	0	0	3	3
10	3	2	5	9	12	31
11	2	2	6	6	11	27

APPENDIX K (Continued)

PERFORMANCE OF INDIVIDUAL APHASICS ON THE
PICA, TOKEN TEST, AND SSW TEST

	% Errors on the C-SSW			
Subject	RNC	RC	LC	LNC
1	0	0	40	18
2	9	14	26	11
3	5	8	16	4
4	16	56	13	5
5	13	58	33	8
6	56	96	69	44
7	13	13	28	25
8	6	11	23	13
9	1	16	3	- 2
10	65	70	33	30
11	37	69	27	5

APPENDIX L

CLASSIFICATION OF APHASIC SUBJECTS ON THE BASIS OF THEIR PERFORMANCE ON THE SSW TEST AND THE DICHOTIC LISTENING TASK

Subject	Dichotic Listening Task	SSW
1	Right Ear Advantage	Right Ear Advantage
2	Right Ear Advantage	Right Ear Advantage
3	Right Ear Advantage	Normal
4	Right Ear Advantage	Left Ear Advantage
5	Right Ear Advantage	Left Ear Advantage
6	Right Ear Advantage	Bilateral
7	Left Ear Advantage	Right Ear Advantage
8	Left Ear Advantage	Normal
9	Left Ear Advantage	Normal
10	Left Ear Advantage	Left Ear Advantage
11	Left Ear Advantage	Left Ear Advantage

APPENDIX M

ANALYSIS OF SINGLE CORRECT ITEMS

Group	Subject	Right Ear Correct	Left Ear Correct	Total Correct	POE	Double Incorrect	Double Correct
RE Advantage Aphasics	1	34	7	41	67.08	11	8
	2	38	6	44	71.05	8	8
	3	25	13	38	57.31	22	0
	4	34	21	55	60.00	5	0
	5	23	19	42	52.55	18	0
LE Advantage Aphasics	6	20	13	33	54.02	20	7
	7	13	15	28	48.91	27	5
	8	15	21	36	46.42	10	14
	9	14	22	36	45.23	15	9
	10	10	22	32	43.18	23	5
	11	10	34	44	34.21	15	1
Non-aphasics	1	24	21	45	52.00	4	11
	2	28	15	43	58.44	1	16
	3	25	14	39	56.79	5	16
	4	23	21	44	51.31	2	14
	5	20	20	40	50.00	6	14
	6	22	19	41	51.89	8	11
	7	16	17	33	49.42	10	17
	8	21	16	37	53.01	7	16
	9	21	14	35	54.11	1	24
	10	26	11	37	59.03	8	15
	11	23	19	42	52.56	4	14

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