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HEMISPHERIC SPECIALIZATION FOR SPEECH PERCEPTION IN KINDERGARTEN CHILDREN WITH LANGUAGE DEFICIENCY

by

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CHAPTER I. INTRODUCTION

It has long been known that one side of the brain, usually the left, bears the major responsibility for language processing and production in the normal population. Since the motor functions on each side of the body are controlled by centers in the opposite hemisphere, most left-brained individuals are right-handed. Consequently, there exists a contralateral relationship between the dominant hand and the side of the brain which controls its motor performance and the language functions. The Ortonian hypothesis of mixed dominance, first articulated nearly half a century ago, associates speech, language and reading disorders with the failure of one hemisphere to maintain a clear lead in the control of both motor and speech processes. In such cases, the normal ipsilateral speech/motor control relationship will not exist; neither hemisphere will be able to assume dominance over the other, and the resulting conflict will cause the deficiencies which Orton (1937) described.

Until recently, attempts to test Orton's theory have been hampered by a paucity of valid and reliable handedness measures and the lack of any method at all for the assessment of cerebral dominance for language. These obstacles have been partially removed by the development of tests of relative manual proficiency, lately recognized as a more legitimate means of determining handedness in individuals, and the use of the dichotic listening technique for establishing the hemisphere in which the speech processes reside. Using these newer techniques, this research investigated the question of whether right-handed language deficient children, as defined by an elicited sentence imitation task, differ in cerebral lateralization of language and/or degree of handedness from their more proficient peers. An additional undertaking was the examination of other linguistic and nonlinguistic aspects of their functioning to determine if deficient children perform less ably, and if so, to what degree. Further, the possibility of a relationship between any single variable or combination of variables and cerebral lateralization of language as revealed by ear advantage was explored.

If it could be demonstrated that early language deficiency was accompanied by different hemispheric organization for motor and speech functions than exists in normal children, some inferences regarding the neurological correlates of language disorders could be drawn. By implication, the long-held notion that some lateralization of function is necessary for optimal language development in most individuals would be given support, and additional knowledge of the neurological processes related to language acquisition and development in the non-disordered population would be gained. The only direct non-surgical window to the functioning of the brain as it relates to language, is through dichotic listening, which is believed to identify the hemisphere in which speech is processed. Since it is known that a contralateral relationship between the dominant hemisphere and the dominant hand generally exists, comparing this relationship in normal and linguistically deviant populations would best reveal differences which, if found, might help to explain the differences in linguistic ability.

Relatedly, if it could also be demonstrated in a search of the literature, that children labelled language disordered are actually not very different, behaviorally speaking, from those nominally placed in other diagnostic categories, progress toward the establishment of a more unified, comprehensive and effective approach to their remediation will have been made.

In this research, direction and degree of hemispheric lateralization for speech processing was measured by a synthetic CV syllable dichotic listening task developed at Haskins Laboratories; degree of handedness was determined by a battery of tests which establish hand preference and relative manual proficiency; an examination and correlational study of the test scores of several aspects of the children's functioning in language, nonverbal and cognitive areas was made in the hope of more clearly delineating the parameters of their language usage and discovering possible interrelationships among the variables tested.

By selecting subjects so as to maximize differences between groups, by using dichotic stimuli on which a body of data has already been assembled, by employing a variety of handedness tasks in order to assess more accurately the degree of handedness of each child, and by looking at many related areas of the children's functioning, this study has attempted to produce insights into the phenomenon of cerebral lateralization as it relates to children who fail to develop language optimally.

In order to provide a cohesive framework within which to view the results of this and other dichotic studies, it was necessary to search out and report on a wide range of literature. The objective was to interrelate theories of language development, brain organization, and the varied findings of the many dichotic studies which have investigated lateralization for speech in the different populations. An attempt is made later in this paper to explain the results found by making reference to theories explicated in previous research. A review of studies which describe speech and language deficits in medically diagnosed aphasic and neurologically impaired (organic) as well as behaviorally diagnosed language disordered and learning disabled subjects (functional) was also undertaken in an endeavor to broaden the implications of this study by redefining and recharacterizing the children under scrutiny. The next chapter reports on this diverse literature.

CHAPTER II. REVIEW OF RELATED LITERATURE

This chapter contains two main sections. The first reviews the literature on cerebral lateralization and the second describes certain linguistic deficits which are shared by children who have been placed in different diagnostic groups. It is against this dual background that the results of the present study can best be discussed.

Hemispheric Specialization

This section deals with the broad area of hemispheric specialization for language and handedness. First are reviewed findings related to the lateralization of these functions and the relationship between them in the normal population. Next is presented evidence for and against a prepotency for the asymmetry of function and/or the development of lateralization; and finally, the results of dichotic studies in special populations are discussed.

Lateralization for Language in Normals as Revealed by Dichotic Testing

The auditory rivalry or dichotic listening task, first used by Broadbent in 1954 to test short term memory, consists of determining a subject's relative perception of two different signals simultaneously presented, one to each ear, by comparing the number of stimuli correctly reported from each. Kimura (1961a) adapted this technique as a means of determining language laterality in a group of brain-damaged adults. The only means by which the side of the brain which controlled language could previously be determined in individuals, was either through autopsy of known aphasics to find the site of lesion, or the use of the Wada sodium amytal test (Wada and Rasmussen, 1960). In this test, the injection of sodium amytal into the carotid artery on one or the other side of the neck results in the temporary disruption of speech, thus providing definitive evidence for lateralization. When injections on both sides cause speech disturbance, the patient is presumed to be bilateral for language. The fact that the right ear is superior for verbal material in persons previously established by the Wada test to be left-hemisphere dominant for language, was interpreted by Kimura as suggesting the neural superiority of the contralateral auditory pathways, and/or the inhibition of the ipsilateral pathways; a superiority demonstrated only under the special condition of the overload of the system which occurs during the auditory rivalry task. (This interpretation applies also to the privileged access which the left ear has to the right hemisphere, and which results in a left-ear advantage for nonspeech stimuli.) Testing the same neurologically impaired patients as had been subjected to the Wada test, Kimura found agreement between its results and those of the dichotic procedures. These findings presented researchers with their first opportunity to examine directly hemispheric specialization for speech processing in normals.

Since that time, extensive use of dichotic listening with a variety of stimuli, procedures and subjects, has substantiated the earlier findings by showing that for groups of right-handed subjects of either sex, the right ear, being contralateral to the language-dominant left hemisphere, exhibits a significant and reliable advantage in identifying dichotically presented verbal stimuli (Kimura, 1961b, 1967; Shankweiler, 1966b). This advantage has been shown not only for words and digit pairs, but also for CV and CVC nonsense syllables, particularly for pairs contrasting in stop consonants (Shankweiler and Studdert-Kennedy, 1967). On the basis of their work with stop consonants, these investigators argued that the right-ear advantage (REA) reflected left hemisphere extraction of phonetic features during phonetic analysis. Yeni-Komshian and Gordon (1974) were able to increase the REA for monosyllabic words when a ten- and fifteen-second latency of response was forced, suggesting that short term storage for speech sounds is also a left hemisphere function. These and other studies showed that the right-ear effect occurs with both natural and synthetic speech stimuli, whether the subject is required to respond after presentation of a single pair or several pairs of stimuli, and whether recognition or recall procedures are used (Broadbent and Gregory, 1964). Moreover, when two responses for each pair are required, the advantage occurs whether the subjects are told to report one or the other ear first (ordered recall), or permitted to report the stimuli in the order they prefer (free recall) (Bryden, 1963, 1964).

Zurif and Sait (1970) initially believed that not only segmental phonetic processing, but also the processing of the suprasegmental features of stress and intonation, were lateralized to the left hemisphere. In their first study, strings of nonsense syllables, bound morphemes and intact function words were presented dichotically in two different conditions. In one, the grammatical ordering of these elements was that of natural English sentences; these were read with appropriate intonation and rhythm. In the other, the items were randomly ordered and read like lists. Although a right-ear advantage resulted from both modes of presentation, only in the former condition was it significant. However, Haggard and Parkinson (1971) were able to demonstrate a shift of a right-ear advantage to a left-ear advantage by changing the task from one which is linguistic (voice-voiceless distinction) to one which is nonlinguistic (identification of emotional tone). This and findings such as those of Blumstein and Cooper (1974) in which identification and matching of intonation contours in both linguistic and nonlinguistic conditions yielded a left-ear advantage, led Zurif (1974), in a later paper, to amend his earlier conclusions. He therein conceded that the processing of intonation contours was a right hemisphere function, but added that although "the left hemisphere is not specifically geared to process the overall acoustic properties of an utterance" it "is capable of utilizing these properties in the service of linguistic decisions" (p. 402).

It has also been demonstrated that barring brain dysfunction, the hemisphere not dominant for speech specializes in the identification of such nonverbal sounds as music, (Milner, 1962; Kimura, 1964), and environmental sounds (Curry, 1968; Curry and Rutherford, 1967a); these stimuli usually yield a left-ear advantage, although musical patterns may yield a right-ear advantage in musically trained subjects (Bever and Chiarello, 1974). This is interpreted as suggesting that the left hemisphere is specialized for analytical tasks which may not be verbal. When isolated electronically from the speech stream or synthesized for purposes of experimentation, steady-state vowels of relatively long duration (speech sounds which share some of the acoustical features of musical tones), lateralize in the manner of neither stop consonants nor music, but show only a small and nonsignificant right-ear advantage (Shankweiler and Studdert-Kennedy, 1967). Of course, vowels in their steady state seldom occur in verbal discourse unaccompanied by transitions to other sounds. However, several experimenters (e.g., Godfrey, 1974; Weiss and House,1973) have demonstrated that under appropriate experimental conditions, vowel pairs will induce the standard speech right-ear advantage. Taken together, these studies indicate that speech processing is generally a left hemisphere function, even though both hemispheres may extract information about the acoustic properties of an utterance. In contrast, processing of nonlinguistic auditory patterns appears to be a right hemisphere function. The fact that ear advantages differ in magnitude from study to study and from task to task, reflects different stimulus and/or response paradigms, while differences between individuals suggest different hemispheric capacities for both linguistic and nonlinguistic processing in individual subjects.

Handedness

Samuel Orton (1937) was the first to suggest that cortical lateralization, as revealed by the development of handedness, is prerequisite to the normal development of some aspects of speech and language. He contended that interference with natural handedness would induce mixed dominance and that this would cause difficulties in reading, writing and speaking. He also believed that such difficulties might result from genetically based mixed cortical control of the motor functions in eye, hand and foot use, in children he referred to as "motor intergrades." Continued interest in handedness, especially as it relates to aphasia, has resulted in a large body of literature devoted to the differential consequences of left and right cerebral insult in patients whose handedness was assessed by a variety of means. Only in more recent years has it been recognized that handedness may be a continuous rather than a dichotomous variable (Gloning, Gloning, Haub, and Quatember, 1967; Orlando, 1971: Shankweiler and Studdert-Kennedy, 1975). This insight arose partly from the development of more refined methods of testing handedness (such as measuring relative manual proficiency rather than hand preference or self-report), partly from the recognition that a battery of tests would be more conclusive than any single measure. Self-report, at one time almost exclusively used, is now seen as the least reliable indicator of manual laterality (Satz, Achenbach and Fennell, 1967).

Relation Between Language Lateralization and Hand Lateralization in Normals

Early theories of the relation between handedness and hemispheric dominance for language are exemplified by Chesher (1936), Goodglass and Quadfasel (1954), Penfield and Roberts (1959), and Weisenberg and McBride (1935). The first of these suggests that left-handers are more nearly bilateral for language than right-handers, and the second argues that there is no universal correspondence of hand and language laterality; the third, its conclusions based on the results of electro-stimulation of cortical fields during brain surgery, makes the unequivocal claim that the language centers are always on the left side of the brain, regardless of handedness. The final study, the earliest of the four, simply proposes that left-handers are always right-brained.

More recent work suggests that handedness and speech lateralization may be continuous, correlated variables. For example, Curry and Rutherford (1967b) and Orlando (1971) reported a continuously variable right-ear advantage in almost all right-handers and in most left-handers, although the mean advantages for the latter were smaller. A small proportion of the left-handed samples displayed left-ear advantages, indicating language representation in the right hemisphere. Moderate correlations between ear and hand laterality are reported for eight-year-old boys by Orlando (1971), and for adults, by Shankweiler and Studdert-Kennedy (1975). Both studies found relative manual proficiency as revealed by a battery of tasks, to be a fair and significant predictor (r = approximately 0.6) of dichotic ear advantage. As more precise methods of measuring handedness and more reliable dichotic techniques are developed, even higher correlations may be obtained.

Semmes' (1968) observations linking motor and language functions provide a theoretical underpinning for these recent findings. The results of her experiments, which investigated the sensory and motor processes of neurologically damaged patients, indicated that the more complex sensorimotor functions are represented in the more focally organized left hemisphere, rather than in the right hemisphere, which is organized more diffusely. She suggests that the neural organization for language parallels, and indeed, stems, from that which exists for the control of the dominant hand. Additional evidence for this association is found in Kimura's recent paper, "Language Qua Gesture " (1975). She observed hand movements during speech and compared them to the dichotic results in the same subjects. A strong association was found between side of ear advantage and the hand used for accompanying gestures. Kimura believes that the unique contribution of the left hemisphere is its control of the coordinated, sequential movements necessary in manual manipulation and in articulatory movements. As support for this argument, she cites the high incidence of both verbal and nonverbal apraxias and of disorders of manual signing which result from left hemisphere lesions. She assumes the symbolic aspects of language, also left hemisphere functions, to be secondary consequences of the specialization for fine motor control.

Ontogeny of Cerebral Lateralization

There are two opposing theories of the ontogeny of cerebral lateralization. One holds that the infant brain is structurally differentiated for language dominance at birth. The other holds that the hemispheres are initially equipotential, and that lateralization develops during childhood.

Kinsbourne (1975) is one of the spokesmen for the position that cerebral localization is already established in the neonate, stating that ". . . evidence suggests that some form of lateralization not only accompanies but even precedes the first traces of verbal behavior" (p. 248). Further, he states, "Cerebral dominance for language does not develop; it is there from the start" (p. 248). He concludes that "The building up and the breakdown of language function takes place against an invariant background of cerebral dominance" (p. 249).

Two kinds of evidence support this position: structural (anatomical) and functional. The strongest anatomical evidence comes from a paper by Wada, Clark and Hamm (1975). They found a difference in size between the left and right planum temporalis in 90% of the fetal, infant and adult brains examined (300 in all). The larger size of the left planum relative to the right as early as the fetal stage, was taken as evidence of a genetically based prepotency for left hemisphere language control. Moreover, since the size difference in adults was proportionately larger than that in infants, these investigators did not rule out continued maturation of the area.

Behavioral support comes from several studies. Turkowitz, Gordon and Birch (1968) found that newborn infants spontaneously look to the right more often than to the left. Caplan and Kinsbourne (in preparation) report early asymmetry of hand use. Molfese (1972) studied auditory potentials evoked by speech and noise in infants under the age of one year, and reported significant hemispheric differences in the predicted directions. Other evidence comes from studies which demonstrate group ear advantages equal in magnitude to those of adults, in normal children as young as four and five years (Berlin, Hughes, Lowe-Bell and Berlin, 1973; and Kimura, 1963; respectively). The former investigators, seeking evidence for or against development of the asymmetry, tested children from the ages of five to thirteen years with dichotic CV syllables, and found no ear-by-age interaction.

The second theory, that hemispheric specialization is not innate, but develops after birth, is held by several investigators. Gazzaniga (1970), for example, believes that the hemispheres are equipotential and function independently at birth, and that language begins to lateralize to one hemisphere in very early childhood, as a consequence of the relatively greater use of one hand. "Hand use reinforces hemisphere use, and quickly enough, hemispheric competence reinforces hand use, with the result that the two systems in a circular fashion mutually reinforce each other " (p. 133). Gazzaniga associates this period of rapid lateralization with the maturation of the corpus callosum (the inter-hemispheric connections). He believes that by the time the child is able to demonstrate good communication between hemispheres, starting at about the age of two or three, lateralization has been established and continues to increase during childhood until such time as it is complete; i.e., damage to the nondominant hemisphere will not affect the language functions.

Lenneberg (1967) believed that this process of the development of lateralization occurred during a "critical period" which lasted from about the ages of two to eleven. He based this conclusion on his interpretation of data on children who had sustained hemispheric lesions during childhood. He claimed that if a lesion on the left brain had occurred any time before the age of eleven, these children were able to recover language. (An opposing argument will be discussed in a later section.) He also noted that second language learning is easier up until about the same age. On the other hand, Nagafuchi (1970) found an increase in lateralization only between the ages of three and six, but no difference in the dichotic difference scores of six-year olds and young adults.

Lenneberg's conception of the critical period is supported by Satz, Bakker, Teunissen, Goebel and Van der Vlugt (1975). They examined the cerebral lateralization of children five to eleven years of age, using dichotic digits, with experimental controls intended to avoid a ceiling effect (four pairs of digits comprised each stimulus group). They found an existing ear asymmetry in their five-year-olds, and an increase in the degree of asymmetry with age. However, the difference between ears did not achieve significance for individual children until the age of nine. The authors state that while their findings neither support nor refute theories of innate specialization of the left hemisphere for language acquistion, they do show that whatever the age of onset of the asymmetry, it is not complete until at least late childhood.

In short, the literature abounds with conflicting reports of age of onset and development of lateralization. This has led to several attempts to explain these disparate results. The studies by Satz et al. (1975) and Porter and Berlin (1975) are two examples. The first suggests that failure to demonstrate development of asymmetry is due either to experimental artifacts or misinterpretation of the data. The latter study disagrees, its authors claiming that language processing, far from being a unitary function, is composed of several different types and stages. They postulate the dichotic tests using different stimuli, ranging from CV nonsense syllables to digits to multisyllabic words to sentences, and different modes of presentation, from single to multiple pairs, tap different levels of processing, some of which mature later than others. In particular, studies which use single pairs of CV syllables, thereby directly tapping auditory/phonetic processing, will show early lateralization with no developmental trend, while studies such as that done by Satz et al., in which the stimuli are presented in sets of several pairs, put an additional load on memory, a function which matures later, and consequently will show an ear-by-age interaction. These comments may explain the otherwise puzzling differences in dichotic results when similar ages and populations are tested.

The weight of the evidence appears to be equal on both sides; cerebral specialization can be characterized as both innate and developmental. The evidence for structural asymmetry of the hemispheres is irrefutable, and development of laterality for at least some functions has been persuasively argued. These positions are by no means mutually incompatible. The question of the age at which the asymmetry is complete is still an open one, but it seems reasonable to believe that some functions do lateralize earlier than do others, as is argued by Porter and Berlin (1975).

Dichotic Listening in Linguistically Deviant Populations

Since the dichotic effect has been interpreted as a reflection of the lateralization of speech functions, one might predict that people suffering from disorders of speech and language would exhibit deviant dichotic results. If such was, in fact, found to be the case, it could be used as additional, if circular, evidence for the validity of dichotic testing as a measure of language capacity. Further, the dichotic examination of speech and/or language disordered populations could tell us something about nonpathological linguistic functioning, particularly if the results were found to differ from expected values. More and more studies are being published which use the dichotic paradigm with such groups as aphasics, stutterers, dyslexics, language and articulation impaired children, and children from low socio-economic levels whose language skills are often thought to be delayed or deviant. What follows are brief summaries of some of these investigations.

Cerebral insult in adults. In one of Kimura's earliest dichotic studies (1961b), she found that although the right-ear advantage persisted in neurologically impaired adults with lesions of long standing, the ear advantage was smaller in those with lesions of the left temporal lobe than in those with lesions of the right temporal lobe or of the frontal lobes. Shankweiler (1966a) replicated these findings with a similar population. In both studies, sets of paired digits were used as stimuli. It was found that removal of either temporal lobe caused impairment in the recognition of verbal stimuli in the contralateral ear, although hearing acuity was normal. However, it was only when the left temporal lobe was removed that the score for <u>both</u> ears was significantly reduced. This led Kimura to conclude that the left temporal lobe processes all spoken material, since its removal causes a decrement not only in the right ear, where it might be expected, but in the left ear as well.

Shankweiler (1966a) also examined responses to dichotically presented melodies in pre- and post-operative testing of his lobectomized subjects. He found that damage to the right temporal lobe caused a shift from a left- to a right-ear advantage for the recognition of melodies, while the left temporal lobe damage caused only a reduction, not a shift, in the right-ear advantage for digits. He concluded that nonverbal stimuli are lateralized to the right hemisphere, but not as strongly as verbal stimuli are to the left. Both the Kimura and Shankweiler studies, it should be noted, used subjects who had only anterior temporal lobe lesions.

Schulhoff and Goodglass (1969) drew attention to the "lesion effect," a decrement in the score of the ear contralateral to the side of lesion, regardless of the type of stimulus. (This phenomenon was also demonstrated by Kimura (1961b) and by Zurif and Ramier (1972).) The decrement in the contralateral ear interacts with and sometimes even overrides the natural dominance effect. In the Schulhoff and Goodglass study, although both the left- and right-brain-injured groups retained a right-ear superiority for digits and a left-ear superiority for tones, for individual subjects it was seen that the lesion usually affected the level of performance in the opposite ear. In six of the ten subjects it was suspected that the lesion effect alone was responsible for a left-ear dominance for verbal material.

Another study (Curry, 1968) compared the results of both verbal and nonverbal dichotic tests administered to one twenty-one-year-old subject whose right hemisphere had been removed at the age of eight. The findings include a much larger right-ear advantage for verbal material in the experimental subject than in a group of controls, a decrement in the overall score, and a right-ear advantage for environmental sounds as well. In contrast, and as expected, the normal controls processed only the nonverbal stimuli in the right hemisphere. In this same study, a test of pitch discrimination revealed no ear difference, either in the experimental subject or in the controls. The writer interpreted this finding as suggesting that tonal pitch discrimination, unlike the discrimination of more complex stimuli, is probably a subcortical function.

In summary, studies with neurologically impaired adults reinforce theories of hemispheric specialization. In addition, brain damage is found to cause a lesion effect, with the degree of severity of the lesion determining whether or not the dominance effect will be overridden. The capacity of one hemisphere to process both verbal and nonverbal stimuli when the other has been damaged or excised has also been demonstrated.

<u>Cerebral insult in children</u>. Goodglass (1967), using sets of digit pairs in groups of brain-injured subjects aged six to twenty-two, found suppression of the signal to the ear opposite the damaged hemisphere, to varying degrees in the individuals tested. This effect in turn caused left-ear advantages in those with widespread early left hemisphere damage. He believes that these results represent a strong lesion effect, which may be caused in part by an impaired ability to direct attention to the weaker ear, and which obscures the actual side of dominance. He therefore cautions against postulating dominance in brain-damaged subjects.

In a somewhat different vein, Lenneberg (1967) contended that in cases of early left hemisphere lesion, the right hemisphere has the capacity to develop language in its stead. He called this phenomenon "transfer of function." Agreeing that such transfer occurs, but questioning the age beyond which it cannot, Krashen (1973) reexamined the data (Basser, 1962) on which Lenneberg's conclusions were based. He found that no right hemisphere lesions occurring after age five resulted in speech disturbance, indicating that lateralization to the left hemisphere had already been completed by that age. He therefore rejected Lenneberg's claim that transfer of language function can occur after the age of five. Hemispherectomies offer additional evidence on the critical age: in all the data examined by Krashen, wherever left hemispherectomy did not result in permanent aphasia, the original injury to the left hemisphere was found to have occurred before the age of five.

It appears that although there is agreement that children have the capacity for some transfer of language function in the case of early damage to the dominant hemisphere, the age beyond which transfer can no longer occur is still an open question.

Stuttering. Findings in the area of stuttering are contradictory. A group of adult stutterers is reported by Curry and Gregory (1969) to have no significant group ear advantage for CVC words presented in sets of six pairs, thus differing from the nonstuttering controls. Similarly, Brady, Sommers and Moore (1973), using words and digits and scoring only first responses, found that stutterers had a significantly smaller right-ear superiority than normals. Within their sample, which includes ages four through forty-seven, there is an ear-by-age interaction for the words, with stutterers never achieving the magnitude of right-ear superiority shown by normals.

In a study using digits as stimuli, Slorach and Noehr (1973) report a significant though somewhat smaller than normal ear advantage in their first- to third-grade stuttering population. More recent studies with adults have found no differences in the dichotic ear effect between normals and stutterers (Dorman and Porter, 1975; Sussman and MacNeilage, 1975). It may therefore be tentatively concluded that whether or not the dichotic indices for stutterers are of equal magnitude to those of normals, it seems likely that stutterers as a group are also lateralized for language to the left hemisphere.

Language and articulation disorders. Studies of children exhibiting language and/or articulation deficits are even more sparsely represented in the literature. Slorach and Noehr (1973) tested articulation defective children with dichotic digits. They found a normal right-ear advantage in their "dyslalic" (functional articulation) group in the free recall condition. But in a second dichotic test using ordered recall, the right-ear effect did not appear. They interpret this as suggesting that these children have a true perceptual deficit, perhaps due to the lack of a relatively stronger neural trace in the dominant hemisphere. Without this stronger trace, they argue, the information from the right ear is lost during the enforced latency of the right ear response when the left ear is reported first.

In an unpublished dissertation, Del Polito (1972) compared the group ear advantages of normal and retarded subjects and found no significant difference between them. This confirms the findings of Jones and Spreen (1967) who were able to demonstrate a right-ear advantage for educable retardates, especially for concrete words. Del Polito's stimuli were simple noun monosyllables; error and ear difference scores were used for the analysis. An attempt was made to predict, _a posteriori_, at what levels the retardates were functioning; i.e., to classify them into subgroups using the dichotic results alone. Not only could this goal not be accomplished, but the dichotic scores failed even to distinguish the retardates from the normals.

Starkey (1974) described a dichotic test using single pairs of words and requiring a pointing response to one of a set of four photographs. This was administered to groups of both "language delayed" children and trainable mental retardates. Using an ear difference score, both groups failed to demonstrate a significant ear advantage, while the normal controls did.

Pettit and Helms (1974) reported a dichotic study with language impaired and articulation defective groups.

Their stimuli were digits and animal names requiring a verbal response. Only the language impaired children failed to demonstrate significant ear differences. Sommers and Taylor had earlier (1972) tested both hand and ear laterality in children with "serious" language disorders. Handedness was assessed by means of the Harris Test of Lateral Dominance (Harris, 1955); the dichotic stimuli were of two types: single minimal pair words and sets of three digit pairs. The authors reported that the two groups' handedness and the dichotic word test results were not signicantly different. However, the second dichotic task, which used sets of digit pairs, did reveal a difference in performance between the two groups; the language disordered children showed more left-ear preferences.

No difference in right-ear advantage for CV syllables was found between normals and a group of eight-to ten-year-old school children with "auditory processing deficits" in a study by Tobey, Cullen and Rampp (1975). However, in requiring two responses for each stimulus pair, they uncovered the interesting finding that the experimental group was less able than the controls to report both members of the dichotic pair correctly--i.e., had significantly fewer double corrects, although the number of single correct responses was equal in both groups. Berlin et al. (1973) had found similar results for their younger normal subjects.

In summary, of the seven studies on speech or language disordered children reviewed in this section, two found a smaller or no right-ear advantage in their experimental groups and three found no difference in the right-ear advantage between the experimental and control groups; two of these three were with retarded subjects. The two remaining studies reported that experimental children who had demonstrated ear advantages comparable to normal controls on one dichotic task showed a reduced ear asymmetry when either the stimulus type, stimulus presentation or response mode was altered in a subsequent test. There is therefore some preliminary evidence that nonretarded language or speech impaired children may not process language as their normal peers. However, the small number of studies available for analysis and the differences in design, protocols, stimuli and scoring, make comparisons of results across the studies difficult.

Lower socio-economic levels. Kimura (1963) tested five- to eight-year-old lower to middle socioeconomic level children with a dichotic digit task presented in sets of three pairs each. She found all groups to have a significant right-ear advantage except for the five-year-old boys. She did not find this exception in upper level children whom she tested in the same year.

Two later studies examine possible differences in lateralization for speech between low and middle socioeconomic level children and come to different conclusions regarding a possible delay in achieving lateralization in those from the lowest level (Dorman and Geffner, 1974; Geffner and Hochberg, 1971). The latter investigation found a significantly smaller right-ear advantage in the population of lower class children until age seven, while the former found no difference between groups. It is possible that among other factors the use of different stimuli presented differently is responsible for the contradictory results: the first study used groups of two digit pairs, the second, single pairs of synthetic CV syllables. These two papers are discussed further in chapter III.

Dyslexia and learning disability. The laterality of dyslexics has interested researchers since the first publication of Orton's theory. Witelson and Rabinowitz (1972) and Zurif and Carson (1970) tested such children with sets of dichotically paired digits and reported a tendency toward left-earedness.

In 1967 Kimura tested dyslexic boys and girls over the age of eleven and found no right-ear advantage in the boys, although that of the dyslexic girls did equal the established norms. Similar findings were reported by Taylor in 1962 with males aged seven to eleven. Kimura notes that one of her earlier studies (1963) revealed a developmental lag for boys aged five, and suggests that it is merely accentuated when there are reading difficulties. She did not find this sex difference in a group of older dyslexic subjects. Dermody, Noffsinger, Hawkins and Jones (1975) report differences between their learning disabled group and normals, both in direction and magnitude of ear advantage until age thirteen, and in number of double corrects, the latter finding paralleling those of Berlin et al. (1973) and Tobey et al. (1975).

Satz (1975) in a comprehensive review of dichotic studies with poor readers points out that in many studies, wherever the experimental subjects fail to demonstrate a significant right-ear advantage, so do the normal controls. He characterizes the results of most dichotic studies with dyslexics as being equivocal at best, due either to defects in design, such as failure to use a control group for comparison; or to experimental artifacts, such as floor or ceiling effects. These problems are reflected in the repeatedly demonstrated lack of predictability of reading skill from dichotic results. He concedes that there may be a developmental lag in poor readers, but finds no conclusive evidence for it.

It is apparent from a review of the dichotic/dyslexic literature, that a lag in the achievement of hemispheric asymmetry in the learning disabled population has been neither proven nor disproven, despite claims to the contrary. However, the weight of the evidence is against such a delay.

Linguistic Deficits in Aphasic, Aphasoid, and Learning Disabled Subjects

The purpose of this section is to provide evidence that there are language and learning correlates of proven neurological dysfunctions, and that within the population of children who demonstrate language and learning deficits, the symptoms characterizing those who are medically certified as being neurologically impaired are very similar to those of children who are not. One argument of chapter V (Discussion) will draw on this material for support.

Symptomatology: Evidence for a Common Etiology

Since validation of subclinical neurological dysfunction is impossible short of surgical exploration or autopsy, one useful approach might be to describe the language deficits of subjects known to be brain damaged and compare them with those of children for whom no such definitive etiological statement has been made; where common factors exist, we might posit a common cause. Indeed, this may be the only method of providing evidence, albeit circumstantial, for brain pathology in language or learning disordered children in whom no actual brain pathology has been found or even sought. What follows are a few of the many citations that could be made to support this proposition.

An investigation by Parker, Freston and Drew (1975) based on a previous study by Freston and Drew (1974), provides strong evidence for a common etiology. In this case, medically certified neurologically impaired children and a group of "learning disabled" subjects, both demonstrated an inability to profit from the clustering of words which are in the same category, in a memory task. In the earlier study subjects diagnosed by means of neurological criteria as children with "acute brain dysfunction" were tested on recall of word lists. The later study replicated the experiment with "learning disabled" children and a group of normal controls. Both experimental groups failed equally to show an improvement in recall when words of the same category were presented together, while the normal controls' performance was improved in the clustered condition. The authors attribute this failure to a deficiency in short term memory, not necessarily in the ability to classify since they will not presume the latter until the former has been eliminated as the cause. In discussing their findings they remark: "These congruent results further substantiate a deficiency in the ability to take advantage of input organization in this heterogeneous population, regardless of whether an etiological or behavioral definition is employed" (p. 391).

Stark, Poppen and May (1967) discovered difficulties in the sequencing of as few as three items in a group of eight-year-old children identified as aphasic by both behavioral and neurological criteria. Aten and Davis (1968) used as subjects children who demonstrated soft signs of neurological impairment and who had been medically diagnosed as having "minimal cerebral dysfunction." Many skills were assessed, both verbal and nonverbal, all of which require the ability to sequence stimuli in time. In all of the skills tested the experimental children's performance was found to be significantly poorer than that of the matched controls. A similar sequencing deficit is reported by Lowe and Campbell (1965), in a group of behaviorally diagnosed "aphasoid" children, aged seven to fourteen. Here the task on which they did poorly was to judge which of two tones--one high and one low in pitch--was presented last. Although the last three studies cited did not measure the identical skills, the sequencing mechanisms called into play may be related.

Weiner (1972) reported that a group of "dysphasic" children did not perform well on vowel and sentence repetition tasks, and posited deviant linguistic rule systems as the cause. In Aram and Nation's (1975) study, one of six groups of children, each of which exhibited discrete patterns of language deficiency, had a similar repetition deficit. While the children in these last two studies were behaviorally defined as "dysphasic" and "language disordered" respectively, there is known to be an analogous,if more severe form of adult aphasia, termed "conduction aphasia," in which the ability to repeat stimuli is impaired (Geschwind, 1965; Goodglass and Kaplan, 1972). Other forms of aphasia also involve some decrement in the ability to repeat.

Sections of tests originally designed to assess the residual skills of aphasics were used in a study by Wiig and Semel (1975). They measured the language abilities of adolescent "learning disabled" subjects, so diagnosed by a team of school examiners. Like the group of younger learning disabled children tested by these same researchers in 1973, these youngsters were found to have several linguistic and cognitive deficits. The earlier study had noted a relative inability of these seven- to eleven-year-old subjects to process what Wiig and Semel called "logico-grammatical" sentences, having difficulty understanding such syntactic forms and language concepts as comparatives, passive constructions, and spatial relations. The older children tested in the later study had difficulty in the areas of sentence length, grammatical constructions, categorization and naming, and demonstrated significantly longer latency of response.

In a study by Flynn and Byrne (1970), poor readers in the third grade who bore no diagnostic label were selected for the testing of several auditory abilities and compared with good readers of the same age. Discrimination of words, syllables and pitches were among the areas of greatest deficit. Using other paradigms, speech discrimination skills were also found to be deficient in studies by McReynolds (1966) and Tallal and Piercy (1974), who found neurologically diagnosed aphasic children less able to discriminate among speech sounds than normals.

Theories of the Nature of Neurological Substrata and Common Causality

The studies reviewed in the previous section reported evidence that similar behavioral deficits may be manifested in different groups of children bearing a variety of diagnostic labels. Some of these have been definitively diagnosed as neurologically impaired, and many of this group are called aphasic. But, as seen, others are variously categorized as language impaired, language disordered, language deficient, language delayed, dyslogic, aphasoid, and later, learning disabled. These children's prenatal and developmental histories and current medical status suggest no reasonable etiological explanation (congenital deafness, birth trauma, fetal disease, chromosomal abnormality, emotional illness, abnormal electroencephalogram, etc.) for their deviant language behavior. They are differentiated from those who are merely delayed in their acquisition of language by the fact that the rules by which they process language are different from those of younger children. One of those instrumental in pointing out these differences is Menyuk (1964, 1969). Her earlier work contributed in part to Lee's (1966) observations of syntax in normal and language deviant children, which later led to the development of a quantitative system of measurement of their grammatical structures (Lee and Canter, 1971). This measure, Developmental Sentence Scoring, permitted the differentiation of language delay from language deviance, and both from normal linguistic development.

Many attempts have been made to postulate neurological deficit at a subclinical level as the primary etiological factor in these children. Some writers have gone so far as to posit specific sites of the dysfunction, even where it cannot be proven by medical means. For example, where memory or ordering is faulty, the hippocampus is implicated by Johnson and Myklebust (1967) in their book <u>Learning Disabilities</u>. Other neurological correlates are similarly posited for different verbal-behavioral symptoms.

In the same work, Johnson and Myklebust also put forth the notion that the learning disabled population contains a sizeable number of children with manifestations of a variety of auditory deficits (p. 66). This indirectly associates language disorder with learning disability, since they see auditory deficits as basic to both language disorder and some forms of learning disability. Chase (1972) has gone even further in suggesting that specific developmental dysphasia and dyslexia may be but different manifestations of the same basic disorder.

Myklebust (1971) presumes the existence of neurological impairment in childhood aphasia, as can be seen in his definition[1] which has since received wide acceptance. By his criteria, children are more often considered aphasic or dysphasic as a result of the process of elimination than because of any positive neurological findings.

Chase (1972), like Johnson and Myklebust (1967), supports localization of function in his discussion of the neurological aspects of specific language and speech disorders. For example, he correlates the myelination of specific areas of the cortex with the stages of language learning. However, he suggests caution in extrapolating knowledge of adult brain function to children because of the latter's constantly developing behavior. He is particularly interested in lateralization, making this state ment:

> Although inconsistent, the evidence concerning ambidexterity among dyslexics favors continual investigation of the possible role of altered patterns of cerebral dominance in this, as in most of the language disorders of childhood.[2]

Eisenson (1972) describes the "dyslogic" child as one who is perceptually impaired as a result of brain damage. He states that the failure to formulate symbols results from the primary perceptual deficit, which interferes with the setting up of appropriate categories, from the phonetic through the semantic levels. He agrees with Chase (1972) and with Masland (1967), both of whom posit the existence of multiple and bilateral lesions in these children, occurring either in cortical areas or in the lower centers.

An underlying theme in much of the newer research in speech science is that language processes may be illuminated by the study of speech processes. Studdert-Kennedy (in press) hypothesizes that one of the most basic requirements for normal development of language may be the ability of an infant to establish an "articulatory-auditory correspondence" via "sensori-motor interaction" during the babbling stage:

> We hypothesize then, that the infant is born with two distinct capacities, . . . Auditory feedback from its own vocalizations serves to modify the articulatory template, to guide motor development and to establish the links. The process endows the communicatively empty outputs of auditory analysis and articulatory gesture with communicative significance.

Tallal and Piercy (1974), arguing that a processing failure is at the root of language disorder, have isolated the stage which they call auditory analysis as the level of the difficulty. The brevity of the formant transitions, they claim, is the major factor in the dysphasic child's inability to perceive many speech sounds, particularly the stop consonants. They have identified the deficit as being one of processing rate, since their subjects can process transitions as well as normals when the transitions are lengthened in the synthetically produced stimuli. Curtis, Stark and Tallal (1975), in an extension of Tallal and Piercy's original work, show an analogous deficit in the children's productions, this being additional evidence for the connection of perceptual with productive functions.

Many studies cited in this section consider auditory processing factors to be basic to language disorders. This position has been challenged by Rees (1973) who reinterprets the relevant literature to argue that the so-called auditory processing deficits, which are defined in a variety of ways by different investigators, have been and can be shown to coexist with language difficulties, but not to cause them. She points out in a later paper (1976) that it might well be said that speech perception, in involving phonemic assignment, is a skill which requires prior linguistic knowledge, and that therefore

> . . . if we really managed to identify a child with speech sound perception deficit, we might conclude that we have found a child with a language learning problem, not that we have found the <u>source</u> of his language learning problem.

An attempt has been made to bring together the literature on lateralization, language development and language disorder. Evidence has been provided that neurological dysfunction may be the etiological base, not only in children characterized as dysfunctional by organic criteria, but also in children from the populations of the so-called language disordered and learning disabled. Parallel language behaviors and atypical patterns of hemispheric organization are among the factors cited as support for this argument.

Notes

1. "Childhood aphasia refers to one or more significant deficits in essential processes as they relate to facility in use of auditory language. Children having this disability demonstrate a discrepancy between expected and actual achievement in one or more of the following functions: auditory perception, auditory memory, integration, comprehension, expression. The deficits referred to are not the result of sensory, motor, intellectual, or emotional impairment, nor to the lack of opportunity to learn. They are assumed to derive from dysfunctions in the brain, though the evidence for such dysfunctioning may be mainly behavioral, rather than neurological, in nature." (p. 1186).

2. Chase, 1972, p. 116.

CHAPTER III. METHOD

To facilitate the reader's understanding of the organization of this chapter, the following outline is offered. The first section of the chapter is in three parts. These are: Prescreening, Screening and Testing Procedures. While the prescreening is treated in a single paragraph, each of the screening procedures is discussed under separate headings. The tests are organized into subcategories of lateralization measures, which include both dichotic listening and a handedness battery, language measures of various types, and non-verbal tests. The second section of the chapter offers rationales, where they appear to be necessary, for the choice of some of the measures and scoring systems used in the study.

The key to all of the abbreviations used will be found on pp.143-4. Order of testing procedures is listed on page 145 .

Procedures and Scoring

Forty subjects were selected from a pool of approximately six hundred kindergarten children from eight of the nine elementary schools in the New Rochelle, New York, Public School System (the Principal of the remaining school refused permission). After the application of the criteria described below, there remained two right-handed groups of twenty, comprised of ten boys and ten girls each, selected from seven schools (one had no children who met criteria for either group). One group, to be referred to as the Experimental Group (EG), is composed of children who exhibited inferior sentence repetition skills, articulation irrelevant, as evidenced by relatively high language error scores on the Stephens Oral Language Sentence Test, experimental form (SOLST) (Stephens, 1974); the other group, to be referred to as the Control Group (CG) consists of children who exhibited superior sentence repetition and articulation skills as evidenced by relatively low language and articulation error scores on the SOLST. This measure was the sole basis for decisions on experimental or control group placement. The chronological age range and means are, for the EG and CG respectively, 5 years 2 months, to 6 years 1 month (mean, 5.7 years); and 5 years 4 months to 6 years 3 months (mean, 5.8 years). Five major socioeconomic groups (semi-skilled, skilled, business, semiprofessional and professional) are represented in both groups, although not equally.

Prescreening Procedures

In order to eliminate from screening children who did not meet the established criteria, class lists were first checked against school records and reviewed with the classroom teacher, school nurse, and the school speech clinician. A child was eliminated from further screening if he/she came from a family on welfare or if the family breadwinner's occupation appears in Group 7 (unskilled labor) of Hollingshead's Two Factor Index of Social Position (1957); was a foster child; had any known organic anomalies or damage or had a physical disability which could interfere with the administration of any of the tests; was refused permission by the parent to participate in this study. The results of this prescreening eliminated all but 373 children to whom the next set of criteria was applied.

Screening Procedures

Each child remaining on the list was then screened for right-handedness, ability to repeat stop-consonant syllables, ability to repeat sentences, normal intelligence and normal hearing at the speech frequencies.

Handedness

This was determined by throwing a ball, using a pencil, cutting with scissors. Criterion for continued inclusion: at least two of the three tasks performed with the right hand. (Only two children eventually placed in the EG and one in the CG failed to do all three tasks with the right hand.) Thirty-three additional children were excluded on this basis.

Repetition of Stop-Consonant Syllables

The child was asked to repeat the syllables ba, da, ga, pa, ta, ka, listening with his/her eyes closed. Criterion for continued inclusion: ability to repeat all six accurately. This resulted in the exclusion of three additional children.

<u>Repetition of Sentences</u>

The seventeen sentences in the SOLST were presented for repetition. Scoring is on a hierarchy of error types (see pages 146 and 147 for sentences and scoring protocols). Criterion for continued inclusion: a language error score of 25 or above (articulation score irrelevant) or language and articulation scores of 2 or below. Children with the higher error scores were considered possible experimental subjects; those with the lower error scores, possible controls. At this point, seventy-eight children remained; twenty-seven with high error scores and fifty-one with low error scores. The other two hundred fifty-nine received SOLST scores in the middle range, and were eliminated.

<u>Intelligence</u>

The <u>Peabody Picture Vocabulary Test</u> (PPVT) (Dunn, 1965) was administered for this purpose. Criterion for continued inclusion: an IQ of 90 or above. Five children failed to meet this criterion; all potential EG subjects.

<u>Hearing Level</u>

Threshold tests at the speech frequencies were administered, using a Beltone audiometer, Model 9D, calibrated to ISO standards. Criterion for continued inclusion: a pure tone average (PTA) of better than 25 dB in each ear at 500, 1000 and 2000 Hz; no more than a 5 dB difference between ears at any two frequencies and of PTA. Another two children were dismissed for failing to meet this criterion. Remaining were the twenty experimental subjects used in the study, and fifty-one possible controls.

The numbers from each school have been pooled in the description of procedures above, for convenience in reporting. In actual practice, the screening and testing procedures were completed in one large or two small schools at a time, before going on to another school. In each of the three largest schools, as many controls were selected, beginning with the lowest error scores on the SOLST, as there were experimental subjects; where scores were equal, matching was done for sex. The smaller schools were paired in regard to type of neighborhood when equating the two groups.

Testing Procedures

The testing consisted of a set of measures of laterality, one for degree and direction of hemispheric specialization for speech processing, and a battery to determine degree and direction of handedness as well as general manual dexterity, and a number of language and other nonverbal measures. In addition, the scores of two tests given by classroom teachers were made available for this study; one was a test of language concepts administered at the time of entrance into kindergarten; the other was a test of reading readiness administered during the first month of the children's first-grade year. See pages 48 and 49 for a discussion of these tests.

Lateralization measures

Dichotic listening

Preparation of stimuli. The stop-consonant syllables ba, da, ga, pa, ta, ka, were generated by the Haskins Laboratories computer controlled parallel-resonance speech synthesizer. These three-formant, 300 msec. stimuli were combined into fifteen possible pairs (no stimulus was paired with itself) and electronically aligned for simultaneous onset. Each pair was used four times, twice in reversed position, totalling sixty pairs. They were recorded onto a Scotch C60 low-noise high density tape, separated from one another by a four second interval, with a ten second interval following every tenth pair. The dichotic pairs were preceded by three groups of the six test syllables presented binaurally, which were used for training purposes.

Apparatus. Presentation of the dichotic tape was on a Panasonic RS 279US stereo tape deck using matched Telephonics TDH 39 300-Ohm headphones. A Hewlett-Packard voltmeter was used to calibrate the output of each tape channel while the output of the headphones was determined to be equal by means of a Grayson-Stadler sound level meter with a headphone coupler. A 1,000 Hz calibration tone on both channels preceded the training syllables and was used prior to each testing session to assure equal output at the desired SPL of 81 dB.

Procedure. The dichotic test was preceded by three binaurally presented trials of the six test syllables. All subjects met the criterion of training to at least five of the six syllables with only three subjects (two in the experimental group, one in the control group), failing to train to all six. The sixty dichotic pairs were then presented twice, separated by a fifteen minute interval during which the handedness tasks were administered. The headphones were reversed for the second trial to control for a possible channel effect. Only one response was given for each stimulus pair presented.

Scoring. A relative ear advantage score (REA) was computed for each child using the formula R-L/ R+L x 100, where R = the total number of items correctly reported from the right ear and L = the total number of items correctly reported from the left ear. Except for a zero score indicating no ear advantage, the resulting scores have either a plus or minus value; the former indicating a right-ear advantage and the latter, a left-ear advantage. An absolute score (AEA) was derived by eliminating the sign of the REA. The significance of each subject's between-ear difference was determined by means of a z statistic ($R-L\sqrt{R+L}$). Instructions and protocols for the dichotic testing can be found on page 148. In this text dichotic values refers only to REA.

Handedness measures (administered in the order listed, right hand first, with each task yielding right and left hand scores.)

Hand preference. The section of the Harris Test of Lateral Dominance (Harris, 1957), consisting of ten items testing hand preference, was administered. Right and left scores are the number of items performed by each hand.

Relative manual proficiency.

Pegboard: Using the Purdue Pegboard, Model 4502, containing two vertical columns of holes and metal pegs to insert into them, the subject was given three alternating thirty-second trials with each hand, during which time he/she placed the pegs in the holes from the top of the board down. Right and left scores are the total number of pegs placed by each hand.

Tapping: This task consists of three alternating trials for each hand of ten seconds each. A stylus and a metal plate were attached to a battery-operated counter. The subject tapped the plate with the stylus as many times as possible within the time allotted. Right and left scores are the total number of taps for each hand.

Card dealing: Holding half a pack of playing cards first in the left hand, then in the right, the subject stacked them in a pile one at a time, with his free hand. Right and left scores are the number of cards stacked by each hand in a single ten-second period.

Scissors cutting: The subject was given a pair of five-inch metal scissors and a piece of 8½ x 11 inch paper with two wavy lines drawn, one a mirror image of the other. (see page 149) With each hand in turn, he/she was instructed to cut the line on the same side as the hand being used. Right and left scores are the number of seconds it took each hand to accomplish the task.

Strength of grip: On three alternating trials for each hand, a Charles Stoelting Company hand dynamometer yielded a value in kilograms of pull. Right and left scores are the total number of kilograms registered for each hand.

For each subject, a separate Dextrality Index (DI) was computed for each handedness task using the same formula as for the REA (R-L/R+L x 100), except for the scissors cutting which was L-R/R+L x 100. In addition, a z test for significance of between-hand differences was done on each hand task. All DIs were used in a stepwise multiple regression equation to determine the best possible prediction of degree and direction of cerebral dominance for speech processing. The instructions and protocols for the handedness testing are found on page 150.

Language Measures

Articulation

Although the results of the Fisher-Logemann Test of Articulation Competence (FLTAC)(Fisher and Logemann, 1971), are not quantifiable according to manual directions, an articulation score (AS) was derived for each subject by computing an error score consisting of one point for each error of place or manner. Where a substitution for a sound was of both place and manner, such as [r/l], or in omissions, two error points were scored. The total for both consonants in a blend erring in both place and manner was an error value of 4. Therefore, the resulting scores to some degree reflect intelligibility as well as number of errors. Articulation error type (AT) was also scored. See page 143 for the coding used for errors of place and/or of manner.

Comprehension

Sentences. The Developmental Language Comprehension Test, experimental form (DLCT) (Weiner-Mayster, 1975) was administered as follows: four colored pictures on a single page were shown to the subject and a sentence best illustrated by one of the pictures was said twice by the examiner. The child's task was to point to the picture he/she felt best exemplifies the statement. Each sentence is composed of from seven to eleven words. Four groups of twelve sentences each test four major categories: morphological inflections, simple syntax, complex syntax, and semantic inference. Scoring is one point for each correct answer, out of a possible 48 points. A list of the sentences is provided on pages 151-153.

Concepts. The Boehm Test of Basic Concepts (BTBC) (Boehm, 1971) was administered by the kindergarten teacher during the first month of the kindergarten year. The data were made available for use in this study. The test contains fifty sets of three pictures each. A sentence containing a concept term such as bottom, wide, first, etc., is read aloud by the examiner. The child then marks with a pencil the picture in the set which he/she thinks illustrates the concept.

Expression

A Complexity Measure of Expressive Language, experimental form, (CMEL) (Wurtzel, Roth and Cairns, 1975), was used for the purpose of quantifying the grammatical complexity of the subjects' spoken language. Spontaneous utterances were taped in a thirty- to forty-minute play session and subjected to analysis and scoring according to the protocols on pages 154 -158 .

Reading Readiness

During the first month of the school year immediately following the collection of data for this study, the children, now first graders, were given the Murphy-Durrell Reading Readiness Analysis (MDRRA) (Murphy and Durrell, 1965). It consists of three parts: phoneme recognition, letter and name identification, and learning rate. These are each scored separately and also combined into a total score. Each score is then translated into a percentile score equivalent, only the latter of which was made available by the schools for purposes of comparison in this study. Stanine and quartile placement can then be determined from the percentiles (see page 144).

Nonverbal Measures

Intelligence

The Goodenough Draw-a-Man Test was scored for IQ (GIQ) by means of Goodenough protocols (1926). Two drawings, one of each sex, were elicited. The better one was then used for scoring.

Visual-Motor Skills

The Developmental Test of Visual-Motor Integration, short form (VMI) (Beery and Buktenica, 1967), which yields an age equivalence score, is a test of the ability to copy up to fifteen geometric forms.

Manual Dexterity

A dexterity score (MDS) was computed for each child. This consisted of all raw hand scores, both right and left, added together, except for the scissors scores which were subtracted from the total.

Rationale and Background for Some Prescreening and Screening Decisions and Test Choices

Prescreening

Elimination of the lowest socioeconomic group

The decision to eliminate the lowest economic group from the pool of prospective subjects was dictated in part by the choice of sentence repetition as the critical screening and separation device. Since its use is predicated on the observation that given a sentence beyond the child's operating memory span, or one syntactically more complex than the child's own productive rule system allows, he/she will filter the incoming stimulus for repetition through his/her own system of grammatical rules[1] (Menyuk, 1971). Therefore, a child with an immature or a deviant set of inflectional, syntactic or semantic rules will respond at the level of and according to his own internal grammar and semantic feature system. Since the economically lowest level families in the selected school district are overwhelmingly Black, it was felt that many of these non-standard-English-speaking children might have been erroneously placed in the experimental group since their filtering mechanism contains different linguistic rules than those of Standard English. In addition, there is still a question about whether lateralization is delayed in children from very low socioeconomic backgrounds (Dorman and Geffner, 1974;[2] Geffner and Hochberg, 1971). The resulting decision to eliminate children in the lowest category has had the added advantage of making the populations less heterogeneous.

Screening

Elicited Sentence Imitation

The problem of screening out language deficient or delayed kindergarten children from a large public school population is a difficult one. Not enough is known about a child's communication skills this early in his/her school career to be able to depend on school records, the speech clinician, or on classroom teacher referral. Most existing screening procedures are limited to determining the articulation skills, while those measures dealing with parameters of language are too cumbersome to be practical for screening purposes.[3] Others depend on visual stimuli to elicit a response, which introduces questions about the child's ability to utilize yet another channel, and the efficacy of the visual stimuli themselves,[4] and therefore may select children for the wrong reasons. Sentence imitation avoids these disadvantages in that it is quick and easy to administer and uses only the auditory mode. Admittedly, it is difficult to separate out the components of the task; besides grammatical performance it also taps, among other things, the child's ability to process the phonological elements, to interpret sentences semantically, and the limits of his short term auditory store. As Bloom (1974) rightly suggests, the absence of intention and contextual support for the child's production of an utterance presented may <u>alone</u> prevent a recoding of the stimulus sentence which will adequately reflect the child's actual ability to produce the same structure in his spontaneous speech (see her example of thirty-two month-old Peter's imitations on page 299). But in cases of such failure one might posit the short-term memory factor as being primarily responsible, provided the child's attention, understanding of and willingness to do the task are all engaged (three factors which are more likely to be operating in kindergarten-age children than in children of Peter's age). This in itself would be a valuable piece of information to have, since memory, like all of the components already named, is recognized as playing a major role in linguistic functioning. However, since the elicited imitation task is used in this study not for diagnostic purposes, but for identification of children who function less well in the general area of language, its tapping of so many albeit inseparable elements is an asset rather than a liability. Presentation of sentences for repetition has been used to differentiate between the linguistic control possessed by the speech and language deviant population and that of normally developing children (Menyuk, 1969), to determine differences in repetition of standard English sentences by differing dialectal groups (Menyuk, 1970; Osser, Wang and Zaid, 1969), and to discover contextual aids to the articulation of deviant sounds (Stephens and Daniloff, 1974) among other purposes. The Stephens Oral Language Sentence Test (1974) permits the use of sentence imitation as a screening for language deficiency. It utilizes a cut-off error score, below which a child is believed to be functioning linguistically within normal limits and above which it is felt that he is not.

Tests

Intelligence Tests

In order to eliminate children of low intelligence from the study, a lower limit of 90 IQ was decided upon. The school district's policy was to allow only the Peabody Picture Vocabulary Test (Dunn, 1965) and the Goodenough Draw-a-Man Test (1926) as measures of intelligence in all projects not designed and administered by school personnel or trained psychologists. Working within this limitation it was thought to be of interest to compare the scores of both of these tests, both within and between the groups to see if verbally and non-verbally derived IQs differ in the two samples. The PPVT was chosen to serve as the screening device while the Draw-a-Man Test was used for comparative purposes.

Language Tests

Comprehension

Since the two groups were differentially defined only by means of a sentence imitation task, it seemed desirable that several other dimensions of language be measured so as to be able to describe the populations further in terms of their language differences or similarities. A simple language performance model can be drawn to include comprehension (of single word units and of sentences), and production, (encompassing both phonological and syntactic-semantic components). Comprehension of single word meanings can be inferred from the results of the PPVT, while the comprehension of sentences can be inferred from another task, similarly constructed: pointing to one of a closed picture set of possible responses to the stimulus. An early effort to measure this ability was made in a study which compared the imitation, comprehension and production skills of a group of young children (Fraser, Bellugi and Brown, 1963). The second half of a later measure, the NSST (Lee, 1970), was considered for use in this study, as was the Carrow Test for Auditory Comprehension of Language (1968). This last was rejected after being administered to the first five subjects in each group. It proved not to be sensitive enough to detect differences between the groups, since a ceiling effect was observed. The NSST was rejected in favor of the non-standardized experimental form of the Developmental Language Comprehension Test (Weiner-Mayster, 1975), partly arbitrarily and partly because of the division of the DLCT into the four areas of simple syntax, morphology, complex syntax and semantic inference. The intention was to compare groups not only in their total scores, but in the subparts, with the recognition that while norms were not available, if significant differences did indeed occur, it would be a simple matter to determine in which areas these differences lay. Both the test chosen and the two rejected have an inherent flaw, that of the requirement that the visual stimuli be carefully examined and discriminated among in order that the most correct choice be made by the subject. This requires a fine visual-perceptual and discriminative ability after the child's initial selection of the critical feature(s) to be discriminated.

Expressive Language Measures

Spontaneous utterances. Most of the first attempts to analyze the spontaneous verbal productions of children were concerned with their earliest utterances (Braine, 1963; Weir, 1952). These were in addition to the use of length of utterance measures (Templin, 1957) and sentence completion (Berko, 1958; Kirk, McCarthy and Kirk, 1968). Laura Lee's Developmental Sentence Types (1966) used Menyuk's observations of differences in the use of spontaneous language between normal and atypical children (Menyuk, 1964) to develop a means of describing the productions of normal children in a developmental sequence. From this came Developmental Sentence Scoring (Lee and Canter, 1971) which, as noted in the previous chapter, permitted a quantifiable analysis of the spontaneous utterances of children. However, one of its criteria is that to be scoreable, sentences must contain both a noun and a verb. Therefore its use as a metric with a language deficient population was felt to be contraindicated, since their speech may contain many incomplete sentences. Adherence to the noun-plus-verb criterion may make another, that of consecutiveness, impossible to meet. It was mainly for this reason that another unstandardized metric, the Complexity Measure of Expressive

Language Skills (Wurtzel, et al., 1975) was used in this study. Since no criteria for inclusion of utterances were suggested by the authors, it was possible to set up those deemed most useful for the purposes of this examination, among them the scoreability of both complete and incomplete utterances. See pages 154 - 158 for protocols. While the CMEL does not penalize heavily for incorrect or fragmentary grammatical forms, this not being its purpose, it does distinguish among those children who use the various forms often, seldom or never, by scoring the frequency of their appearance in each utterance. Much of what is reflected in the total score for each child, among other things, is the number of underlying sentences per utterance as well as their complexity. The purpose here again was not to compare the groups' performances with a norm, but with each other.

Articulation. In the area of production there remains to be discussed the phonological component. While there are many picture-type articulation tests available, the Fisher-Logemann Test of Articulation Competence (FLTAC) (Fisher and Logemann, 1971) offers an advantage in the organization of its record form. It provides at a glance the particular pattern of the child's phonemic or articulatory errors, making it possible without additional analysis to determine those errors which are only of place, only of manner, or of both. It is of little importance that the errors are not scored in the test itself; a method of scoring was devised which is described on page 48. However, as the test was devised for the purpose of implementing "the application of the linguistic methodology of phonemic analysis to a more viable system of articulatory examination and diagnosis. . ."[5] it lends itself easily to a discussion of types of error in relation to the results of other tests in this battery, if this is shown to be desirable, and was selected for that reason.

Non-Verbal Measures

The last two procedures to be discussed are the Visual-Motor Integration Test, short form (VMI) of Beery and Buktenica (1967), and the manual dexterity score (MDS). In designing this study it seemed reasonable to include some non-verbal tasks to answer the question of whether differences between the poor sentence repeaters and the children with superior repetition skills, if indeed they are shown to exist, are only in the sphere of language, or whether other areas of functioning similarly differ. One such non-verbal measure is the Goodenough Draw-a-Man Test, discussed elsewhere. Another is the VMI, chosen because of its reportedly high correlation (0.89) with chronological age (particularly with younger children), its ease of administration and the possibility of later investigation into type and degree of error. Beery's conception of the integration of basic skills, among them visual and motor, as being necessary to the smooth functioning of the entire information-processing system (of which language is a major part), is one reason for inclusion of the VMI in the test battery. The manual dexterity score (MDS) is a measure of each child's absolute motor dexterity on the handedness tasks described elsewhere, regardless of the relative efficiency of the hands. It is simply another numerical value given to an operation, this one purely motoric, with which other operations of many different kinds were compared and relationships sought.

NOTES

1. ". . .repetition can be merely mimicry of the surface structure of the utterance or it can reflect the availability of matching structures in the subjects' grammars (or their linguistic competence) depending on the structure and length of the utterances presented for repetition." (p. 149)

2. "One possible explanation for the difference in outcome between the present study and that of Geffner and Hochberg (1971) is that the low SEC Ss examined by the latter investigators may have been raised in more deprived environments than those of the present study. Geffner and Hochberg argued that abnormal rearing conditions may have resulted in a retarded rate of cerebral lateralization of function. However, an alternative and somewhat less radical explanation is that abnormal rearing conditions engender Ss who function at very low cognitive and motivation levels. . . .Until (other) data have been collected the effect of rearing conditions on the rate of cerebral lateralization of functions remains unclear."

3. The Illinois Test of Psycholinguistic Ability (Kirk, McCarthy and Kirk, 1968), for example.

4. The Northwestern Syntax Screening Test, (NSST) (Lee, 1970), for example.

5. Therapist's Manual for the FLTAC (1971), page 34.

CHAPTER IV. RESULTS

Treatment of the Data

The data generated by the measures described in the preceding chapter and displayed as raw and transformed scores in Tables A through G in the Appendix, were examined for mean differences across the groups and between the sexes and for correlations among the variables; selected measures were also subjected to a variety of by-subject analyses. First, the dichotic and handedness data were transformed into individual indices according to formulae described in chapter III, and the means computed and compared by a t-test.[1] Then types of correct and incorrect dichotic responses were analyzed and the means of those results compared similarly for the purpose of discovering possible speech-processing differences. Also compared were the Peabody IQ (PIQ) means of the most strongly and most weakly lateralized subjects, and the dichotic and several selected language variable means of a subset of eight children in each group, who were matched for PIQ and Goodenough IQ. Scores were also matched on four other variables to determine if the differences in the ear advantage between the groups remained constant. In addition, the dichotic and the handedness scores were tested by a z-statistic $(R-L/\sqrt{R+L})$ for the significance of the between-ear and between-hand differences of each subject. In order to determine on which of the other tested dimensions the groups differed, the remainder of the data was coded where necessary, means computed, and t-tests applied. Then all possible Pearson product-moment correlation coefficients were calculated from the data, yielding a 17 x 17 multiple correlation matrix, and examined to determine if there were relationships among any of the many variables, particularly with and among the several laterality scores. Last, another matrix of the inter-correlations of the subparts of the Complexity Measure of Expressive Language (CMEL) (Wurtzel, et al., 1975) was constructed to examine the possibility of more economical methods of scoring this metric. The results of these statistical analyses follow.

Statistical Results

Differences

Dichotic Listening

Ear advantage: the right and left ear raw scores, ear advantages and number of errors for each individual subject are found in tables C and D in the Appendix.[2] Mean differences between the experimental and control groups' relative and absolute ear advantages were significant at the 0.01 and 0.05 levels, respectively (Table 1). The REA difference was also numerically substantial (14.0%) with the EG mean of 0.5 reflecting nine subjects with left-ear advantages. See Figures 1 and 2 for the distribution of the REAs and AEAs for the two groups. To determine whether individual between-ear differences were significant, a z-statistic ($R-L/\sqrt{R+L}$) was applied to each subject's score. As can be seen in Table 2, only two subjects in the EG had a significant ($p < 0.05$) between-ear difference; in one case, a child with a left-ear advantage, and in the other, one with a right-ear advantage. There were seven controls whose between-ear differences were significant, all with REAs.

<u>Type of error</u>: When type of error on the dichotic test was examined (see Table 1) it was noted that the means and standard deviations of both groups were very close in the case of blend errors, where the response syllable contained the place feature from one stimulus syllable and the voicing feature from the other--(ba/ka is perceived either as ga or pa)--and although less close in place errors, did not prove to be significantly different across the groups. (Girls, however, made significantly more crossblend errors than boys.)[3] Voicing and voice + place errors as well as no-responses were extremely few and were therefore not included in the analysis.

Tables 4 and 5 reveal that blend errors account for 55.57% and 61.67% of the total errors in the EG and the CG respectively, while place errors were responsible for 43.41% and 37.17%. The EG has a smaller gap between the two types of errors than does the CG. It is evident that blend errors predominate over other types.

TABLE 1

Means, Standard Deviations and t-Tests on All Dichotic Scores

		Experimental	Control	t	p
Right ear Advantage	(mean)	0.50	14.50	3.41	<.01
	(S.D.)	12.10	13.80		
Absolute ear Advantage	(mean)	9.35	16.29	2.26	<.05
	(S.D.)	7.57	11.47		
Dichotic Error total	(mean)	39.05	34.70	1.43	n.s.
	(S.D.)	10.71	8.45		
Dichotic Blend errors	(mean)	21.70	21.40	.19	n.s.
	(S.D.)	4.64	5.25		
Dichotic Place errors	(mean)	16.95	12.90	1.22	n.s.
	(S.D.)	11.35	9.52		
# Correct, Voice and Place contrast.	(mean)	20.80	22.95	1.25	n.s.
	(S.D.)	6.06	4.69		
# Correct, Voice contrast.	(mean)	19.30	21.10	1.37	n.s.
	(S.D.)	3.10	4.99		
# Correct, Place contrast.	(mean)	40.95	41.55	.45	n.s.
	(S.D.)	5.16	3.05		

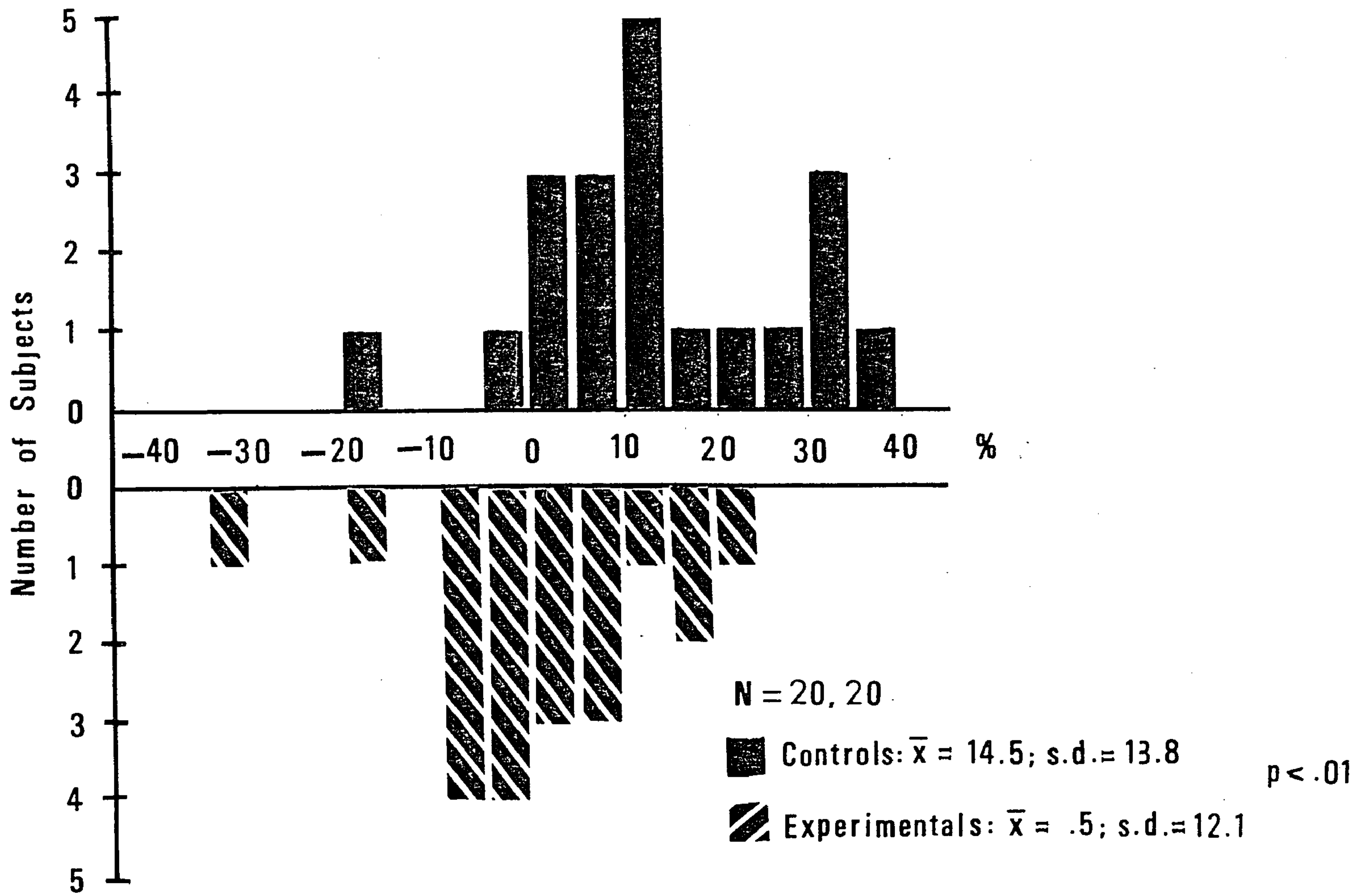


Fig.1 Distribution of the Right Ear Advantage

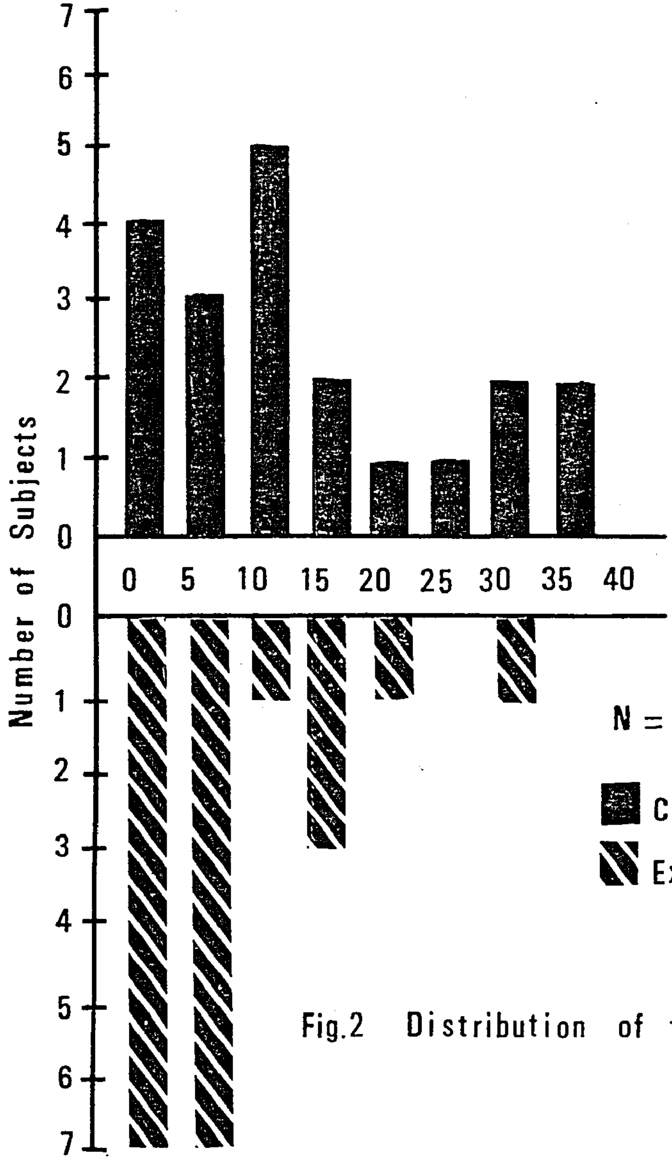


Fig.2 Distribution of the Absolute Ear Advantage

TABLE 2

Significance of Ear Differences by Subject
$(R-L/\sqrt{R+L})$

Experimental Subject	z	p	Control Subject	z	p
KC	1.778	<.05	AH	3.222	<.01
VT	1.376	n.s.	AB	3.470	<.01
RBG	1.287	n.s.	JB	3.183	<.01
SA	.965	n.s.	HL	2.871	<.01
TL	.750	n.s.	LM	2.830	<.01
GH	.843	n.s.	JR	1.919	<.05
FW	.508	n.s.	CBD	1.823	<.05
BC	.342	n.s.	LK	1.309	n.s.
JS	.329	n.s.	MG	1.178	n.s.
DG	.327	n.s.	MBB	1.265	n.s.
HS	0	n.s.	SD	1.078	n.s.
DS	- .211	n.s.	KBC	1.105	n.s.
TS	- .232	n.s.	DE	.831	n.s.
CD	- .422	n.s.	MB	.904	n.s.
MM	- .508	n.s.	LG	.524	n.s.
DA	- .671	n.s.	LBM	.436	n.s.
LV	- .825	n.s.	DP	.422	n.s.
MA	- .863	n.s.	RG	.221	n.s.
MT	-1.434	n.s.	SH	- .120	n.s.
KS	-2.92	<.01	RZ	-1.463	n.s.

Number of errors. In no individual case did the percentage of errors of the total number of stimulus pairs represented (120) exceed 48.33% or fall below 17.5%, with the mean percentage of total errors for the groups being EG: 32.54%; CG: 28.91% (Tables 4 and 5). As can be seen, the range of numbers of errors in the EG is 23 to 58 with a mean of 39.05; and in the CG is 21 to 51 with a mean of 34.7. This difference does not reach significance. This finding makes clear the fact that no floor or ceiling effect occurred in the dichotic testing for either group.

Type of correct responses. In the light of recent evidence (Oscar-Berman, Zurif and Blumstein, 1975) that left brain-damaged subjects are less capable of benefitting from double place cues in a dichotic task than normal or right brain-damaged subjects, an analysis of each correct response vis-a-vis the features of voice and place contrasted in each dichotic syllable pair was undertaken. The by-subject results are seen in Table 6 (see also Table 1 for significance of differences across the groups), and clearly indicate that in all three conditions (both features contrasted, voicing contrasted, place contrasted) no significant differences exist between the EG and the CG. Therefore, both groups benefitted equally when double place cues were available, and can be said not to behave like the left brain-damaged subjects of the study by Oscar-Berman et al.

Dichotic results and IQ. The large IQ differences

TABLE 3

Means, Standard Deviations and t-Tests
On All Measures: By Sex

	Females		Males			
	Mean	S.D.	Mean	S.D.	t	p
Rt. Ear Advant.	8.60	14.1	6.37	15.51	- .47	n.s.
Absolute Ear Advantage	12.99	9.96	12.65	10.73	- .10	n.s.
Total No. Dichotic Err.	36.45	9.54	37.3	10.23	.06	n.s.
No. Dichotic Blend Errors	23.15	5.16	20.00	4.12	2.13	<.05
No. Dichotic Place Errors	13.75	8.48	16.10	17.65	.54	n.s.
Harris Hand Preference	88.00	16.41	87.00	17.50	- .19	n.s.
Pegs	6.03	7.36	3.77	7.71	- .95	n.s.
Tapping	8.56	4.51	5.23	6.36	-.191	n.s.
Card Dealing	8.40	20.82	6.09	18.27	- .37	n.s.
Scissors Cut.	48.37	15.33	36.53	18.17	-2.23	<.05
Grip Strength	3.69	7.07	5.74	5.24	-1.04	n.s.
Manual Dext.	312.62	42.22	318.42	46.95	.41	n.s.
Sentence Imit. (SOLST)	16.10	16.07	17.45	19.91	.24	n.s.
Age	69.15	2.60	69.20	3.66	.05	n.s.
Sentence Comprehension (DLCT)	29.85	5.94	31.55	5.77	.92	n.s.
Syntactic Complexity (CMEL)	520.76	115.82	515.96	155.35	- .11	n.s.
Articulation Errors	6.20	14.91	7.65	13.05	.33	n.s.

TABLE 3 (cont'd.)

	Females		Males			
	Mean	S.D.	Mean	S.D.	*t*	*p*
Visual-Motor Skills (VMI)	67.25	9.46	73.15	9.60	1.96	n.s.
Peabody IQ	110.30	15.59	114.80	9.95	1.09	n.s.
Goodenough IQ	115.75	19.27	113.10	21.10	- .41	n.s.

TABLE 4

Number of Dichotic Blend and Place Errors by Subject:

Experimental Group Means and Standard Deviations

Subject	Blend Errors	Place Errors	Voicing Errors	Voice and Place Errors	No Response	Total Errors
KC	32	26	0	0	0	58
VT	23	21	0	0	0	44
RBG	16	31	0	0	0	47
SA	25	8	0	0	0	33
TL	21	35	0	0	0	56
GH	18	12	0	0	0	30
FW	21	2	0	0	0	23
BC	21	20	1	1	0	43
JS	15	22	0	0	0	37
DG	23	12	0	0	0	35
HS	26	6	0	0	0	32
DS	24	6	0	0	0	30
TS	28	17	0	0	1	46
CD	23	7	0	0	0	30
MM	22	36	0	0	0	58
DA	20	18	0	1	1	40
LV	17	9	0	0	0	26
MA	25	9	0	0	0	34
MT	12	38	0	0	0	50
KS	22	4	2	0	0	28
Total	434	339	3	1	2	781
Mean	21.70	16.95	not	not	not	39.05
S.D.	4.64	11.35	computed	computed	computed	10.71
% of Total Errors	55.57%	43.41%	0.43%	0.14%	0.26%	32.54%

TABLE 5

Number of Dichotic Blend and Place Errors by Subject:

Control Group Means and Standard Deviations

Subject	Blend Errors	Place Errors	Voicing Errors	Voice and Place Errors	No Response	Total Errors
AH	15	24	0	0	0	39
AB	21	3	0	0	0	24
JB	19	17	0	0	1	37
HL	27	11	0	0	0	38
LM	18	10	0	0	1	29
JR	15	17	0	0	0	32
CBD	20	11	0	0	0	31
LK	17	19	0	0	0	36
MG	36	12	0	0	0	48
MBB	21	9	0	0	0	30
SD	20	14	0	0	0	34
KBC	19	2	0	0	0	21
DE	14	34	1	0	0	49
MB	19	1	1	0	0	21
LG	21	7	1	0	0	29
LBM	24	12	0	0	0	36
DP	27	3	0	0	0	30
RG	26	10	0	1	1	38
SH	25	26	0	0	0	51
RZ	25	16	0	0	0	41
Total	428	258	3	1	3	694
Mean	21.4	12.9	not	not	not	34.7
S.D.	5.22	9.52	computed	computed	comput.	8.45
% of Total Errors	61.67%	37.17%	0.43%	0.14%	0.43%	28.91%

between the experimental and control groups, which will be discussed later in this chapter (see Table 19), suggested the need for a different perspective on the data to see if IQ was a factor in the dichotic results. Therefore two new analyses were made. First, a comparison of PIQ means was made between the twenty more strongly lateralized children (larger AEA) and the twenty less lateralized children (smaller AEA), regardless of group. The direction of the advantage was ignored since only the degree was relevant to this analysis. Table 7 demonstrates that the difference between the means of the PIQ was nonsignificant when strongly and weakly lateralized youngsters of this age were compared. Table 8 represents the second analysis,which matched PIQs across the groups within two points (mean for both groups was 116.5). With this subset of eight subjects in each group there still remained a large and highly significant difference in REA (-5.46% and 18.45% respectively), even greater than that between the complete EG and CG. The wide range in variability of the absolute ear advantages accounts for the low t value and resulting nonsignificance of the difference between the means despite a large numerical difference. The same analysis was done using matched GIQs (Table 9), and although the mean ear difference was approximately ten percentage points, it too proved to be nonsignificant, again because of the overlapping distributions. Table 10 shows the results of comparisons of the REAs and PIQs of the remaining twelve subjects in each of the

TABLE 6

Effect of Features Contrasted on Correct Responses in the Dichotic Test: By Subject

Experimental Group				Control Group			
Subject	Place & Voicing*	Voicing*	Place*	Subject	Place & Voicing*	Voicing*	Place*
SA	24	17	46	MB	30	24	45
MA	22	18	46	AB	27	23	46
DA	23	22	35	MBB	27	18	45
BC	21	17	39	JB	21	24	38
KC	10	19	23	KBC	29	24	46
CD	23	24	53	SD	19	24	43
DG	22	17	46	CBD	23	21	45
RBG	14	22	37	DE	20	15	36
GH	29	20	41	MG	11	22	39
TL	13	19	32	RG	21	22	39
MM	14	14	34	LG	27	22	42
JS	24	16	43	SH	19	11	39
DS	19	24	47	AH	21	21	39
HS	22	22	44	LK	26	17	42
TS	17	14	43	HL	18	23	41
KS	24	22	46	LM	28	20	43
MT	19	18	33	LBM	22	22	40
VT	19	17	40	DP	22	22	46
LV	29	21	44	JR	25	24	39
FW	28	23	46	RZ	18	23	38
Mean	20.80	19.30	40.95		22.95	21.10	41.55
S.D.	6.06	3.10	5.16		4.69	4.99	3.05
% Correct of possible total in each category	43.33	80.42	85.31		47.81	87.92	86.56

*Place and voicing contrasted: t = 1.25 n.s.
*Voicing contrasted: t = 1.37 n.s.
* Place contrasted: t = 0.44 n.s.

TABLE 7

t* Test of Peabody IQ Differences Between Most Strongly and Most Weakly Lateralized Subjects

Weakly Lateralized			Strongly Lateralized		
Subject	Absolute Ear Advantage	PIQ	Subject	Absolute Ear Advantage	PIQ
TL	9.37	104	AH	35.80	119
MA	9.30**	110	AB	35.42	115
MB	9.09	125	JB	34.94	132
GH	8.89	115	HL	31.70	108
LV	8.51**	91	KS	30.43**	125
DA	7.05**	106	LM	29.67	91
MM	6.54**	97	KC	22.58	91
LG	5.49	125	JR	20.45	123
LBM	4.76	138	CBD	19.54	112
CD	4.44**	108	MT	17.14**	110
DP	4.44	115	RZ	16.64**	123
FW	5.15	130	VT	15.79	97
BC	3.90	90	RBG	15.07	104
JS	3.61	95	LK	14.28	121
DG	3.53	117	MG	13.89	115
TS	2.70**	95	MBB	13.33	121
RG	2.44**	121	SD	11.63	140
DS	2.22**	100	KBC	11.11	123
SH	1.45**	110	SA	10.34	104
HS	0.00	117	DE	9.86	121

PIQ Mean = 110.45 S.D. = 13.10

PIQ Mean = 114.75 S.D. = 12.51

*t = 1.06 (n.s.)

** left ear advantage

TABLE 8

Differences in Ear Advantage in a Subset of Subjects Matched for Peabody IQ

Experimental Group			Control Group		
Subject	Right Ear Advantage	PIQ	Subject	Right Ear Advantage	PIQ
CD	-4.44	108	HL	31.70	108
MA	-9.30	110	SH	- 1.45	110
MT	-17.14	110	CBD	19.54	112
GH	8.89	115	MG	13.89	115
DG	3.53	117	AB	35.42	115
HS	0.00	117	DP	4.44	115
KS	-30.43	125	MB	9.09	125
FW	5.15	130	JB	34.94	132

Experimental Group		Control Group		
Peabody IQ Mean:	116.5	Peabody IQ Mean:	116.5	
Right Ear Advantage, Mean:	-5.47	Right Ear Advantage, Mean:	18.45	t = 3.51 (p<.01)
S.D.:	13.12	S.D.:	14.12	
Absolute Ear Advantage, Mean:	9.86	Absolute Ear Advantage, Mean:	18.81	t = 1.23 (n.s.)
S.D.:	9.95	S.D.:	18.09	

TABLE 9

Differences in Ear Advantage in a Subset of Subjects Matched for Goodenough IQ

Experimental Group			Control Group		
Subject	Right Ear Advantage	GIQ	Subject	Right Ear Advantage	GIQ
JS	3.61	96	AH	35.8	97
GH	8.89	100	SH	- 1.45	100
SA	10.34	105	JB	34.94	107
MT	-17.41	109	KBC	11.11	108
FW	5.15	109	RZ	-16.45	108
BC	3.90	110	RG	2.44	110
DS	- 2.22	130	CBD	19.54	131
HS	0.00	150	DP	4.44	152

Experimental Group		Control Group		
Goodenough IQ Mean:	113.62	Goodenough IQ Mean:	114.12	
Right Ear Advantage		Right Ear Advantage		
Mean:	1.53	Mean:	11.3	t = 1.37
S.D.:	8.70	S.D.:	18.07	(n.s.)
Absolute Ear Advantage		Absolute Ear Advantage		
Mean:	6.44	Mean:	15.77	t = 2.07
S.D.:	5.57	S.D.:	11.46	(n.s.)

TABLE 10

Differences in Right Ear Advantage in the Remainder of Subjects After Matching of Peabody IQs

Experimental Group			Control Group		
Subject	Right Ear Advantage	PIQ	Subject	Right Ear Advantage	PIQ
RBG	15.07	104	AH	35.80	119
SA	10.34	104	LM	29.67	91
TL	9.37	104	JR	20.45	123
DS	- 2.22	100	LK	14.28	121
DA	- 7.05	106	MBB	13.33	121
KC	22.58	91	SD	11.63	140
VT	15.79	97	KBC	11.11	123
BC	3.90	90	DE	9.86	121
JS	3.61	95	LG	5.45	123
TS	- 2.70	95	LBM	4.76	138
MM	- 6.45	97	RG	2.44	121
LV	- 8.51	91	RZ	-16.45	123
Mean:	4.48	97.83	Mean:	11.96	122

two original groups. Here the IQ gap becomes even larger (EG: 97; CG: 122), while the REA difference gets smaller (EG: 4.48; CG: 11.96). These results suggest that ear advantage is independent of IQ. The matched subjects represented in Table 8 were also compared on four of the other variables. The differences on three of the four remain significant (Table 11), although the t values are reduced.

The same matching procedure as was used for the PIQ and GIQ was applied to four other measures: the DLCT (sentence comprehension), CMEL (syntactic complexity), BTBC (basic concepts) and VMI (visual-motor integration). The resulting two subsets for each of these comparisons, with the exception of the CMEL, consisted of an unequal number of subjects, a factor which contributed to slightly unequal but nonsignificantly different means across subsets for each test. The results of these comparisons can be seen in Tables 12 through 15. Only the VMI score matching produced a significant REA difference. The other resulting mean REA differences, although even larger than that resulting from the matching of the VMI scores, did not reach significance.

Handedness measures. Tables E and F in the Appendix contain raw hand scores and Tables A and B note the dextrality indices (DI) for each subject on all of the handedness tasks. It will be noted (Table 16) that degree of right-handedness on all six measures did not differ significantly across the groups, unlike degree of earedness, which did.

This results in the EG having ten right-handed, left-eared or bilaterally controlled, children, whereas the CG has only two such subjects. The results of the application of the z-statistic ($R-L/\sqrt{R+L}$) for all but the scissors scores, (for which $L-R/\sqrt{R+L}$ was used) to the handedness scores, are displayed in Tables 17 and 18. Only in the hand preference and the scissors cutting tasks were there a substantial number of significant between-hand differences; approximately the same for each group. Sex differences were nonsignificant in all handedness tasks except scissors cutting, where the girls were more dextral than the boys (Table 3).

Other Measures

The groups differed significantly not only on ear advantage, but also on the following: number of articulation errors (AS) and SOLST (by design): GIQ and manual dexterity (MDS) ($p<0.05$); PIQ, sentence comprehension (DLCT), comprehension of language concepts (BTBC), expressive language complexity (CMEL), and visual-motor integration ($p<0.01$). This same trend is seen in articulation error type, where the EG had more errors of both place and manner than the CG. There was also a striking difference in birth order. The CG was made up mostly of first-born or only children, in contrast to the EG, which contained mostly middle or last-born children. Also, the EG contained a somewhat greater number of children of parents from the lower socioeconomic strata (semi-skilled and skilled workers), while the CG was

TABLE 11

t Tests on Some Other Measures on
Subjects Matched for Peabody IQ
(See Table 8)

		Experimental	Control	t	p
CMEL					
	Mean	453.96	622.5	4.32	<.01
	S.D.	73.31	157.96		
DLCT					
	Mean	29.62	34.62	5.81	<.01
	S.D.	3.11	2.27		
VMI					
	Mean	69.62	76.25	2.73	<.05
	S.D.	5.42	9.42		
MDS					
	Mean	309.25	335.5	2.18	n.s.
	S.D.	29.74	44.64		

TABLE 12

t-Test of Difference in Right Ear Advantage Between Subsets of Subjects Matched for the Developmental Language Comprehension Test Scores (DLCT)

Experimental			Control		
Subject	Right Ear Advantage	DLCT	Subject	Right Ear Advantage	DLCT
DS	- 2.22	26	RG	2.44	26
SA	10.34	31	HL	31.70	31
GH	8.89	30	CBD	19.54	31
FW	5.15	30	SD	11.63	32
MT	-17.14	30	LM	29.67	33
DG	3.53	33	JR	20.45	34
CD	- 4.44	34	KBC	11.11	34
			SH	- 1.45	34
			RZ	-16.45	34
Mean:	.68	30.59	Mean:	12.07	32.1
S.D.:	9.95	2.57	S.D.:	15.44	2.62

Right Ear Advantage: $t = 1.68$ **(n.s.)**

TABLE 13

Difference in Right Ear Advantage Between Subsets of Subjects Matched for the Complexity Measure of Expressive Language (CMEL) Scores

Experimental			Control		
Subject	Right Ear Advantage	CMEL	Subject	Right Ear Advantage	CMEL
RBG	15.07	420.3	MG	13.89	422.1
HS	0.00	442.5	SH	- 1.45	442.5
MA	- 9.30	477.9	AB	35.42	489.3
DS	- 2.22	494.0	MB	9.09	499.8
MT	-17.40	588.5	CBD	19.54	581.9
Mean:	- 4.85	489.90	Mean:	13.10	497.43
S.D.:	14.77	65.14	S.D.:	13.54	63.04

Right Ear Advantage: t = 2.00 (n.s.)

TABLE 14

Difference in Right Ear Advantage Between Subsets of Subjects Matched for Boehm Test of Basic Concepts (BTBC) Scores

Experimental			Control		
Subject	Right Ear Advantage	BTBC	Subject	Right Ear Advantage	BTBC
FW	5.15	34	LM	29.67	34
DS	-2.22	34	SH	- 1.45	34
MA	-9.30	35	RG	2.44	36
SA	10.34	35	MG	13.89	41
TS	-2.70	41	SD	11.63	41
GH	8.89	42	AB	35.42	42
			LK	14.28	42
			MB	9.09	42
			RZ	-16.45	42
Mean:	1.69	36.8	Mean:	10.95	39.33
S.D.:	7.68	3.67	S.D.:	15.61	3.57

Right Ear Advantage: t = 1.34 (n.s.)

TABLE 15

Difference in Right Ear Advantage Between Subsets of Subjects Matched for Visual Motor Integration (VMI) Scores

Experimental			Control		
Subject	Right Ear Advantage	VMI	Subject	Right Ear Advantage	VMI
VT	15.79	59	RG	2.44	59
BC	3.90	63	MG	13.89	63
MM	- 6.45	63	LM	29.67	66
LV	- 8.51	63	LK	14.28	66
SA	10.34	66	SH	- 1.45	67
DG	3.53	66	SD	11.63	70
DS	- 2.22	66	MBB	13.33	82
TS	- 2.70	66	DP	4.44	82
KS	-30.43	66			
FW	5.15	67			
JS	3.61	67			
CD	- 4.44	67			
MA	- 9.30	67			
HS	0.00	70			
MT	-17.14	82			
Mean:	4.07	66.53	Mean:	11.03	69.37
S.D.:	13.20	4.89	S.D.:	9.60	8.42

Right Ear Advantage: $t = 3.04$ $p < 0.05$

TABLE 16

Means, Standard Deviations and t Tests on Handedness Measures

		Experimental Group	Control Group	t	p
Harris Hand Preference	(mean)	84.0	91.0	1.33	n.s.
	(S.D.)	17.9	15.2		
Pegs	(mean)	3.9	5.9	.85	n.s.
	(S.D.)	8.4	6.5		
Tapping	(mean)	7.0	6.8	.08	n.s.
	(S.D.)	5.7	5.8		
Card Dealing	(mean)	8.7	5.8	- .47	n.s.
	(S.D.)	21.6	17.2		
Scissors	(mean)	42.0	42.9	.16	n.s.
	(S.D.)	18.3	17.4		
Strength of Grip	(mean)	5.7	3.8	- .96	n.s.
	(S.D.)	4.7	7.4		

TABLE 17

Significance of Hand Differences by Subject ($R-L/\sqrt{R+L}$): Experimental Group

Subject	Harris	Pegs	Tapping	Cards	Scissors***	Grip
KC	2.530**	-0.530	1.056	0.655	4.341**	0.078
VT	3.162**	0.774	1.048	1.414	6.131**	0.225
RBG	3.162**	0.141	1.816*	0.730	0.000	0.560
SA	2.530**	1.549	1.394	1.347	3.064**	0.615
TL	2.530**	1.260	0.917	1.507	4.154**	0.000
GH	2.530**	0.000	0.757	1.042	3.355**	0.437
FW	3.162**	0.555	-0.346	0.774	5.347**	0.177
BC	3.162**	0.543	1.753*	0.000	2.064**	0.385
JS	2.530**	0.944	2.165*	2.065*	4.503**	0.514
DG	1.265	0.855	-1.200	0.943	3.457**	0.000
HS	3.162**	0.126	1.435	0.426	2.889**	0.000
DS	3.162**	0.122	1.099	-0.853	4.826**	0.220
TS	1.897*	0.404	1.691*	1.347	1.347	0.702
CD	2.530**	-0.390	0.662	0.000	0.707	0.556
MM	1.897*	0.000	1.272	-0.577	4.126**	0.566
DA	3.162**	-0.845	2.274*	0.000	4.428**	0.487
LV	3.162**	-0.651	1.494	0.200	3.850**	1.013
MA	3.162**	0.000	0.085	-0.447	1.870*	0.729
MT	2.530**	0.630	0.386	-1.225	1.640	0.367
KS	1.897*	0.356	1.157	-1.569	5.657**	0.146
No. Significant	19	0	5	1	16	0

*$p<0.05$ **$p<0.01$ ***$L-R/\sqrt{R+L}$

TABLE 18

Significance of Hand Differences by Subject (R-L/$\sqrt{R+L}$): Control Group

Subject	Harris	Pegs	Tapping	Cards	Scissors***	Grip
AH	3.162**	0.250	0.661	-0.447	3.255**	0.184
AB	3.162**	1.457	1.048	0.894	2.921**	0.000
JB	3.162**	0.000	0.733	0.218	-4.061**	0.074
HL	1.897*	0.843	1.457	1.225	-1.147	0.000
LM	3.162**	1.050	3.434**	-0.555	-3.015**	0.320
JR	3.162**	-0.549	0.295	-0.213	-4.473**	-0.070
CBD	3.162**	1.050	1.606	0.242	-6.047**	1.182
LK	3.162**	0.674	1.739*	0.229	-4.500**	0.408
MG	2.530**	0.500	0.837	1.671*	-1.809*	0.312
MBB	3.162**	0.485	0.123	-0.192	-0.750	0.458
SD	3.162**	0.525	1.104	-1.042	-5.435**	-0.950
KBC	3.162**	1.104	2.461**	-0.229	-2.200*	0.593
DE	2.530**	0.640	0.351	0.447	-2.629**	0.809
MB	3.162**	-0.132	-0.191	-0.816	-4.025**	-0.245
LG	1.897*	0.492	1.584	1.225	-6.833**	0.359
LBM	3.162**	0.242	0.782	-0.784	-4.817**	0.408
DP	1.897*	-0.611	0.365	-0.229	-1.372	0.502
RG	3.162**	0.267	0.392	1.213	-4.924**	0.000
SH	3.162**	0.525	1.170	1.225	-1.443	0.669
RZ	3.162**	0.404	1.010	0.632	-2.646**	1.140
No. Significant	20	0	0	1	16	0

*$p<0.05$ **$p<0.01$ ***L-R/$\sqrt{R+L}$

composed of children whose parents tended more to be semi-professionals or professionals. Examination of AT, BO and occupational coding on Tables A and B of the Appendix demonstrates this. See Table 19 for all means, standard deviations and t values of the non-laterality measures, and Figures 3 to 10 for histograms of the distributions of all significantly different scores.

The DLCT differed in all of its four subparts and the CMEL in several of its categories, most importantly in the number of major and minor grammatical relations and number of verbs, nouns and unified negative and auxiliary (<u>can't</u>, <u>don't</u>, etc.). Raw scores for the CMEL and its subcategories are in the Appendix, Table G. The t values for subparts of the DLCT and CMEL are displayed in Tables 20 and 21. The differences in the types of errors made by EG and CG children on the SOLST occurred because of its use as a group determiner; the CG's errors, permitted only up to an error score of 2, were restricted to paraphrases, synonyms, or use of substitute contractions of auxiliary verb forms. Therefore, their errors have not been charted. However, a breakdown of the types of EG subjects' errors on the SOLST, displayed in Table 22, reveals that grammatical errors predominate, while errors of meaning and errors combining semantic-syntactic elements are approximately equal and each only half as frequent as those of syntax. Paraphrases, somewhat more frequent than the semantic and combination errors, as often involve a contraction (<u>I'd</u> for <u>I</u>

TABLE 19

Means, Standard Deviations and t-Tests on All Non-Laterality Variables

Criterion Variables		Experimental	Control	t	p
Sentence Imitation (SOLST)(error score)	(mean)	32.70	00.85	-13.36	<0.01
	(S.D.)	10.64	00.74		
Articulation (AS) (error score)	(mean)	13.05	00.80	- 3.90	<0.01
	(S.D.)	17.54	2.60		
Age	(mean)	68.45	69.90	1.48	n.s.
	(S.D.)	3.03	3.14		
Test Variables					
Sentence Comprehension (DLCT)	(mean)	26.45	34.95	6.71	<0.01
	(S.D.)	4.24	3.76		
Comprehension of Basic Concepts (BTBC)	(mean)	30.74	42.20	6.16	<0.01
	(S.D.)	7.15	3.91		
Syntactic Complexity (CMEL)	(mean)	425.99	610.73	5.90	<0.01
	(S.D.)	66.06	123.42		
Peabody IQ (PIQ)	(mean)	105.30	119.80	4.17	<0.01
	(S.D.)	11.34	10.65		
Goodenough IQ (GIQ)	(mean)	107.6	121.25	2.27	<0.05
	(S.D.)	22.18	15.19		
Visual Motor Skill (VMI)	(mean)	64.25	76.15	4.75	<0.01
	(S.D.)	7.16	8.62		
Manual Dexterity (MDS)	(mean)	298.82	332.22	2.55	<0.05
	(S.D.)	41.05	41.59		

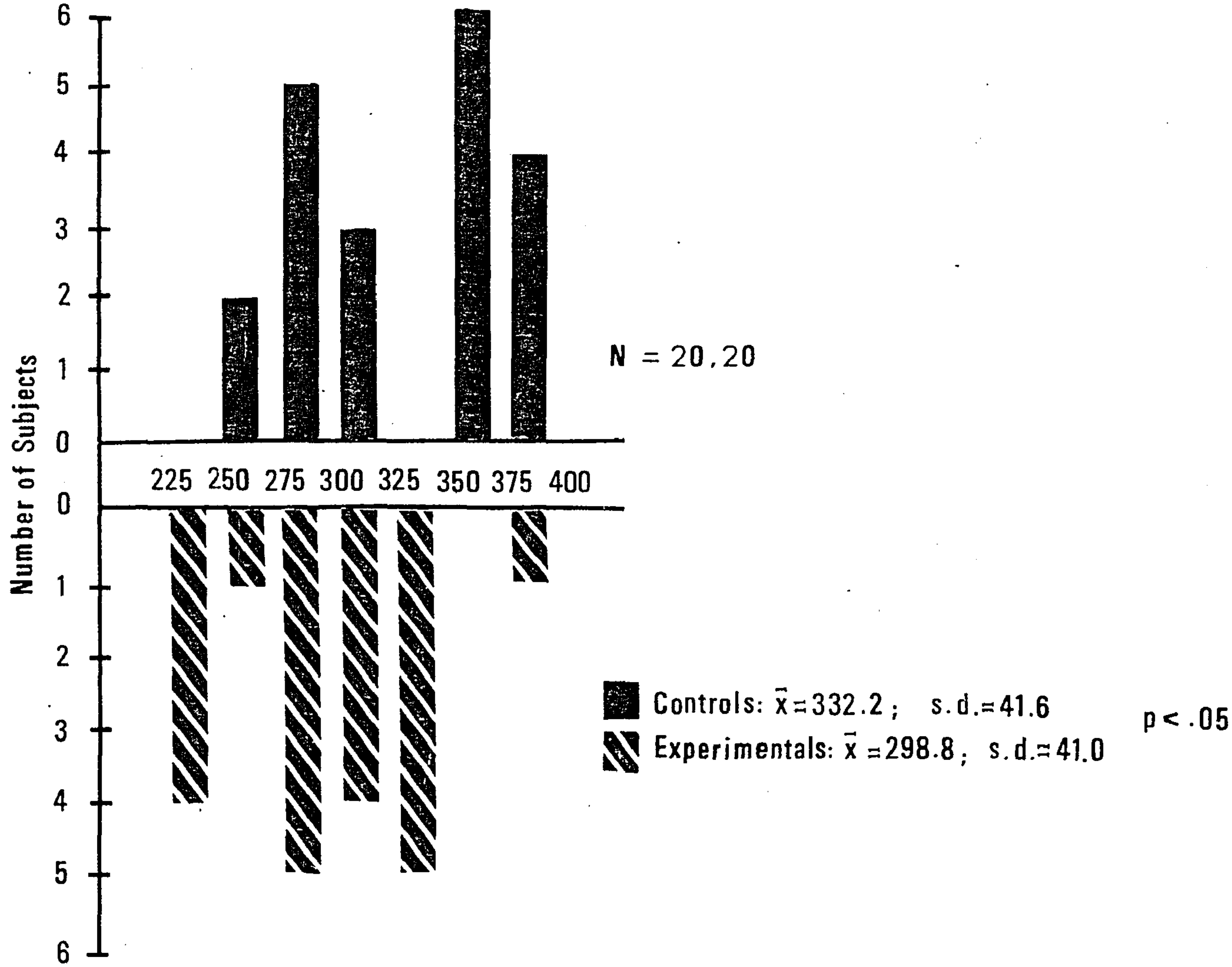


Fig.3 Distribution of Manual Dexterity Scores

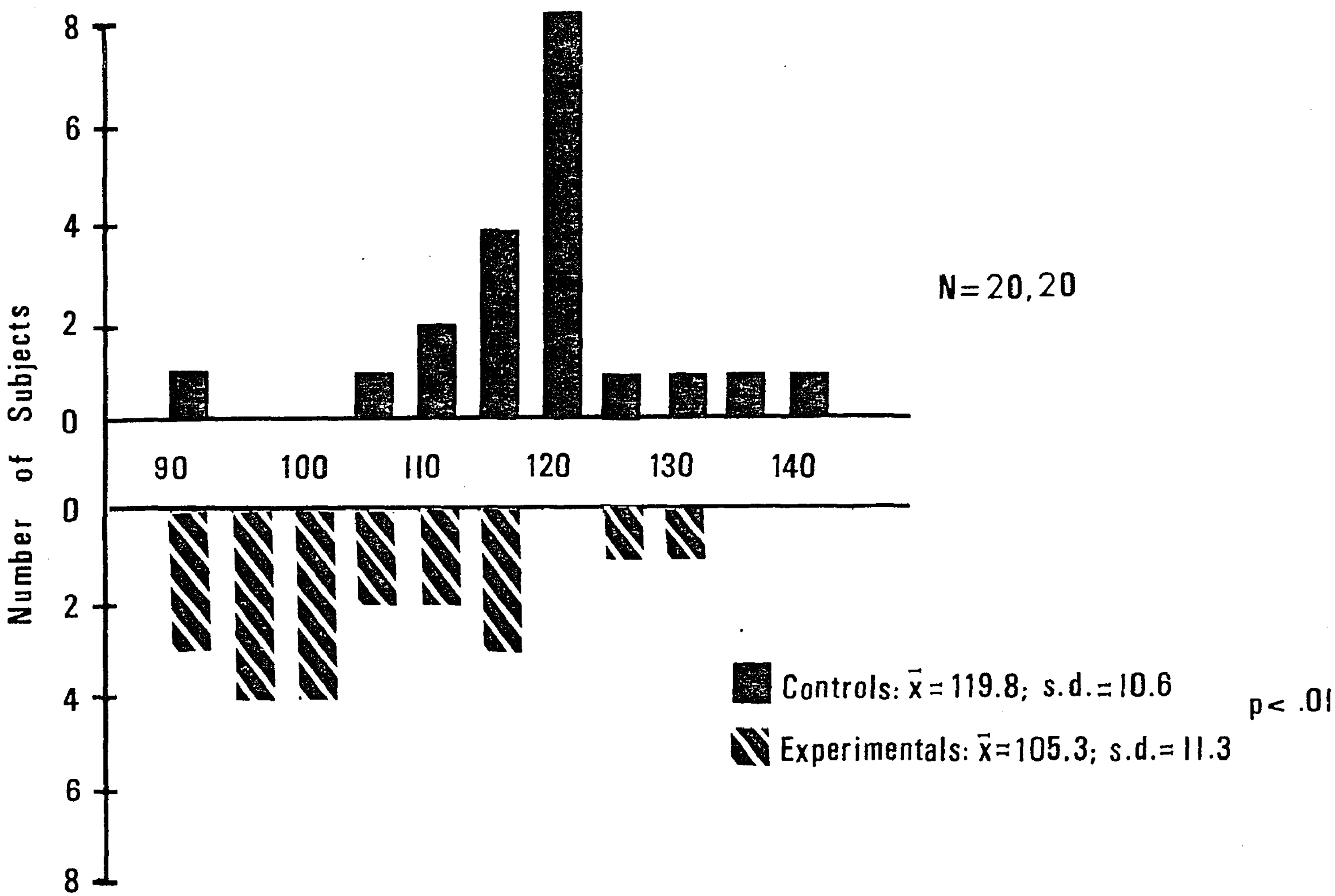


Fig. 4 Distribution of the PPVT IQ

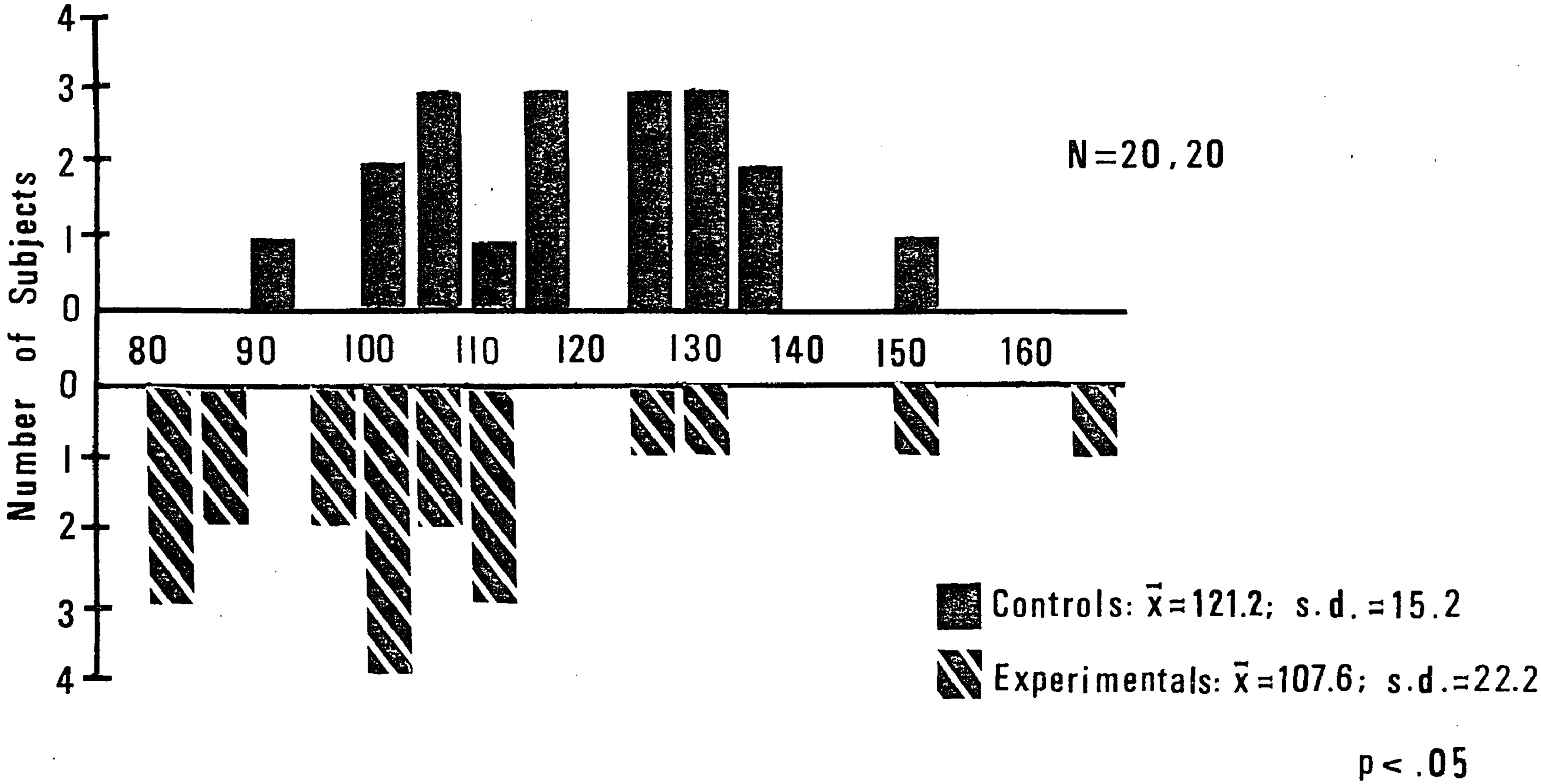


Fig. 5 Distribution of the Goodenough IQ

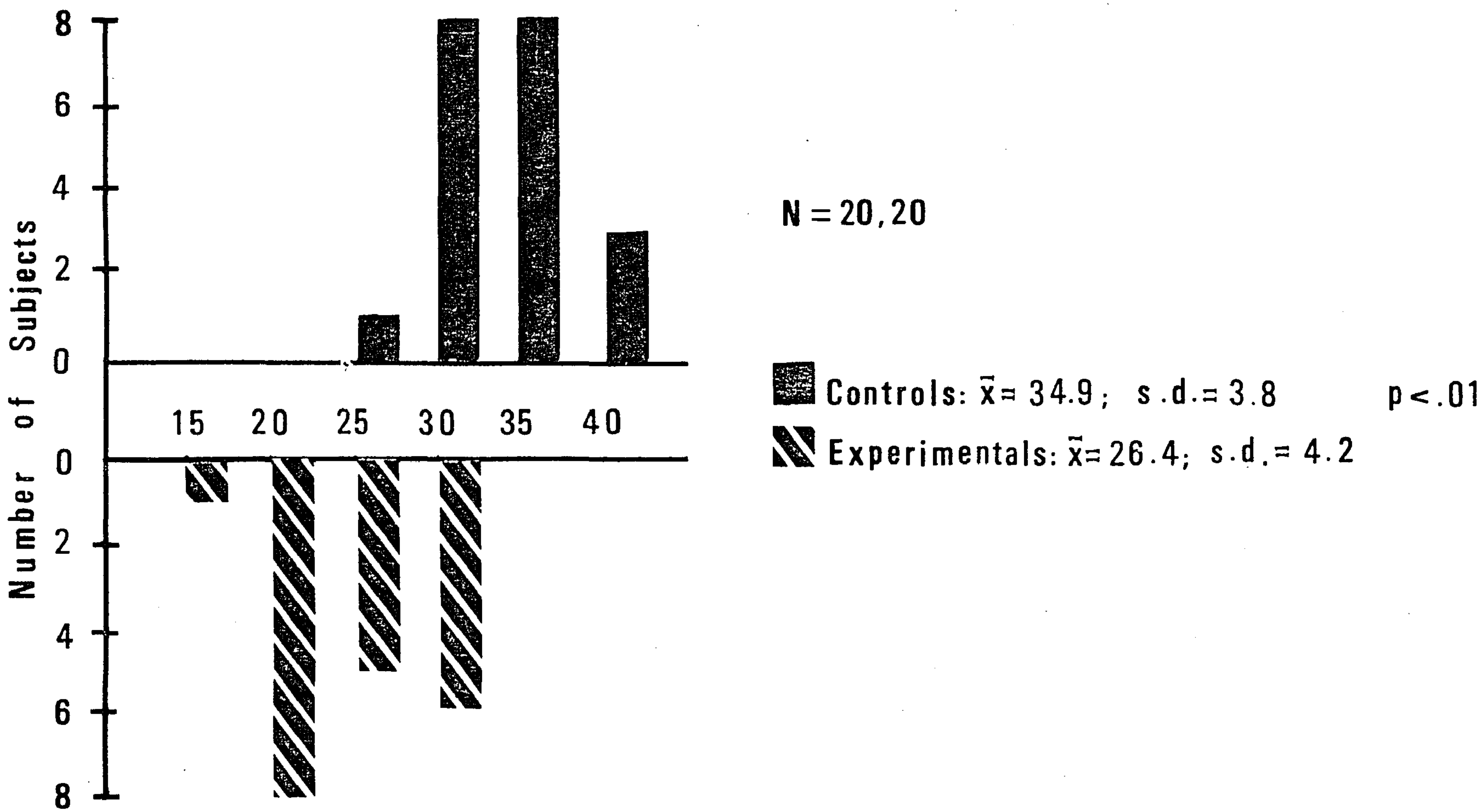


Fig. 6 Distribution of the Developmental Language Comprehension Test

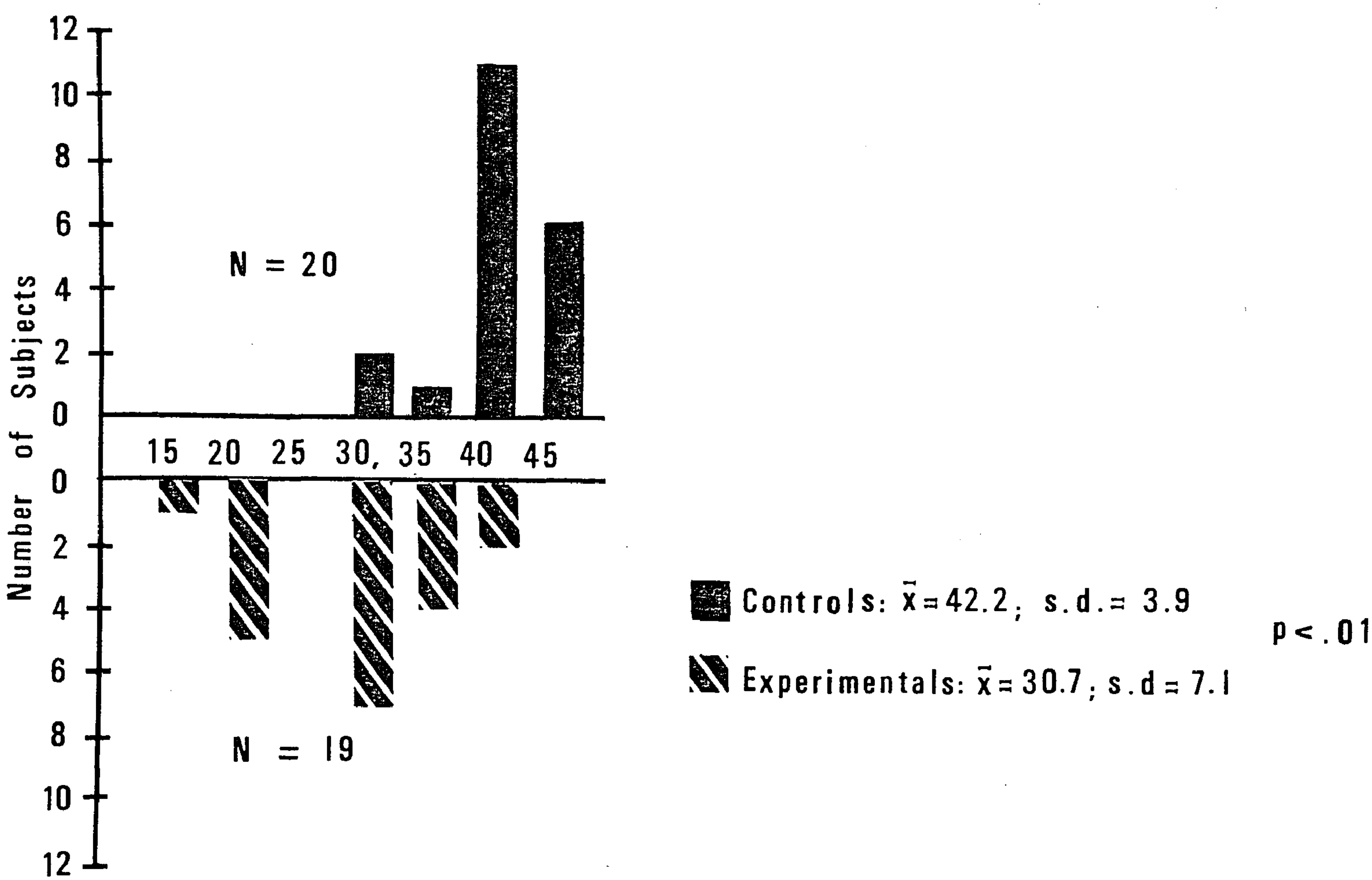


Fig. 7 Distribution of the Boehm Test of Basic Concepts

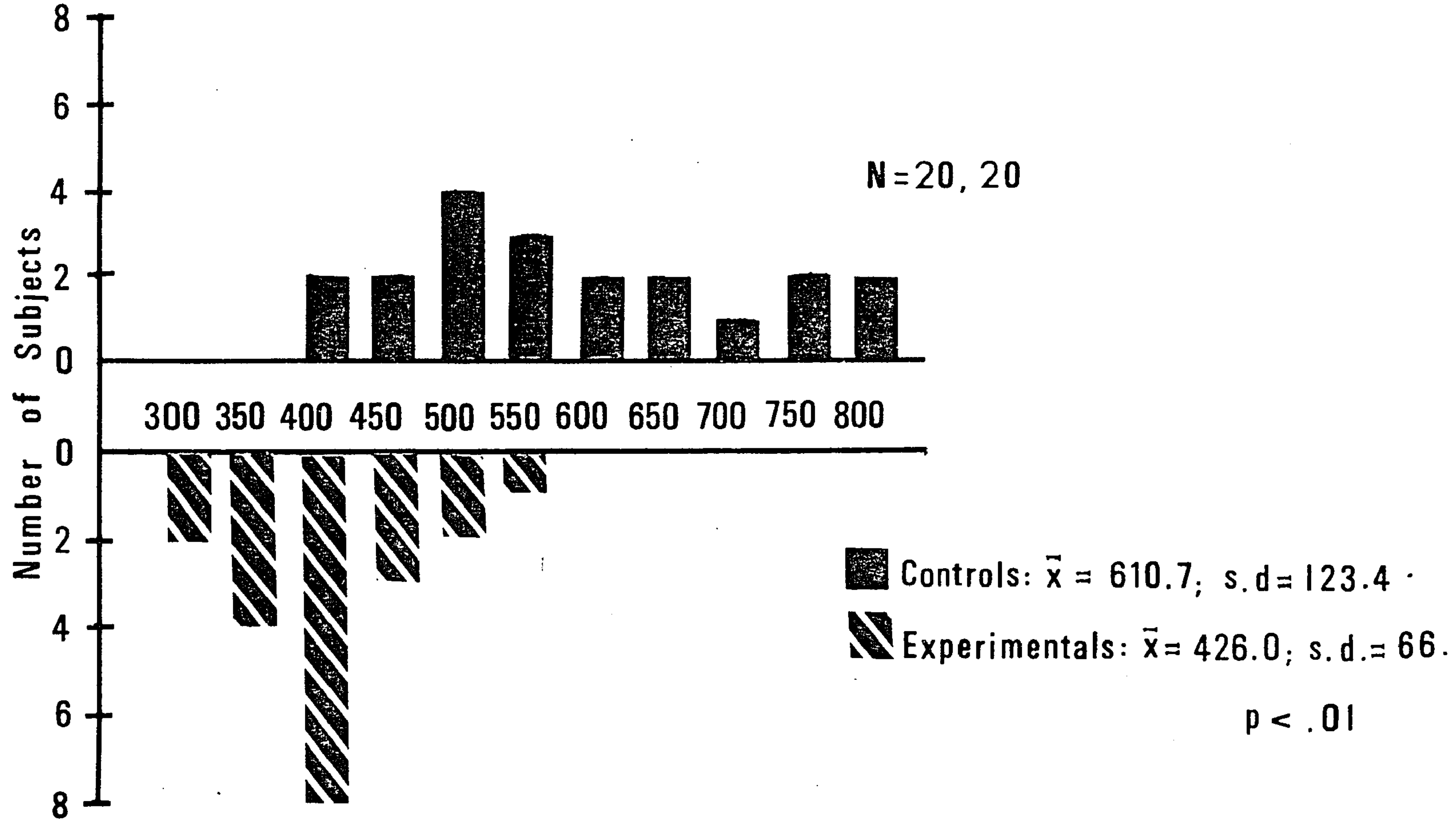


Fig. 8 Distribution of the Complexity Measure of Expressive Language

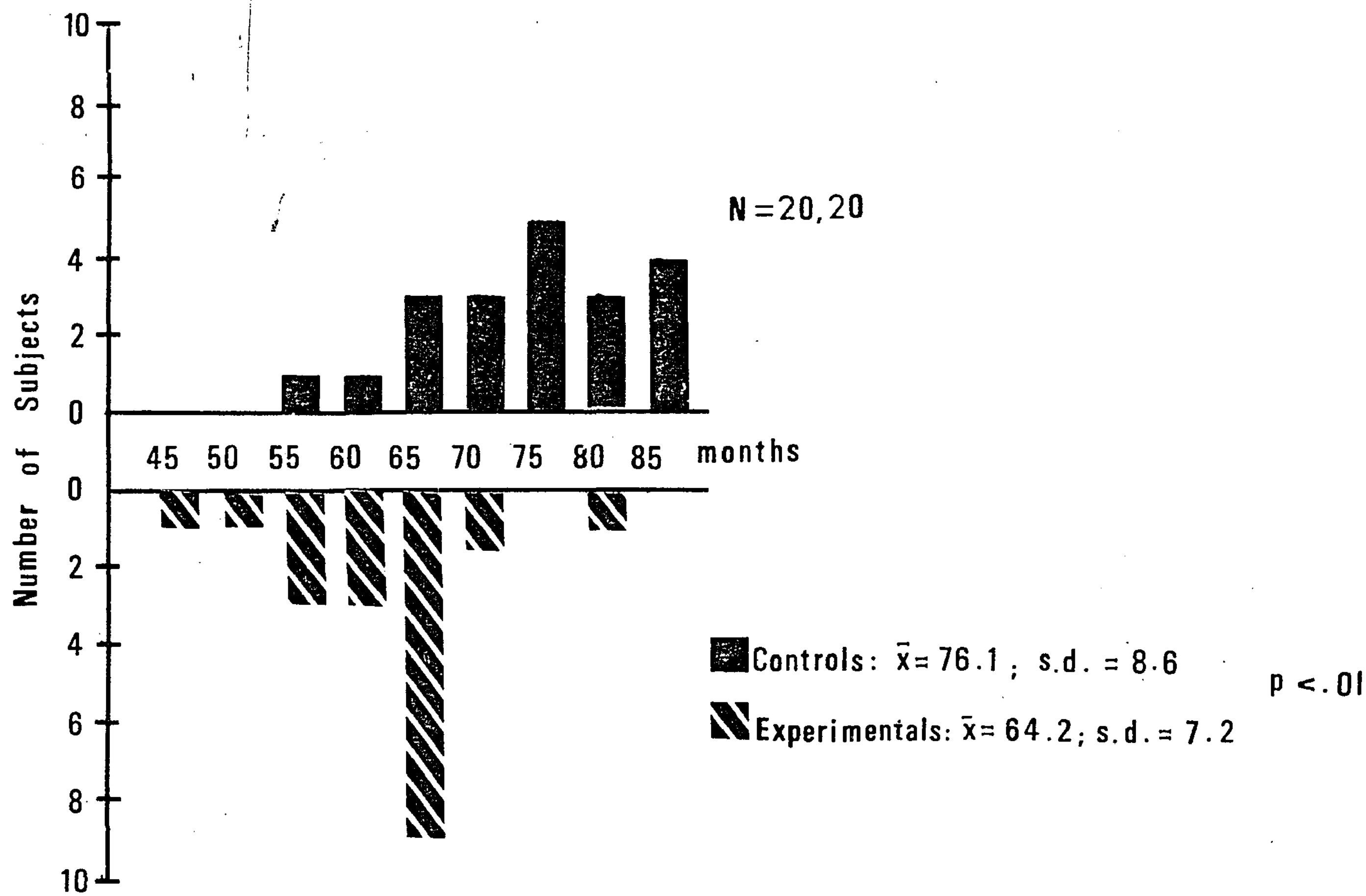


Fig. 9 Distribution of the Visual-Motor Integration Test

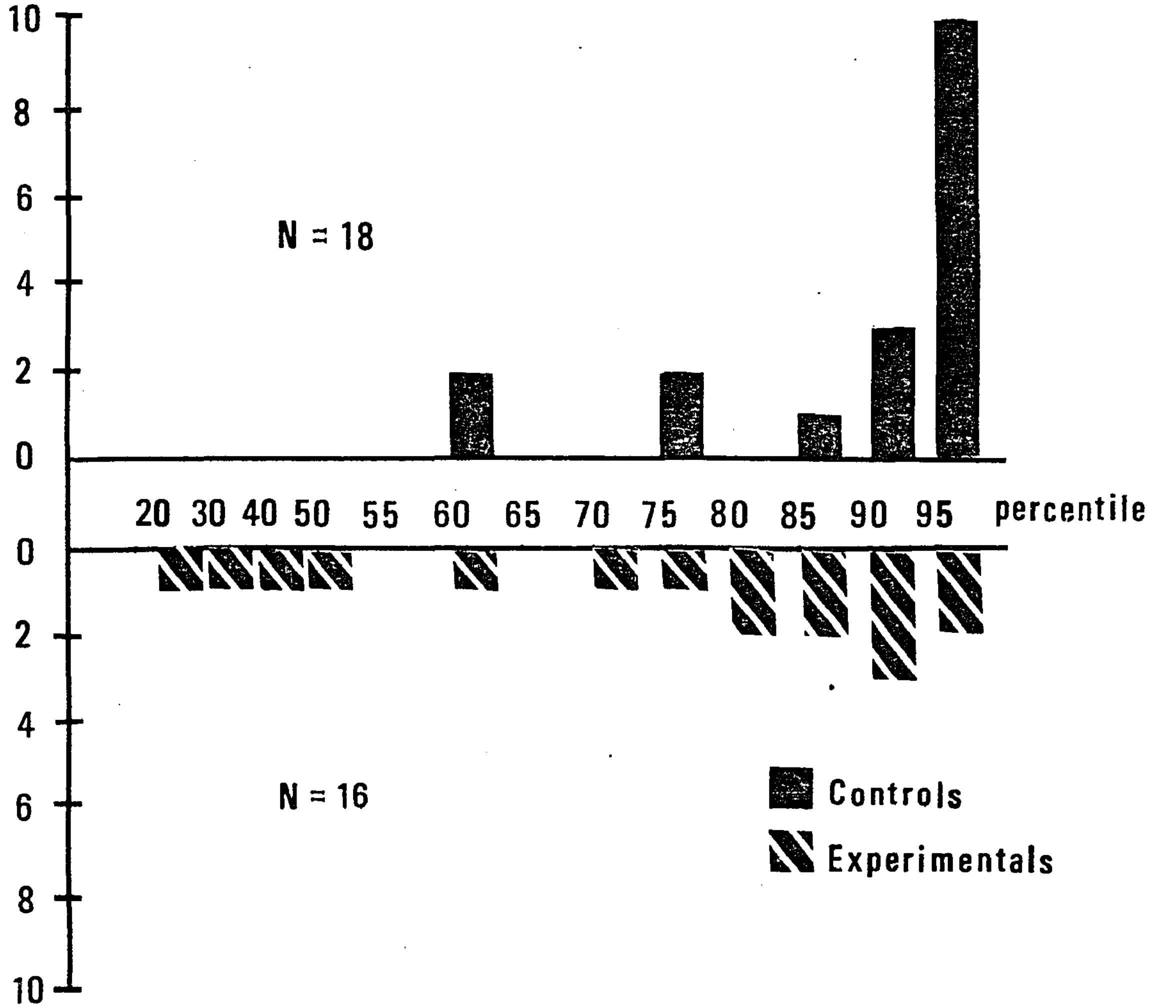


Fig 10 Distribution of the Murphy-Durrell Reading Readiness Analysis

would), or use of a synonym, (somebody for someone), as it does a substitution of an acceptable grammatical form for the one used (there's no reason to fight for there's no reason for fighting).

Reading Readiness

The results of the Murphy-Durrell Reading Readiness Analysis (MDRRA) were available only as percentile scores. Since deriving means from these would violate the assumption of an interval scale of measurement, only medians are reported (see Tables 23 and 24). Beyond this, no statistical analysis was carried out. As seen in these tables, six sets of scores are missing from the data; the two children in the CG and three of the four in the EG transferred out of the district before the administration of the test. One of the latter was DA who had done poorly in kindergarten on all cognitive tasks including the pre-phonics program, and whose parents had chosen to place him in an ungraded private school rather than have him retained in kindergarten. One experimental child (MM), found subsequent to this testing to have soft signs of neurological impairment, was placed in a special education class, and given the test individually over several sessions. The fourth child, BC, was retained in kindergarten because of predictions of failure to learn first grade material, and was not tested. Of the sixteen experimental group children tested, six earned scores at or below the 50th percentile for phoneme identification, six

TABLE 20

Means, Standard Deviations and t Tests for The Developmental Language Comprehension Test and its Subtests

		Experi-mental	Control	*t*	*p*
Total Score	(mean)	26.45	34.05	6.71	<0.01
	(S.D.)	4.24	3.76		
Morphology	(mean)	7.60	9.95	3.52	<0.01
	(S.D.)	2.78	1.10		
Simple Syntax	(mean)	8.95	10.60	3.74	<0.01
	(S.D.)	1.73	0.94		
Complex Syntax	(mean)	4.85	7.00	3.19	<0.01
	(S.D.)	1.93	2.31		
Semantic Inference	(mean)	5.24	7.00	3.04	<0.01
	(S.D.)	1.52	1.92		

TABLE 21

Means, Standard Deviations and t Tests of the Complexity Measure of Expressive Language and its Subparts (See pages 154-158 for code)

Subpart		Combined Groups	Experim. Group	Control Group	t	p
1	(mean)	96.42	80.20	112.65	5.20	<0.01
	(S.D.)	25.48	14.52	23.82		
2	(mean)	38.57	32.10	45.05	3.18	<0.01
	(S.D.)	14.30	10.17	15.10		
3	(mean)	70.80	60.40	81.20	5.11	<0.01
	(S.D.)	16.51	8.07	16.32		
4	(mean)	6.47	0.35	12.60	-1.61	n.s.
	(S.D.)	12.31	9.63	11.81		
6	(mean)	23.45	22.05	24.85	1.02	n.s.
	(S.D.)	8.69	8.65	8.72		
7	(mean)	16.05	14.85	17.25	0.66	n.s.
	(S.D.)	11.39	10.74	12.16		
8	(mean)	27.40	20.20	34.60	3.76	<0.01
	(S.D.)	14.00	11.34	12.83		
9	(mean)	40.37	27.12	53.62	3.08	<0.01
	(S.D.)	29.99	22.33	31.26		
10	(mean)	79.70	67.00	92.40	4.36	<0.01
	(S.D.)	22.27	16.32	20.29		
11	(mean)	49.50	39.72	59.28	3.85	<0.01
	(S.D.)	18.70	11.55	19.58		
13	(mean)	10.76	7.72	13.80	3.19	<0.01
	(S.D.)	6.69	5.09	6.82		
15	(mean)	0.30	0.48	0.12	-1.44	n.s.*
	(S.D.)	0.80	0.98	0.54		
16	(mean)	3.12	2.12	4.12	1.71	n.s.
	(S.D.)	3.79	2.95	4.31		
17	(mean)	7.22	6.32	8.12	1.49	n.s.
	(S.D.)	3.87	3.33	4.24		
18	(mean)	4.12	4.05	4.20	0.11	n.s.
	(S.D.)	4.36	5.14	3.53		
19	(mean)	3.12	4.20	2.05	-1.91	n.s.
	(S.D.)	3.67	4.74	1.67		
20	(mean)	2.07	1.38	2.76	1.81	n.s.
	(S.D.)	2.47	2.07	2.70		
21	(mean)	3.11	2.19	4.03	1.53	n.s.
	(S.D.)	3.86	2.82	4.56		
22	(mean)	2.05	1.59	2.52	1.28	n.s.
	(S.D.)	2.31	1.84	2.67		

TABLE 21 (cont'd.)

Subpart		Combined Groups	Experim. Group	Control Group	t	p
23	(mean)	0.25	0.00	0.51	2.04	<0.05*
	(S.D.)	0.82	0.00	1.12		
24	(mean)	1.20	0.15	2.25	1.88	n.s.*
	(S.D.)	3.65	0.37	4.99		
25	(mean)	1.85	1.45	2.25	1.20	n.s.
	(S.D.)	2.12	1.70	2.45		
26	(mean)	4.90	2.30	7.50	2.05	n.s.
	(S.D.)	8.34	4.41	10.45		
27	(mean)	0.32	0.30	0.35	0.15	n.s.*
	(S.D.)	1.05	0.66	1.35		
28	(mean)	0.03	0.05	0.00	-1.00	n.s.*
	(S.D.)	0.17	0.25	0.00		
29	(mean)	0.03	0.00	0.06	1.00	n.s.*
	(S.D.)	0.19	0.00	0.27		
30	(mean)	0.13	0.19	0.06	-8.10	n.s.*
	(S.D.)	0.49	0.63	0.29		
32	(mean)	0.01	0.02	0.00	-1.00	n.s.
	(S.D.)	0.08	0.11	0.00		
33	(mean)	2.00	3.40	0.06	-2.70	<0.05*
	(S.D.)	3.53	4.13	2.09		
34	(mean)	9.62	12.50	6.75	-1.56	n.s.
	(S.D.)	11.84	14.19	8.31		
35	(mean)	1.22	1.20	1.25	0.09	n.s.
	(S.D.)	1.66	1.98	1.31		
36	(mean)	0.50	0.32	0.67	1.11	n.s.
	(S.D.)	1.00	0.83	1.14		
37	(mean)	8.76	5.60	11.90	4.03	<0.01
	(S.D.)	5.83	3.47	6.07		
39	(mean)	0.52	0.45	0.60	0.31	n.s.
	(S.D.)	1.50	1.49	1.57		
40	(mean)	0.10	0.20	0.00	-1.00	n.s.
	(S.D.)	0.63	0.89	0.00		
41	(mean)	0.05	0.10	0.00	-1.00	n.s.
	(S.D.)	0.32	0.45	0.00		
44	(mean)	2.10	1.50	2.70	1.00	n.s.
	(S.D.)	3.79	4.19	3.36		
46	(mean)	-0.37	-0.56	-0.19	2.29	<0.05
	(S.D.)	0.54	0.64	0.33		
47	(mean)	-0.09	-0.09	-0.08	0.30	n.s.
	(S.D.)	0.15	0.15	0.16		

TABLE 21 (cont'd.)

Subpart	Combined Groups	Experim. Group	Control Group	t	p
48 (mean)	-0.45	-0.73	-0.18	2.92	<0.01
(S.D.)	0.65	0.78	0.32		
49 (mean)	-0.03	-0.05	-0.02	1.06	n.s.*
(S.D.)	0.09	0.11	0.06		
50 (mean)	-0.02	-0.03	-0.02	0.39	n.s.*
(S.D.)	0.08	0.10	0.06		
51 (mean)	-0.01	-0.03	0.00	1.37	n.s.*
(S.D.)	0.07	0.10	0.00		
52 (mean)	-0.02	-0.02	-0.02	0.25	n.s.*
(S.D.)	0.06	0.06	0.06		
53 (mean)	-0.04	-0.04	-0.04	0.00	n.s.
(S.D.)	0.07	0.09	0.06		
54 (mean)	-0.45	-0.06	-0.02	1.42	n.s.
(S.D.)	0.09	0.11	0.05		
55 (mean)	-0.26	-0.48	-0.03	2.34	<0.05
(S.D.)	0.63	0.85	0.07		
CI (mean)	518.36	425.99	610.73	5.9	<0.01
Total (SD)	135.27	66.06	123.43		

* Very few data for this form: See raw data, Table G, in Appendix.

TABLE 22

Types of Errors* on The Stephens Oral Language Test: Experimental Group

Subject	Para-phrase	Syntactic Error	Semantic Error	Syntactic and Semantic Error
SA	3	5	0	2
MA	2	2	4	0
DA	1	2	5	0
BC	2	3	1	4
KC	3	4	2	0
CD	2	5	1	1
DG	1	4	3	3
RBG	3	2	1	2
GH	2	5	1	1
TL	1	4	1	2
MM	1	4	1	8
JS	1	3	1	1
DS	3	1	5	0
HS	2	3	0	2
TS	2	6	3	0
KS	3	6	1	1
MT	2	2	1	2
VT	4	4	2	3
LV	3	6	0	1
FW	2	8	2	0
Total	43	78	34	33

* numbers represent the number of sentences in which the specific type of error occurred.

TABLE 23

Murphy-Durrell Reading Readiness Analysis
Percentile Scores and Stanines: Experimental Group

Subject	Phonemes Identificat. Total %ile	stanine	Letter Names Total %ile	st.	Learning Rate Total %ile	st.	Total Test %ile	stanine	Quartile
KC	34	4	82	7	84	7	70	6	3
VT	16	3	92	8	42	5	52	5	3
RBG	26	4	62	6	12	3	40	5	2
SA	99	9	89	8	78	7	90	8	4
TL	2	1	62	6	34	4	24	4	1
GH	74	6	89	8	24	4	76	6	4
FW	92	8	82	7	78	7	89	8	4
BC	Retained in Kindergarten; not tested								
JS	18	3	82	7	34	4	38	4	2
DG	84	7	99	9	99	9	96	9	4
HS	89	8	92	8	78	7	89	8	4
DS	89	8	82	7	92	8	90	8	4
TS	89	8	80	7	94	8	90	8	4
CD	99	9	96	9	99	9	98	9	4
MN*	40	5	72	6	42	5	60	6	3
DA	Transferred out of school district; was to have been retained in kindergarten.								
LV	Transferred out of school district								
MA	Transferred out of school district								
MT	66	6	96	9	78	7	84	7	4
KS	70	6	80	7	78	7	80	7	4
Median:	72	6	82	7	78	7	82	7	

* Tested six months later than other children, individually, and over several sessions; in special education class.

TABLE 24

Murphy-Durrell Reading Readiness Analysis
Percentile Scores and Stanines:
Control Group

Subject	Phonemes Identif. Total %ile.	Phonemes Identif. Total Stan.	Letter Names Total %ile.	Letter Names Total Stan.	Learning Rate Total %ile.	Learning Rate Total Stan.	Total Test %ile.	Total Test Stan.	Quartile
AH	92	8	99	9	99	9	98	9	4
AB	99	9	96	9	99	9	98	9	4
JB	99	9	80	7	99	9	94	8	4
HL	84	7	89	8	92	8	90	8	4
LM	50	5	82	7	12	3	62	6	3
JR	99	9	99	9	99	9	99	9	4
CBD	Transferred out of school district.								
LK	76	6	70	6	66	6	76	6	4
MG	80	7	82	7	94	8	89	8	4
MBB	99	9	82	7	99	9	94	8	4
SD	99	9	99	9	92	8	96	9	4
KBC	54	5	82	7	78	7	77	7	4
DE	99	9	96	9	99	9	98	9	4
MB	99	9	89	8	99	9	96	9	4
LG	99	9	99	9	99	9	99	9	4
LBM	99	9	99	9	99	9	99	9	4
DP	99	9	99	9	94	8	98	9	4
RG	Transferred out of school district.								
SH	99	9	82	7	99	9	96	9	4
RZ	38	4	62	6	92	8	64	6	3
Median	99	9	89	8	99	9	96	9	

for learning rate and three for total test. If one adds to these the two untested children who were not placed in first grade because of poor skills, and assuming low scores in every area, the numbers change to eight, eight and five, respectively. In contrast, only one control group score fell at or below the 50th percentile in phoneme identification and one in learning rate. It can also be seen that relatively fewer of the experimental children reached the upper stanines and quartiles of readiness, while most of the controls did. The medians of the percentiles and stanines of the three subtests and the total test for both groups are also displayed in Tables 23 and 24. Even in the absence of t values it is clear that there are substantial differences in their performance, with many EG children promising to develop reading skills less easily than their language proficient peers.

Correlations

Although an attempt has been made to intercorrelate a large number of variables for the purpose of examining possible relationships among them, it is not possible to determine a level of significance for the resulting correlations. The use of procedures for testing the significance level of multiple correlations is predicated on the same measure being used on different population samples, not, as in this study, different measures on the same sample.

Hays (1963) in his argument to this effect states: "One should either not test for significance in the ordinary way or he should interpret the significance levels with CONSIDERABLE latitude" (p. 576). For purposes of prediction he suggests instead the use of a multiple regression technique for which significance levels can be determined, which was in fact utilized in this study for the prediction of ear advantage from combinations of other scores. However, since otherwise, the existence of relationships was being sought, not a prediction of scores, all of the variables were included in the correlation matrix. The prohibition on the computation of a lower limit of significance was observed. Therefore, for purposes of discussion, only the highest (above 0.5) of all the resulting correlations will be commented upon, although the complete matrix is displayed in Tables H and I in the Appendix. The selection of 0.5 as the criterion is arbitrary. The internal correlations of the 48 categories of the CMEL with its own total score will be treated in the same manner.

Measures of Laterality

Simple correlations. Intercorrelations among all of the laterality measures are displayed in Table 25. Note that for the CG no correlations above 0.5 between the REA or AEA and any of the handedness tasks are found. In the EG, however, a correlation of 0.71 ($p<0.01$) exists between

TABLE 25

Simple Correlations Among Laterality Measures

Experimental Group

	Harris	Pegs	Tapping	Cards	Scissors	Grip	Absolute Ear Advantage
Right Ear Advantage	.21	.26	.02	.71	-.05	-.19	-.15
Harris		-.26	.33	.04	.02	.21	-.13
Pegs			-.21	.47	-.02	-.31	-.01
Tapping				.07	-.02	.36	-.01
Cards					.05	-.04	-.31
Scissors						.35	.17
Grip							-.09

Control Group

	Harris	Pegs	Tapping	Cards	Scissors	Grip	Absolute Ear Advantage
Right Ear Advantage	.12	.26	.19	-.19	.10	-.29	.84
Harris		.15	.04	-.45	.47	-.05	.23
Pegs			.63	.27	.10	.16	.31
Tapping				-.05	.18	.18	.22
Cards					-.24	.29	- .07
Scissors						-.17	.03
Grip							-.03

the REA and card dealing. Among the handedness measures themselves, there is only one correlation of note, this being pegs with tapping (0.63, $p < 0.01$ in the CG). The complete simple correlation matrices in the Appendix (Tables H and I) show no substantial correlations between the REA and any other measure except with the AEA in the control group, and only a very few among the six sets of dextrality indices and the other measures. It is a curious fact that although there appear to be relationships between tapping and PIQ and tapping and DLCT in the EG, they are negative.

Stepwise multiple regression. Where generally positive but weak correlations exist, as is true in this sample, it has been discovered that weighting the scores of several variables differentially may predict a dependent variable better than any one of them alone. A stepwise multiple regression method has been used previously for this purpose, with handedness measures combining to better predict ear advantage (Orlando, 1970; Shankweiler and Studdert-Kennedy, 1975); it was therefore applied to the data in this study. When the handedness measures were used as the predicting variables for REA, there were no significant increments above the simple correlation of the first variable used in the equation. It was not possible to use the same procedure with the other measures, since many of the simple correlations were negative.

Intelligence tests. It was of interest to see if the Peabody and the Goodenough IQs were related, especially since their means in each of the two groups are nearly identical and the two groups' means are significantly different from one another on both measures. In neither group was a relationship shown above our arbitrary criterion of 0.5 (see Tables H and I in the Appendix). The highest of the correlations with the Peabody IQ in the EG is with the Developmental Language Comprehension Test. Thus, sentence comprehension as measured by the DLCT links with verbal intelligence. A negative correlation with tapping is shared by both groups although only those of the EG reach the criterion used herein. There are no correlations with GIQ as high as 0.5 in either of the groups.

Language measures. Inspection of Table 26 which displays intercorrelations of the language test reveals that there is only one correlation above 0.5; this is in the EG, between articulation and syntactic complexity. One interesting fact is that the dichotic scores are only weakly correlated with the other tests scores. These generally low correlational values exist in the face of significant differences between groups in all of the measures.

Language with non-language variables. In seeking these relationships, it is found that there are few correlations above 0.5 in either the EG or the CG, with the only one for the EG being DLCT with tapping (-0.65). These

TABLE 26

Simple Correlations Among Language Measures
(Including Right Ear Advantage)

Experimental Group

	SOLST	AS	CMEL	REA
Sentence Comprehension (DLCT)	-.32	-.31	.46	-.02
Sentence Imitation (SOLST)		.17	-.39	-.01
Articulation (AS)			-.53	.40
Syntactic Complexity (CMEL)				-.44

Control Group

	SOLST	AS	CMEL	REA
Sentence Comprehension (DLCT)			-.09	.10
Syntactic Complexity (CMEL)				.02

correlations can be seen in Tables H and I in the Appendix.

Internal correlations of the CMEL. The CMEL has numerous internal correlations with its subparts, some so high as to be able to serve as a screening if a diagnostic analysis is not immediately required. For example, the three categories representing numbers of (1) major grammatical relations, (2) underlying verbs, and (3) nouns not requiring an article, or non-demonstrative, non-possessive pronouns, have correlations with the total CMEL score of 0.95, 0.97, and 0.92 respectively within the combined groups; 0.85, 0.87, and 0.91 respectively in the EG; and 0.93, 0.97, and 0.88 respectively in the CG (Table 27).

Summary of Results

In summary, while differences between the means of the EG and CG are significant on both indices of ear advantage and on most other variables with the important exception of handedness, most correlations, especially with ear advantage, are relatively weak and seldom better than moderate, although they are generally higher in the EG. It can be concluded from this that relative ear advantage is not predictable on the basis of any single measure used in this study with the possible exception of degree of right-handedness for card dealing in the experimental group ($r = 0.71$). Combining hand tasks in a multiple regression procedure was not successful in improving the predictability of dichotic scores.

TABLE 27

Internal Correlations Above 0.5 of The Complexity Measure of Expressive Language, Total Score, With its Subparts

Subpart	Combined Groups	Experimental Group	Control Group
Major Grammatical Relations	.95	.85	.93
Minor Grammatical Relations	.76	.66	.70
No. Verbs per Underlying Sentence	.97	.87	.97
Correct Regular Verb Inflections	.65	below criterion	below criterion
Noun or Non-Demonstr., Non-Possessive Pronoun, No Article.	.92	.91	.88
Noun with Article or With Dem. or Poss. Pronoun	.82	below criterion	.81
Correct Regular Plural	.62	below criterion	below criterion
Correct Irregular Plural	below criterion	below criterion	.69
Contraction of <u>is</u>, <u>will</u>	.50	below criterion	below criterion
Double Expansion of Auxiliary	.55	below criterion	.57
Yes, No Q with Aux. Inversion	below criterion	below criterion	-.63

Notes

1. Limitations on the amount of time permitted with each child prevented establishment of test-retest reliability of the laterality measures. It should be noted that reports in the literature estimate reliability at approximately 0.7 for similar tasks (Orlando, 1970; Arnett, Hudson and Turner, 1974; Blumstein, Goodglass, and Tartter, 1975), although there are few figures given for children as young as those used in the present study. One study which does, is that of Del Polito (1972), who found a dichotic retest reliability of 0.8 for his retarded and normal children. It is agreed that weak lateralizers are more likely to switch sides than strong lateralizers.

2. In the experimental group, M.M. was found to have "soft" signs of neurological impairment subsequent to this testing, and was placed in a special education class in lieu of first grade. B.C. and D.A. performed so poorly in pre-academic areas that they were retained in kindergarten for a second year.

3. Differences between the sexes on nearly all measures were non-significant; therefore only those few which were significant will be mentioned in this chapter. All results by sex are displayed in Table 3.

CHAPTER V. DISCUSSION

Speech and/or Language as Functions Reflected by REA

The results of the dichotic CV syllable task used in this study should rightfully be used only to infer the side of the brain in which the processing and recognition of speech signals occur. However, this inference has been expanded in this study to include the higher level linguistic functions as well; the ear advantage is described herein sometimes as reflecting speech processing and sometimes as reflecting language processing. Two justifications for the interchangeable use of these terms are offered: first, the well known fact, established by the body of knowledge on stroke and aphasia, that language is usually lateralized to the left hemisphere, in combination with studies previously cited which indicate that speech sound processing also occurs on the left side of the brain; second, the fact that the group of children in this study which failed to demonstrate the expected ear advantage for speech processing was also found to score markedly lower on all language measures. These justifications are cited not to suggest the identity of these processes, but in recognition of their interrelatedness.

The Ear Advantage and Concomitant Factors

In the last chapter, an attempt to identify deficits related to the low dichotic scores in the experimental group was described. This consisted of matching subjects across groups on several variables and comparing the dichotic score means for the new subsets (see Tables 8, 9, and 12-15 for the results). As reported, in the case of the Peabody, the difference in ear advantage remained significant between these new groups, but for the Goodenough, while a large numerical difference remained (CG, 11.3%; EG, 1.53%), it missed significance due to the large difference in variances and the small number of subjects matched. As will be recalled, differences in ear advantage across the remaining subsets, except for VMI, were statistically nonsignificant. This is not surprising in the light of the unequal numbers of subjects being compared and the generally small size of the subsets. However, it is important to note that the numerical differences in the REA means are large in each of these cases, ranging from the smallest (9.26%) for the BTBC to 17.95% for the CMEL. These results strongly suggest that the magnitude or direction of the ear advantage is not dependent on whatever abilities are reflected in any of the tests on which the subjects were matched, despite failure to show significant differences in the REA means.

Two possibilities suggest themselves as explanations: either ear advantage, while not associated with any of the skills tested may be linked to one or more other abilities not assessed in this study, or there is a common skill underlying all the language measures which is not represented by a single test. In the latter case, combining linguistic scores might better reflect this difference. The first possibility is a reasonable one because there are some abilities which were not isolated for testing, among them short term memory for nonsense syllables, unrelated word strings or related words. Although the previously cited study by Tobey, et al. failed to find REA differences across groups that differed in these abilities, they could conceivably have contributed to the lowered REA in the population here studied. Also, the selection procedures, which precluded placement of children with articulation errors in the control group, do not permit matching for number and type of articulation errors across groups, two factors which also might be related to ear advantage. Addditionally, although complexity of grammar in the children's expressive language was measured, deviance from developmentally normal syntactic forms was not.

The second hypothesis, which suggests that a lower level of general linguistic ability will be associated with a lower right ear advantage, is not possible to test, given these data, since a number of the language scores are negatively correlated with the dichotic scores in the experimental group. Such a test awaits a study in which enough positive or negative correlations are found with ear advantage to permit the use of a multiple regression equation to determine if such a relationship exists.

Low Correlations

It is recognized that one can not depend on the validity of correlations found among any set of variables unless the measures have been shown to be reliable; test-retest reliability was not assessed in this study. It may be possible to extrapolate the retest reliability coefficients (upwards of 0.7) found by Orlando (1971) for the same dichotic and hand tasks as were here used, but with the caution that Orlando's children were some two to four years older. There is no way, however, of estimating the reliability of many of the other measures, some of which are not standardized, and were being used for the first time. Therefore, the generally weak correlations found may result from low reliability alone. That caveat having been made, other speculations follow.

Nature of the Sentence Repetition Task

The fact that lack of ear asymmetry is associated with low scores in other areas in the experimental group leads one to wonder why performance on at least some of these measures does not covary more predictably with any of the others. A partial answer to this question may lie in the nature of the group placement determinant used, namely, elicited sentence imitation. There is much disagreement as to what actually is evaluated by this task. Bloom (1974) argues with merit that since spontaneous utterances contain motivational aspects that are not present in elicited imitation, the results of the latter cannot be interpreted as representative of the child's true linguistic capabilities. On the other hand, and whatever position one takes in this dispute, it is nevertheless true that this task, perhaps more than most other language assessment tools, reflects all of the different aspects of the utterance, including many facets of motivation, attention and short and long term auditory/linguistic store in individual children. And because of the nature of the task, the elements are largely inseparable. It may be precisely because some children have difficulties in the comprehension of lexical or syntactic elements, others in syntactic complexity of spoken language, still others in cognitive areas that reflect in lowered IQ scores, etc., any of which singly or in combination can lead to poor performance on a sentence imitation task, that weak correlations result among the intragroup scores, and would, even if reliability were high. Good predictability would occur only if there were one or more areas in which most of the children had deficits. This is not the case. It is the very same holistic quality which causes weak correlations with other single language measures that makes sentence imitation such a good screen for language deficiency; it will select children with every kind of linguistic deficit, any of which, it is suspected, can reflect abnormal lateralization.

<u>Unestablished Handedness</u>

The results of most laterality studies show that both handedness and dichotic values are graded rather than being either dichotomous or bilateral. Most investigators, even when they have noted this fact, have not considered it in any depth; Orlando (1971) and Shankweiler and Studdert-Kennedy (1975) have, however, discussed it at some length. The former not only pointed out the continuum that was formed by both sets of variables, but, in addition, found correlations between them of 0.58 to 0.81, depending on how he grouped his normal second and fourth grade right-and left-handed subjects and which handedness tasks he combined as predictors. Shankweiler and Studdert-Kennedy found the same configuration of results in adults, and suggested further that variations in ear and hand scores represent different degrees of hemispheric representation of speech and hand functions in individuals. Their right-handed subjects' dichotic scores correlated with combined hand tasks at a significant 0.54.

The results of the present study bear out the gradedness of scores in both earedness and handedness, but do not duplicate the strength of the correlations found. In the CG, the hand-ear predictability did not reach significance with any single handedness measure or any combination of hand tasks. For the EG there was an r of 0.71 between card dealing and REA. This relatively strong relationship cannot be adequately explained either in the light of the lack of influence which this variable had in the CG or in the light of the nature of the task as compared with the others in the battery.

These generally low correlations between relative hand proficiency and ear preference might occur because handedness is not fully established at kindergarten age.

Additionally, Orlando's comparison of his second and fourth graders indicates a developmental trend towards a reduction in the asymmetry of hand proficiency as well as increased overall skill. Because the subjects in the present study were three to five years younger than his, this factor probably has some bearing on the results.

Unestablished Cerebral Dominance for Language

The arguments for and against development of language lateralization in childhood have been given at some length in chapter II. If it is true that children are not fully lateralized until puberty, this fact alone could account for the weak correlations between the dichotic scores and any of the other measures, especially handedness, in children as young as these.

Mixed Dominance

One of the most intriguing findings in this study is the contralaterality of hand and ear dominance in about half of the language deficient children. The results clearly indicate that the EG contains many children who are essentially bilateral or left-eared, and whose handedness is not merely right, but as strongly right as that of the controls. It has been amply demonstrated in previous studies that in the normal right-handed population, the language processes are usually situated to one degree or another, in the left hemisphere. This is the case in the control group, where eighteen of the twenty right-handed subjects are right-eared, the proportion also found in the general population. However, in the EG, nine of the twenty are left-eared, and one is bilateral, despite all of the subjects being right-handed.

Orton explained mixed dominance as the result either of the mixing of right- and left-dominant genes or of the practice, prevalent in his time, of discouraging left-handedness in young children wherever it appeared. However, there is another possibility for the occurrence of mixed dominance in these subjects, and that is that they have sustained brain damage, causing a shift either in language functions or in handedness. There is a basic difference between these two approaches, although both accept the presumption of mixed dominance. In Orton's view, it is the inability of one hemisphere to suppress the other that is itself the cause of the difficulties in speech, language and learning. In the hypothesis proposed here, it is, instead, the brain damage which causes the deficiencies observed, with the resulting mixed dominance a sign of the underlying neurological impairment.

The first hypothesis within the latter framework is simply that an early lesion in the language areas of the left hemisphere has prevented the normal establishment of language functions there, causing the right hemisphere to assume some of the functions usually residing in the left. Presuming that the motor areas are unaffected, right-handedness develops as usual. The second hypothesis is somewhat more complicated. It suggests that these children were structurally predisposed to be right-brained and left-handed, but that lesions in the right motor cortex interfered with the establishment of left-handedness. Indirect support for the assumption of brain damage in language disordered children can be found in the many successful attempts to equate the linguistic behavior of children who have known neurological impairment with that of others who bear other labels (see chapter II).

In support of the first hypothesis (left brain damage) several of the studies reviewed in the sections on cerebral insult in adults and children in chapter II may be cited. They indicate different degree and/or direction of ear advantage in subjects who have sustained damage to the dominant hemisphere. The left ear advantage in nine members of the experimental group might be interpreted as indicating transfer of language control to the right hemisphere as a result of early left hemisphere injury, or as resulting from a strong lesion effect, which has reversed the natural dominance.

The remaining children in the experimental group, i.e. those who demonstrate right ear advantages, can also be accounted for by the first of the two postulates, which suggests left brain damage in left dominant children, although it is recognized that there is little evidence for this extension of the hypothesis. If taken together, the mean REA for these ten children is 9.8% with a standard deviation of 6.3%. This compares to a mean for the eighteen right-eared controls of 17.1% and a standard deviation of 14.6%. A far greater proportion of the dichotic values of the EG children bordered on bilaterality than did those of the controls (see Appendix, Tables A and B). The argument for lesions in the left language areas of the brain would have to be modified for these children to posit a lesser degree of damage, qualitatively speaking, than in those whose dominance became right-sided, causing only a reduction, not a reversal of the left brain dominance. Support for the occurrence of such a reduction can be found in chapter II in the discussion of cerebral insult in adults, pp. 18 ff. While mixed dominance is not found in these children, their right ear advantage is weaker in relation to their relative right-handedness than is demonstrated in the CG children.

In developing the argument in favor of the second hypothesis (right cortical motor lesions), both genetic predisposition and environmental factors will be invoked as determinants of cerebral development. As we have seen, this is in accord with much of the evidence. As far as environmental factors are concerned, Gazzaniga (1970) claimed that early hand use creates a "neurological climate" in the opposite hemisphere for the further establishment of language functions. It is not necessary to accept his views regarding original equipotentiality of the hemispheres to accommodate his theory of hand use in what is about to be proposed. For the possible role of lesions, we will draw on Semmes'

(1968) ingenious explanation of the development of left-handedness in individuals who are left-brained for language. Semmes explains these individuals as using their left hands initially because of pinpoint lesions in the left cortical motor area which controls the fingers, which served to discourage early use of their right hands. Added to this account is the presumption, as set forth by Geschwind and Levitsky (1968) and Wada et al. (1975), that some structural factor such as the difference in size between left and right temporal lobes found in fetal and infant brains represents a predisposition towards hemispheric specialization, which includes the control of the rapid fine movements made in manual manipulation and movements of the articulators. (See also pages 12 and 13 of this paper for a related discussion of this matter.)

Let us assume for the moment that the children exhibiting mixed dominance in the present study's sample of language deficient children were among those relatively few individuals intended by neural organization of the hemispheres to be right-brained, and therefore left-handed, but were forced to use their right hands because of small lesions of unknown origin in the cortical motor finger area of the right hemisphere which controls their left hands (Semmes' principle, but with the sides reversed). According to Gazzaniga's theory this could cause the left hemisphere, not normally set up for language control in these children, to develop linguistic functions along with the predisposed right hemisphere, because of the stimulation it receives from the use of the right hand. These, then, may be children who were intended by nature to be right-brained for language (and thus left-handed), but whose left hemisphere also received some stimulation for language development due to the early forced use of the right hand. As a result, both sides of the brain share language functions, precluding a clear lead (in Orton's terms) and thereby preventing efficient or normal language (and by extension, cognitive) development. These children do appear to be less lateralized; the mean for those with left ear advantages, including the one zero score is -8%. This explanation could account for the lower group means for the EG, not only for ear advantage, but on all of the dimensions tested, with the exception of handedness. It could also explain the lower manual dexterity scores, despite the same relative manual proficiency.

There is some intriguing evidence for this last hypothesis in the correlation matrices (tables H and I in the Appendix). Although, as reported, there are no correlation coefficients of any variable with ear advantage above 0.5 in either group, a curious tendency is seen in the experimental group which does not occur in the control group: as ear advantage becomes less left-sided and moves into right-earedness, performance on four variables--namely, complexity of expressive syntax (CMEL), intelligence (PPVT IQ), visual motor integration (VMI) and articulation (AS)--worsens.

These r values are respectively: with CMEL, -0.44; with PPVT IQ, -0.32; with VMI, -0.5; with AS (an error score), 0.4. An inspection of articulation type coding in Table A of the Appendix reveals a similar trend, with more errors of both place and manner being made by experimental children with right-ear advantages. In other words, when ear advantage is ranked from strongest left through bilateral through strongest right, correlations with those sets of scores are negative. Although the values are no better than low to moderate, they indicate a trend which bears further investigation. One can interpret these results in the light of the Semmes hypothesis which posits forced use of the right hand in children predisposed to right-brainedness. The more right-brained they remain, i.e., the less the left hemisphere contributes to their language functions, the better these abilities; the more left-brained they become, the greater their difficulty with language and other areas. Supportive of this interpretation is that in examining the performance of the two children in the control group who are left-eared and right-handed, it can be seen that on nearly every measure, their scores are among the lowest in their group (Table B, Appendix). Perhaps the deciding factor as to how much influence the forced use of the right hand will have on the development of language functions in the left hemisphere, is the relative strength of the original predisposition for right hemisphere control. A child who, undamaged, would have demonstrated a large left ear advantage, would be in a better position to resist the shifting of dominance than one whose structurally determined right dominance was weaker to begin with.

It may be of interest that these right-handed language deficient children have approximately the same distribution for the dichotic test results as Orlando's left-handers, while his right-handers are very similar in distribution to the controls. Shankweiler and Studdert-Kennedy (1975) note that a shift to the right occurs in the distribution from their unselected to their right-handed adults, although the variance remains the same. This shift with comparable variances is evident both in Orlando's left- and right-handed groups and in the right-handed language deficient and language proficient children of the present study. The suggestion of a possible cause-effect relationship between a motor finger dysfunction and a disturbance in the normal development of the enormously complex linguistic system may appear to be quixotic, but Semmes points out that Hughlings Jackson has provided the necessary connection in the following simple but provocative statement: "The organ of mind," he wrote, "is only the most complex part of a sensori-motor machine" (Taylor, 1958).

Comparison of Results with Other Studies

It is tempting to compare the results of this dichotic study with those of others, but it has proven to be difficult for several reasons; often the stimuli, the tasks or the samples are not sufficiently alike in the important dimensions to justify comparison. In some studies, insufficient data were given to be able to determine if they were indeed similar. Of the very few dichotic studies on language deficient non-retarded children, only three supply enough data to make even a limited comparison feasible. These are the studies of Sommers and Taylor (1972), Starkey (1974), and Tobey et al. (1975).

The study in which the subjects are most similar to those described herein is that of Sommers and Taylor. The sets of experimental children are nearly identical in age and in differences between groups on most receptive and expressive language measures, including the PPVT, although most of the tasks are different. While both left-and right-handers were used in the Sommers and Taylor study, both groups were equal on the handedness index used. This contrasts with the present study, which utilized only right-handed subjects. Two dichotic listening tasks were administered, one composed of words and one of digits. The results on each were strikingly different. When ear advantage is re-scored for their data, the word test yields values for the experimental and control groups of 25.3% and 41.4% respectively, both strongly right, but with a 16% difference. In sharp contrast, the digits test yields indices of -9.1% for the EG and 59.7% for the controls. This represents a small left ear advantage for digits in the experimental group. Neither of these values compare with those of this study. Moreover, since the stimuli used in the present study were neither words nor digits, but synthetic stop consonant syllables, with the digits in the Sommers and Taylor study presented in sets rather than in single pairs, any comparison between these results might be invalid.

When ear advantage is computed by the same formula, the Starkey study yields dichotic means not very different from those found in this study (EG, -3.9%; CG, 13.3%). Between the means of these four-year-old language disordered children and those of the matched controls, is a gap of 17.2%. The stimuli were simple CVC nouns presented at a higher (90 dB) intensity level than used in this study (81 dB), and the response mode was pointing. But what makes equation of the results impractical is that neither the children's language syndromes nor the selection procedures used for their group assignment is described.

The last study, using children labelled "auditory processing impaired" because of deficits in receptive language, found comparable right-ear dominance for the five experimental children and the five normal controls. Differences did exist, however, in the ability to name both stimuli correctly when two responses were required. The stimuli were natural, not synthetic, CV syllables, and were presented at a lower level of intensity (60 dB) than was used in this study. Testing of receptive language skills revealed a deficit, but except for articulation, spontaneous expressive skills were not assessed. In addition, few of the tests used were the same across the two studies. Although both sets of experimental children were required to repeat sentences, the measures used were not the same. While both experimental groups did less well in sentence imitation than their controls, the preponderance of errors made by the Tobey et al. subjects were paraphrases. Subjects in the present study made errors primarily of a syntactic, but also of a semantic nature. Their experimental children, as do those in this study, place in lower percentiles than the controls in reading tests, but in neither study are these differences tested for significance. Their deficient children were found wanting in short term memory for strings of stimuli; that skill was not tested in this study. Finally, their subjects were an average of three and one-half years older than those in this research. It can be seen that although both sets of experimental children can be characterized as having auditory processing deficits, they may be of a very different nature. Also,the deficits of the children in the present study extend into the areas of verbal expression and to visual motor integration, on which the Tobey et al. children were not assessed. One factor that could be responsible for the difference in the dichotic results of both studies is age; but it is not likely that this is, in fact, the critical variable, since there is only weak evidence in the literature for a lag in the development of lateralization for CV syllables. Even if one wished to make a case for a developmental lag, one is still confronted by the fact that there are too many variables unaccounted for and too many differences in the designs and samples of both studies to be able to draw any valid conclusions from such a comparative analysis.

Despite their differences, results of this and the three studies discussed support the hypothesis that there are differences in the way language deviant and normal children process speech. Whether these differences are in the area of type of error, side of hemispheric dominance, bilaterality or a significantly lowered but still substantial REA, is a question that cannot be settled by comparing studies, mainly because the relatively few samples available for analysis are not homogeneous. It is not inconceivable that different types of language deficits carry with them their own deviant speech processing patterns, and that they will have to be clearly identified as separate before they can be understood.

It may be that the key to the dichotic results of the present study lies within the elicited sentence imitation task itself. Even though we are not certain what it is actually measuring in individual children, it has revealed itself as a sensitive tool for selecting those who show abnormal dichotic values and concomitantly lesser verbal and nonverbal skills.

Language Ability and Reading Readiness

Some time was spent in chapter II justifying the notion that the language disordered and the learning disabled are one and the same. In the latter population are included what Myklebust (1971) would call the auditory dyslexics. In this regard, the reading readiness scores of the subjects in each group are interesting, but not conclusive. Since no statistical treatment of the percentile scores can be done, any comments that will be made are based on individual and median scores only. The Murphy-Durrell Reading Readiness Analysis (1965) yields four separate numerical values, each representing one of the following: identification of phonemes in spoken words, identification of letter names, the rate of learning to recognize written words, and a total score made up of the first three. In two of the three subtests, and in the total score, the experimental children did substantially less well than the controls (see Tables 23 and 24). The total score translates into equivalent percentiles, stanines, and quartiles, and are used to predict the student's readiness to begin formal reading instruction. The manual identifies the quartiles as representing the following: fourth quartile children are ready to begin reading instruction; third and second quartile children will require help to differing degrees in their weak areas before they can benefit from formal reading instruction; first quartile children require intensive training in prereading skills before a reading program is initiated. Sixteen of the eighteen CG children tested fall into the fourth (highest) quartile; the others fall into the third. While ten of the sixteen EG children tested also place in the fourth quartile, two of these border on the third. Three more are in the third quartile, two are in the second, and one is in the first. However, of these last six, all but one did poorly in phoneme identification, which is a task requiring the identification of the two out of four words presented in which a pre-identified phoneme occurs. This skill, the ability to segment sounds from the speech stream, is thought by some researchers to be critical in learning to read (Liberman, 1971; Shankweiler and Liberman, 1972), especially by means of the phonics method used widely today in schools. One might therefore wonder if the total score is a true prediction of reading success. We may recall that there are two additional children not tested in this group who were retained in kindergarten mainly because they were unable to keep up with prereading kindergarten work.

These results add some limited evidence to that which has already been presented in an earlier chapter for a connection between language ability and reading potential. However, despite the trend shown by the EG as a whole to be less ready to learn to read, and in view of the impossibility of testing this trend statistically, it must be remembered that ten of the experimental children still place in the highest quartile for readiness. The reading progress of these children will be followed throughout the next two years. Until such time as this information is available, these results are to be considered inconclusive.

Characterizing the Experimental Group Children

The meaning of the differences that have been shown to exist between these two groups remains to be discussed. Only in the case of the dichotic index can the EG actually be said to have demonstrated values significantly below the norm, because 16% has been found to be the approximate average magnitude of the REA in the normal population for the Haskins syllables, and because the control group in this study evidences a comparable value. Only three standardized tests were used here, and on none of these (the PPVT, Goodenough and VMI test) were either group's means below normal, the first by design. The Boehm Test of Basic Concepts, while standardized for individual items, is not constructed so that one can equate scores with chronological or mental age, only with grade combined with socio-economic levels. Therefore this test was not used for making comparisons with norms in this study, due to the difficulty of assigning children to low, medium and high levels, based on the information known.

As stated previously, the assessment tools used in this study, most of which are not standardized, were intended only for purposes of intergroup comparison, not comparison with a norm. Therefore, it is not possible to state whether the operational definition of language deficiency used in this study, i.e., error scores above 24 on the SOLST, translate in the real world as actual language deficiency. In fact, the early form of the SOLST originally suggested that all children with an error score above 16 be tested. However, in this examiner's clinical judgement, this cutoff was too low for the purposes of this study, as it was likely to screen in too many false positives. This judgement was later proven to be sound, but did not go far enough. The later edition of the SOLST raises the suggested cutoff to 30-35 error points, for the very reasons mentioned.

It is obvious that some children who are indeed language deficient in the clinical sense were screened in by the SOLST. But by choosing an error score as low as 25 for the lower limit, others who were placed in the EG may merely inhabit the lower end of the spectrum of normal language ability, and not have a true language deficit at all. It is this possibility that limits the drawing of conclusions from these results. Nonetheless, the two groups formed by the procedures described do differ in brain organization for speech functions as inferred from dichotic testing, in a variety of linguistic and cognitive abilities, manual dexterity, and reading readiness. Before the reasons for these results can be understood, studies will have to be conducted which use standardized tools within the sentence repetition/dichotic listening paradigm. These will yield a far better understanding of exactly how much and in which dimensions children so selected differ from established norms so that they can be identified as language deficient or language superior with greater certainty. Similar studies using left-handed children could further test the mixed dominance hypothesis. When additional studies of this nature have been carried out, the relationships among hemispheric specialization for speech processing and the higher language functions can be better explicated, perhaps eventually leading to the use of dichotic listening for the determination of mixed dominance in the differential diagnosis of children who do not develop language normally.

CHAPTER VI. SUMMARY

A group of twenty right-handed kindergarten children with language deficiency as defined by an elicited sentence imitation task was examined for hemispheric specialization for speech perception by means of a dichotic listening task using synthetic CV syllables. Their relative handedness was assessed by six measures, one of which determined hand preference, and the other five of which determined relative hand proficiency. Also measured were intelligence, a number of language and nonverbal skills, and reading readiness. Their performance was compared with that of a matched language-superior group. Finally, correlation coefficients were derived for all sets of scores in each group.

The results were that the language deficient children failed to show a group right-ear advantage (0.5%), while their matched controls demonstrated a value in the normal range (14.5%). On an individual basis, nine of the experimental children had left-ear advantages, and one was bilateral, as compared to right-ear advantages in eighteen of the twenty control subjects. Despite this discrepancy, both groups were equally right-handed. The groups also differed significantly on the other variables compared. These were: intelligence on two measures: comprehension of concept words; comprehension of sentences; expressive syntactic complexity; reading readiness; visual motor skill; manual dexterity. There were also striking differences between the groups in birth order. The controls were almost all first-born or only children, while the experimental subjects were almost all middle or last-born. Efforts to account for the difference in the groups' ear advantages by matching scores within each variable and comparing the resulting sets of dichotic means, were unsuccessful. Ear advantages remained widely divergent, suggesting that no single factor tested can be associated with aberrant dichotic results.

A correlational study revealed no r above 0.5 between the dichotic scores and any single variable except card dealing in the experimental group. Combining hand tasks failed to enhance predictability of the ear advantage. In the light of other evidence that handedness covaries with earedness in older children and adults, it is postulated that as yet unestablished handedness in these five-year-old children is responsible for the lack of substantial ear/hand correlations.

The hypothesis that mixed dominance is associated with language and learning deficiency is supported by these results. The mixed dominance itself is hypothesized in this study to have resulted from early brain lesions which have prevented the normal lateralization of speech functions to the left hemisphere in those children predisposed to be left dominant, or which have prevented normal left hand use in those children predisposed to be right dominant. Some very tentative evidence for the latter position can be found in the low but negative correlations between a few of the variables and right-ear advantage in the experimental group, which indicate a trend towards a worsening of these skills as the left-ear effect lessens and the right-ear effect increases.

In summary, young right-handed language deficient children as defined by sentence imitation, have been found to be more likely to be right-hemisphered for speech perception and more likely to score lower on tests of linguistic, intellectual and visual motor ability than their more linguistically able peers. Although they do not differ in degree of right-handedness, their overall manual dexterity tends to be somewhat depressed. They are also far less likely to be only or first-born children. The reading readiness test results suggest that some of these children may become part of the learning disabled population later in their school years. Mixed dominance, such as is found in many of these children, is posited as being a differentially significant symptom of a neurologically based disorder which causes decrements in language and learning ability.

APPENDIX

KEY TO ABBREVIATIONS, TESTS, SCORES AND CODES USED

AEA: An index of absolute ear advantage for CV syllables; same formula as for REA but with sign ignored in resulting index.

AS: articulation score based on Fisher-Logemann Test of Articulation Competence (an error score).

AT: articulation type; 0 = no errors; 1 = place errors only; 2 = place and manner (and/or voicing) errors (an error score).

BO: birth order: 1 = only child; 2 = first child in family of two or three children; 3 = middle child; 4 = last child in family of two or three children; 5 = last child in family of four or more children.

BTBC: Boehm Test of Basic Concepts; comprehension of language concepts.

Cards DI: an index of relative handedness for card stacking; (RH - LH/RH + LH x 100).

CA: chronological age in months at time of administration of the SOLST.

CMEL: Complexity Measure of Expressive Language (Wurtzel, Roth and Cairns). See pages 154 - 158.

DI: a dextrality index for each of the tasks in the handedness battery.

DLCT: Developmental Comprehension Test (Weiner-Mayster); sentence comprehension.

FLTAC: Fisher-Logemann Test of Articulation Competence.

GIQ: IQ based on Goodenough Draw-a-Man Test.

Grip DI: an index of relative handedness for strength of grip; same formula as for cards DI.

Harris: an index of relative handedness on the Harris Test of Lateral Dominance (hand preference items); same formula as for cards DI.

MDRRA: Murphy-Durrell Reading Readiness Analysis.

MDS: a score of manual dexterity (Harris + Pegs + Tapping + Cards + Grip - Scissors).

Occ: Occupational category of breadwinner: 1 = semi-skilled; 2 = trained or skilled manual; 3 = business or sales; 4 = semi-professional; 5 = professional.

Quartile: an ordinal standard score which designates the lower 25%, 50% and 75% of the cases.

Pegs DI: an index of relative handedness for placing Crawford Pegs; same formula as for cards DI.

REA: right ear advantage; also called dichotic index; an index of relative ear advantage for CV syllables (RE - LE/RE + LE x 100). No sign indicates a right-ear advantage; a minus sign indicates a left-ear advantage.

Scissors DI: an index of relative handedness for using scissors; (LH - RH/RH + LH x 100).

SOLST Lang./Artic.: Stephens Oral Language Sentence Test; elicited sentence imitation screening (an error score). See p. 147 for protocols.

Stanine: an interval standard score derived from modification of the z score, where the mean is 50 and the standard deviation is 1.96.

Tap DI: an index of relative handedness for rapid tapping; same formula as for cards DI.

VMI: Developmental Test of Visual-Motor Integration (Beery and Buktenica); score in months of age.

ORDER OF SCREENING AND TESTING PROCEDURES*

Day 1. Screening for handedness; SOLST. (8 minutes)

Day 2. PPVT; DLCT; FLACT; Goodenough Draw-a-Man Test; VMI. (50 minutes)

Day 3. Hearing thresholds at speech frequencies; dichotic listening; handedness battery. (40-50 minutes)

Day 4. Elicitation and taping of spontaneous utterances. (35-45 minutes)

The dichotic and handedness tasks were always done no more than three days before the taping of the spontaneous utterances.

* Prior to preliminary screening, class lists were screened; eliminations were made on the basis of the criteria described elsewhere.

STEPHENS ORAL LANGUAGE SCREENING TEST
TEST FORM

Directions: We're going to play a game. You say just what I say. Let's practice. "Hello." ["Hello."] "I'm fine, thank you." ["I'm fine, thank you."] "Is it raining?" ["Is it raining?"] Good. Let's go on.

If the child says "me, too" to practice item 2 or answers the question in practice item 3, say "Whoops, I caught you. Remember to say exactly what I say" and repeat the practice item. If he continues to answer the question, try "Now you ask me." Get the question repeated before proceeding, if possible.

___		1.	Let's talk together.
___		2.	I like you.
___	/ʃ/	3.	Robert found a shiny penny.
___	/ʃ/	4.	He wants to wash himself.
___	/ɝ/ /r/	5.	Someone burned a hole in the rug.
___	/ð/	6.	Why didn't they tell another story?
___	/v/	7.	She put the cover on the jar very tightly.
___	/z/	8.	There's no reason for fighting with him.
___	/f/	9.	Is Ralph playing a different game?
___	/ɚ/ /r/	10.	After Dad fixed my bike I rode around a lot.
___	/k/	11.	My aunt who fell couldn't walk.
___	/s/	12.	Let him go to the store because we need some milk.
___	/tʃ/	13.	Where will they sing for the children?
___	/tʃ/	14.	If you eat too much candy, you'll be sick.
___	/θ/	15.	We thought the baby knew how to say thank you.
___	/dʒ/	16.	Joe must have bought three oranges.
___	/l/	17.	It's not for me but I would like to look at it.

Clinical Comments:

Number of contexts per sound:

r	s	l	θ	ð	z	ʃ
25	13	17	4	9	5	2

tʃ	f	v	k	dʒ
2	11	3	13	3

Total Articulation Score ______

Total Language Score ______

TOTAL ______

STEPHENS ORAL LANGUAGE SCREENING TEST
SCORING SYSTEM FOR LANGUAGE COMPONENT

0: an exact repetition of the model sentence

1: minor changes--e.g., "cause" for "because;" "the" for "a;" "tight" for "tightly;" etc.; and the special case of "hisself" for "himself."

2: paraphrase which is grammatical and retains the semantics--e.g., "There's no reason to fight with him."; "When you eat too much candy, you get sick,"; "It's not for me but I like to look at it,"; "My aunt that fell couldn't walk.", etc.

3: grammatical but changed in significant ways. "My aunt fell down and she can't walk."; "Robert found a penny."; "Didn't they tell a good story?"; "Let him go to the store cause we want milk and cookies.", etc.

4: ungrammatical but retains essential message. "Joe have must bought three oranges."; "Why didn't they not tell another story?"; "My aunt who falled couldn't walk."

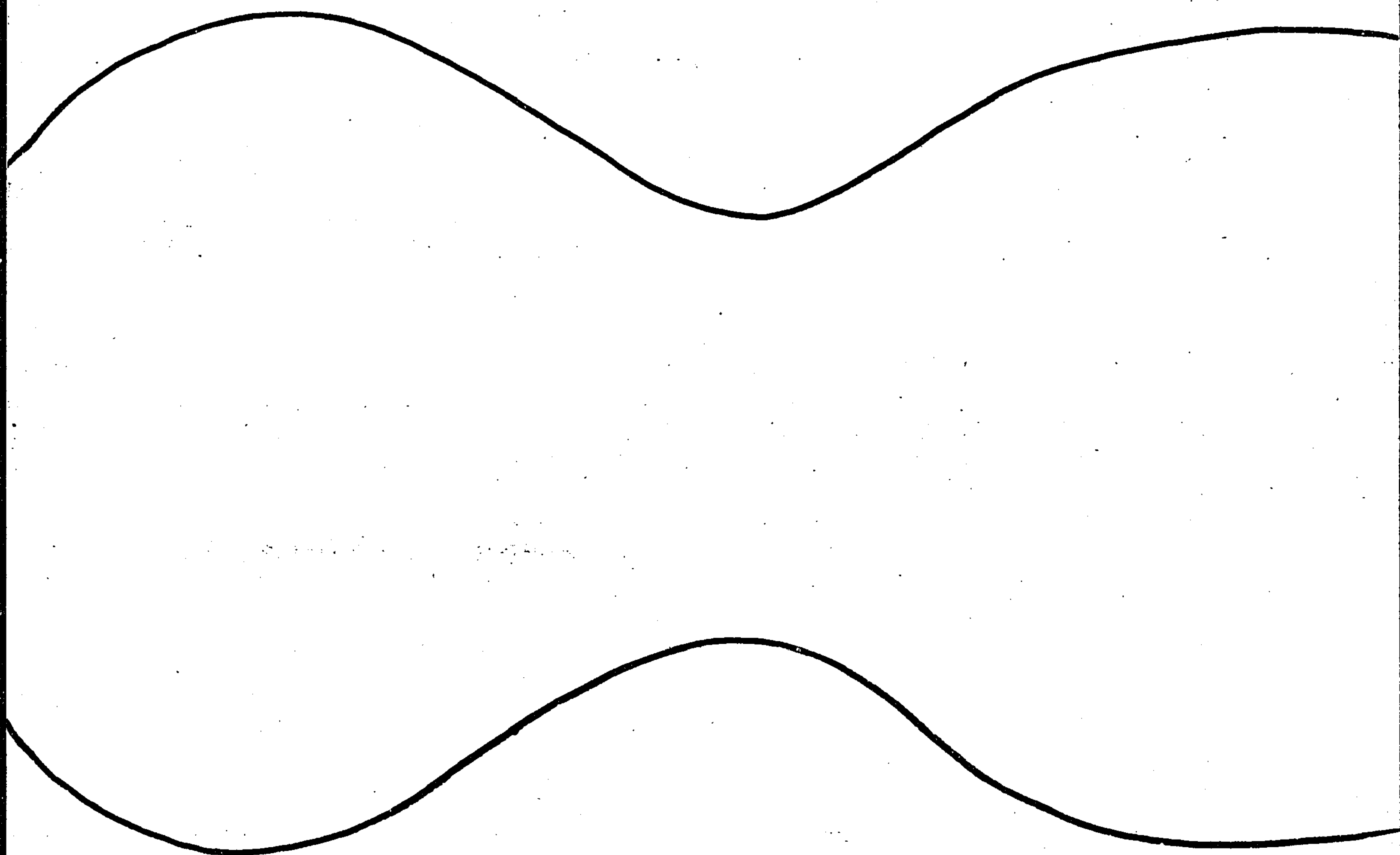
5: sentence is greatly changed and usually reduced considerably; it may be grammatical or ungrammatical--e.g., "I might get to look at it."; "Somebody burned the rug."; "Joe bought oranges."; "Ralph playing game."; "Why tell story."--but an attempt has been made to give some major elements.

6: last few words or first few words; or prosodic features attempted with or without words interjected.

7: unintelligible; no response.

INSTRUCTIONS AND PROTOCOL FOR DICHOTIC TESTING

The tape is introduced as the voice of a robot. "We aren't sure what he's saying--you have to tell us. If you tell us every one, you'll get a present." This resulted in intent interest and listening in all cases. A present of a box of crayons was given at the end of each test. A smile or a short nod was given after each response for numbers 1-10 and 31-40, in each condition, with "You're doing very well" alternating with "You've got them all right," after every ten responses during the longer pauses. Standard and reverse headphone trials were separated by approximately fifteen minutes during which interval handedness was tested.



DIRECTIONS FOR ADMINISTRATION OF HANDEDNESS TESTS

Each task is done by both the right and the left hands, in that order.

<u>Harris Test</u>: Show me how you throw a ball.
Show me how you wind a watch.
Show me how you hammer a nail.
Show me how you brush your teeth.
Show me how you comb your hair.
Show me how you turn a doorknob.
Show me how you hold an eraser.
Show me how you use a pair of scissors.
Show me how you cut with a knife.
Show me how you write with a pencil.

<u>Pegboard</u>: When I say "go," put as many pins as you can into this (pointing) row, starting with the top hole. Work as fast as you can 'till I say "stop." Ready, set, go.

<u>Tapping</u>: When I say "go," try to tap this (pointing) metal plate as many times as you can until I say "stop," Ready, set, go.

<u>Card dealing</u>: When I say "go," I want you to deal out as many cards as you can in a pile with this (pointing) hand. Keep going until I say "stop." Ready, set, go.

<u>Scissors cutting</u>: When I say "go," cut the line on this (pointing) side as well and as quickly as you can. Ready, set, go.

<u>Dynamometer</u>: When I say "go," squeeze this handle as hard as you can with this (pointing) hand, and then let it go fast. Try to squeeze as hard as you can. Ready, set, go.

All handedness tests were administered between the standard and the reverse earphone placement of the dichotic listening task.

DEVELOPMENTAL LANGUAGE COMPREHENSION
TEST SENTENCES

1. The helpful young man paints the big red garage door. (present tense)

2. The hungry woman cuts into the thick juicy steak. (semantic inference)

3. The green dinosaur can't fit through the small cave opening. (negative)

4. The adorable brown dog jumped through the big red ring. (past tense)

5. The mean cruel man shot the small red fox. (semantic inference)

6. The sweet old grandmother was hugged by the pretty little girl. (passive)

7. The furry cats might play with the piece of string. (plural)

8. The boy remembered to write his name in the book. (semantic inference)

9. The bookcase is as low as the table top. (equative)

10. This is a cute little boy's dog. (possessive)

11. The sad man threw the cup against the brick wall. (semantic inference)

12. The duck that the rabbit chases runs into the turtle. (complex syntax--relative)

13. The young brown deer kisses the cute little baby deer. (verb only marked for tense)

14. The chicken pecks at the rooster that the pig sniffs. (complex syntax--relative)

15. This is a tall handsome soldier's boy. (possessive)

16. The careless little boy scratched himself with the sharp pencil point. (reflexive)

17. The big yellow fish is very anxious to eat. (complex syntax--complement)

18. The careless little girl cut herself with the long kitchen knife. (reflexive)

19. The naughty boy spills the milk on the kitchen table. (present tense)

20. The cute little girl is taller than the nice handsome boy. (comparative)

21. The cute little girl is very hard to see. (complex syntax--complement)

22. The naughty little girl gave herself a haircut with the scissors. (reflexibe)

23. The fat happy clown is lots of fun to hit. (complex syntax--complement)

24. The small boy got knocked down by the naughty little girl. (passive)

25. The careless little girl dropped another glass on the floor. (semantic inference)

26. The red clock is higher than the brown picture frame. (comparative)

27. The funny looking man's pen finally ran out of ink. (semantic inference)

28. The tall skinny boy is very unwilling to kick. (complex syntax--complement)

29. The curly white sheep jumps over the wooden fence. (verb only marked for number)

30. The monkey that jumps over the frog falls on the elephant. (complex syntax--relative)

31. The naughty little boy busted the new toy yellow airplane. (past tense)

32. The sweet little girl wrote her name again on the blackboard. (semantic inference)

33. The small young boy is still shovelling the white snow. (semantic inference)

34. This is a nice young mother's cat. (possessive)

35. The spoiled little boy didn't like his tasteless lunch. (negative)

36. This is a cute little girl's doll. (possessive)

DLCT SENTENCES (cont'd.)

37. The big kind policeman got stopped by the little lost boy. (passive)

38. The naughty little girl blew out the big wooden match. (semantic inference)

39. The clumsy young boy slipped on the shiny waxed floor. (semantic inference)

40. The cute little boy was tripped by the naughty little girl. (passive)

41. The kind grandfather is as short as the sweet grandmother. (equative)

42. The cute little girl didn't tune in the television set. (negative)

43. The helpful little boy washed himself with a washcloth and soap. (reflexive)

44. The sweet teenager colored the picture of the tree. (semantic inference)

45. The silly young boy tried to break the long stick. (semantic inference)

46. The big lion can't jump through the trainer's red ring. (negative)

47. The tired owls might fall from the tall tree branch. (plural)

48. The dog stands on the rabbit that bites the pig. (complex syntax--relative)

Scoring for Wurtzel et. al. Measure of Expressive Language

STEP	VALUE
Grammatical Relations:	
1. Major grammatical relations: S-V; V-O.	1.0
2. Minor grammatical relations: any modifier except possessive and demonstrative.	0.5
3. Underlying sentence represented by verb.	1.0
4. Conjunctives, connectives.	0.5
Verb:	
5. No main verb.	0.0
6. Infinitive, imperative.	1.0
7. -ing, overregularization of past tense.	1.5
8. Correct inflection of regular verb in any tense.	2.0
9. Correct irregular verb inflection.	2.5
Noun:	
10. Noun only, or pronoun only.	1.0
11. Article or demonstrative or possessive pronoun with noun.	1.2
Plural:	
12. No plural morpheme where one is indicated.	0.0
13. Correct phonological realization of regular plural.	1.5
14. Correct voicing of final stem fricatives: wolves, etc.	2.3
15. Doubly marked plural: childrens, feets, etc.	2.4
16. Correctly marked irregular plural: children, etc.	2.5
Auxiliary:	
17. Contraction of "is," "are," "will," etc.	0.5
18. Use of "is," "am," "are."	1.0
19. Concatenation: gonna, lemme, etc.	1.0
20. Modals: can, do, got to, get to, will, may, etc.	1.2
21. Subjective modals: could, would, should, supposed to, better, ought to, etc.	1.3
22. Shall, must, has to, used to, etc.	1.4
23. Perfective: "has ----en."	3.6
24. Double expansion of the auxiliary: has been, might have, etc.	5.0

Sentence Types:

25.	Yes, no, question; rising pitch.	1.0
26.	Yes, no question; with auxiliary inversion.	5.0
	Wh- and utterance, but no verb, except two-word utterance such as "Where go?"	
27.	what--	1.0
28.	who and where--	1.1
29.	how	1.2
30.	why	1.3
31.	when	1.4
32.	Wh- word alone.	0.5
33.	Wh- and affirmative sentence including verb: "Where boy is?".	3.0
34.	Wh- and inversion of auxiliary.	5.0

Negative:

35.	"No" alone, "No" + utterance, respectively.	0.5, 1.0
36.	Negative imbedded in utterance; no auxiliary: "They not going," etc.	1.5
37.	Unified auxiliary and negative: can't, don't, ain't, etc.	2.0
38.	(Not used)	
39.	Negative and well formed auxiliary: "They are not going," etc.	3.0

Passive:

40.	Truncated passive: X got hit, etc.	2.0
41.	Truncated passive: X was hit, etc.	3.0
42.	X got hit by Y.	4.0
43.	X was hit by Y.	5.0
44.	Indirect object movement: "I gave the girl the ball."	3.0
45.	(Not used.)	

Negative scores:

46.	Improper tense inflection.	-0.2
47.	Incorrectly inflected auxiliary.	-0.2
48.	Omission of aux., wrong aux., improper insertion of aux.	-0.2
49.	Omission of or incorrect complementizer.	-0.2

50.	Omission of conjunction.	-0.2
51.	Incorrect word order of modifiers.	-0.2
52.	Non-agreement within N.P.	-0.2
53.	Omission of or wrong article.	-0.1
54	Omission of other functors and posssessive morpheme.	-0.1
55.	Incorrect case, modifier, preposition; omission of pronoun, plural morpheme.	-0.2

The above scoring has been slightly modified from the experimental scoring schedule suggested by the authors of this metric. These modifications consist mainly of additions to categories, and in one case, the omission of one category entirely (credit for early use of modals before the unified aux. and neg. have been developed). See scoring protocols for clarification of certain scoring decisions made.

Protocols for Scoring Complexity Measure of Expressive Language

1. 50 consecutive utterances are selected from a 30-45 minute taped play session. Stimuli are a play city with movable parts, pictures, a felt board set up for the story of the Three Bears, bubbles, toy telephones, supermarket.

2. An utterance is considered complete at:
   a. terminal fall
   b. no terminal fall, but a pause followed by a statement about something else.
   c. statement by examiner terminating child's utterance.

3. Spontaneous fragments of any length are scored as an utterance.

4. Under three word answers to, or completions of examiner's WH- questions or other statements are omitted from the scoreable corpus.

5. Utterances which are incomplete in the transcript because of an unintelligible section are not scored.

6. Run-on sentences with or without conjunctions are considered a single utterance until terminal fall or 2b and 2c.

7. Insofar as it is possible, the section to be scored is chosen from any section of the tape in order to include the most complex and spontaneous utterances.

8. Repeated utterances, even if separated from each other by other sentences, are only scored once.

9. "Now, well, oh, hey," etc. are not scored if they appear as utterance starters.

10. Fragments are not scored if followed immediately by a complete utterance: Ex.: "Now these go --- these should go here." In this case only the last four words are scored.

11. "don't, can't, won't" scored as two points on step 37. But "doesn't, wasn't" etc. scored on step 37 PLUS credit for step 9. Similar scoring for "couldn't, wouldn't," etc.

12. Steps 8 and 9 are taken to mean correct inflection of verbs; no judgement of correct tense usage is made.

13. "No" said spontaneously as a phrase in itself or as part of another utterance, is scored 0.5 on step 35.

14. "Yeah" or "yes" as above scored 0.5 on step 2.

15. "They wanna go" is credited as one verb on step 3, a concatenation on step 19, and an infinitive on step 6.

16. "They want him to go" is credited as two verbs on step 3, an inflected verb on step 8 and an infinitive on step 6.

17. "Where is he?" is credited as one grammatical relation on step 1.

18. "goes" is credited as a regular verb on step 8, "does" as an irregular verb on step 9.

19. Nouns with articles are scored on step 11 like nouns with possessives and demonstratives. Nouns without articles are scored on step 10.

20. All instances of "can" are scored on step 20, not on step 38.

21. Pronouns such as "this," "that," "these" are credited on step 10, but if demonstrative followed by a noun, on step 11.

22. "there" is scored on step 2 if it is used locatively, "There's the boy" or "He's over there," but is scored on step 1 if it means "there exists" such as in the statement, "there were three bears."

23. On the other hand, "here" is locative, and as such is scored on step 2.

24. For all cases of "here" and "there" credit is also given for a noun on step 10.

25. In the statement, "There's no fire" or "It's not," the negative is treated as a modifier and credited on step 2. However, in a verbless fragment, it is also credited on step 36.

TABLE A

Rank by Right Ear Advantage	Subject	Sex	Sentence Imit. (SOLST) Lang./Artic. **	Right Ear Advant./ Absolute Ear Advant. *	Harris Dextrality Index *	Pegs Dextrality Index *	Tapping Dextrality Index *	Card Dealing Dextrality Index *	Scissors Cutting Dextrality Index *	Strength of Grip Dextrality Index *	Manual Dexterity (MDS) *	Sentence Comprehension (DLCT)	Syntactic Complexity (CMEL)	No. Artic. Errors/ Artic. Error Type *	Comprehension of Basic Concepts (BTBC)	Reading Readiness (MDRRA) Total	Visual-Motor Skill (VMI)	Peabody IQ (PIQ)	Goodenough IQ (GIQ)	Birth Order *	Age	Family Occupation Level *
1	KC	F	28	22.58	80	- 4.9	10.7	14.3	53.8	1.23	327.5	24	365.9	64/2	23	70	52	91	84	4	73	1
2	VT	F	42	15.79	100	10.0	2.7	25.0	61.6	3.40	310.5	27	408.3	3/1	30	52	59	97	95	4	66	3
3	RBG	M	28	15.07	100	4.0	10.8	13.3	0.0	7.80	342.0	22	420.3	8/2	24	40	57	104	168	1	65	2
4	SA	F	27	10.34	80	13.3	9.2	25.9	36.1	8.40	305.5	31	504.0	0/0	35	90	66	104	105	4	68	2
5	TL	F	30	9.37	80	17.6	6.5	45.4	49.2	0.00	240.0	29	456.8	7/2	23	24	49	104	88	5	68	3
6	GH	M	28	8.89	80	0.0	5.2	21.7	48.9	6.40	306.0	30	338.3	44/2	42	76	72	115	100	4	69	1
7	FW	M	44	5.15	100	7.7	-2.4	20.0	62.2	3.10	254.0	30	402.7	5/2	34	89	67	130	109	1	66	2
8	BC	F	35	3.90	100	7.1	11.8	0.0	30.4	7.40	285.0	22	365.1	5/1	24	***	63	90	110	3	65	3
9	JS	M	26	3.61	80	12.7	15.1	47.4	52.0	8.80	248.0	24	350.9	24/2	37	38	67	95	96	4	62	3
10	DG	M	36	3.53	40	10.7	-7.9	22.2	44.3	0.00	287.0	33	424.3	13/2	33	96	66	117	125	4	64	3
11	HS	F	25	0.00	100	1.6	8.9	9.1	37.9	0.00	333.0	24	442.5	25/2	31	89	70	117	150	5	70	2
12	DS	F	27	-2.22	100	1.5	7.5	-18.2	61.3	3.20	285.5	26	494.0	0/0	34	90	66	100	130	3	67	3
13	TS	F	39	-2.70	60	5.4	10.5	25.9	25.9	8.20	393.0	24	408.7	4/2	41	90	66	95	112	5	71	2
14	CD	M	31	-4.44	80	- 5.1	4.9	0.0	10.5	6.90	295.5	34	445.1	0/0	32	98	67	108	104	5	72	5
15	MM	M	71	-6.45	60	0.0	8.5	-16.7	42.5	8.00	245.0	18	333.8	38/2	17	60	63	97	83	4	69	2
16	DA	M	25	-7.05	100	-14.3	16.1	0.0	63.3	7.90	328.0	24	353.7	0/0	20	***	57	106	85	4	70	2
17	LV	F	29	-8.51	100	- 8.5	9.7	4.0	43.6	18.60	282.5	21	436.6	13/2	***	***	63	91	83	3	70	4
18	MA	M	27	-9.30	100	0.0	0.4	-10.0	25.0	10.60	322.0	28	477.9	1/1	35	***	67	110	104	1	72	2
19	MT	M	25	-17.14	80	7.9	2.5	-25.0	24.4	5.40	342.5	30	588.5	7/2	39	84	82	110	109	4	70	3
20	KS	F	31	-30.43	80	4.2	7.4	-30.8	6.7	2.10	334.0	28	502.4	0/0	30	80	66	125	112	3	72	5

Experimental Group Scores for All Measures

* See page .

** Articulation scores on the SOLST were irrelevant to experimental group placement. See AS above for articulation scores on the FLTAC.

*** Test not taken.

1. Possible lead poisoning at age two; info made available to tester one year after testing.
2. Had fall at age 18 mos., hematoma over right temporal lobe; no fracture or neurological signs at the time. Soft signs reported to investigator one year after testing.
3. Life-threatening fructose intolerance in infancy caused long hospitalization. Information made available to investigator one year after testing.

TABLE B

Rank by Right Ear Advantage	Subject	Sex	Sentence Imitation (SOLST) Lang./Artic.	Right Ear Advant./ Absolute Ear Advant.	Harris Dextrality Index *	Pegs Dextrality Index *	Tapping Dextrality Index *	Card Dealing Dextrality Index *	Scissors Cutting Dextrality Index *	Strength of Grip Dextrality Index *	Manual Dexterity (MDS) *	Sentence Comprehension (DLCT)	Syntactic Complexity (CMEL)	No. Artic. Errors/ Artic. Error Types *	Comprehension of Basic Concepts (BTBC)	Reading Readiness (MDRRA) Total	Visual-Motor Skill (VMI)	Peabody IQ (PIQ)	Goodenough IQ (GIQ)	Birth Order *	Age	Family Occupation Level *
1	AH	M	0/0	35.80	100	3.1	3.9	-10.0	42.3	2.3	378.5	37	622.5	12/2	45	98	74	119	97	4	68	5
2	AB	M	2/2	35.42	100	19.3	7.0	20.0	53.3	0.0	375.0	40	489.3	0/0	42	98	88	115	126	4	71	3
3	JB	M	1/0	34.94	100	0.0	4.5	4.8	56.9	0.9	363.5	35	820.3	0/0	43	94	88	132	107	2	73	5
4	HL	F	1/0	31.70	60	10.1	9.2	25.0	13.1	0.0	320.0	31	522.2	0/0	43	90	66	108	141	2	66	4
5	LM	F	1/0	29.67	100	13.8	23.6	-12.5	45.4	5.1	291.0	33	550.7	0/0	34	62	74	91	101	1	68	2
6	JR	F	0/0	20.45	100	-6.0	1.7	- 4.8	50.0	- 1.0	371.5	34	716.8	0/0	45	99	86	123	125	2	74	5
7	CBD	F	2/1	19.54	100	13.8	11.2	5.9	63.0	15.5	256.0	31	581.9	0/0	40	**	79	112	131	2	67	3
8	LK	F	1/0	14.28	100	9.1	11.2	5.3	56.2	6.7	298.5	41	546.9	0/0	42	76	66	121	118	1	72	5
9	MG	F	2/0	13.89	80	6.2	5.0	31.0	27.3	4.9	380.0	35	422.1	0/0	41	89	63	115	118	4	71	3
10	MBB	M	0/0	13.33	100	5.9	0.7	- 3.7	9.4	6.2	363.5	38	644.4	0/0	43	94	82	121	119	2	72	5
11	SD	F	1/0	11.63	100	6.9	7.2	-21.7	61.5	-16.4	283.5	32	593.7	2/1	41	96	70	140	134	2	67	2
12	KBC	M	2/0	11.11	100	12.2	16.8	- 5.3	44.0	7.8	357.5	34	524.2	0/0	46	77	77	123	108	2	74	3
13	DE	M	0/1	9.86	80	8.2	2.0	20.0	31.4	10.1	362.5	35	797.5	1/1	48	98	86	121	137	2	74	5
14	MB	M	1/1	9.09	100	-1.7	-1.2	-16.7	45.0	- 4.0	295.5	35	499.8	0/0	42	96	77	125	125	1	67	4
15	LG	F	0/0	5.49	60	6.1	10.0	25.0	60.6	5.1	270.5	35	653.8	1/1	44	99	83	123	136	2	68	3
16	LEM	F	1/0	4.76	100	2.9	4.7	-15.4	62.7	5.5	376.0	43	667.5	0/0	48	99	79	138	132	2	70	3
17	DP	M	0/0	4.44	60	-7.5	2.2	- 5.3	20.9	7.2	371.5	36	819.1	0/0	45	98	82	115	152	4	75	4
18	RG	F	0/0	2.44	100	3.6	2.6	29.4	60.6	0.0	309.0	26	775.3	0/0	36	**	59	121	110	4	68	1
19	SH	M	1/0	- 1.45	80	6.9	8.0	25.0	20.8	8.1	322.5	34	442.5	0/0	34	96	67	110	100	2	69	1
20	RZ	M	1/0	-16.45	100	5.4	6.3	20.0	33.3	20.0	298.5	34	524.2	0/0	42	64	77	123	108	1	64	2

<u>Control Group Scores for All Measures</u>

* See Appendix, page .

** Test not taken.

TABLE C

Experimental Group Dichotic Raw Scores in Standard and Reversed Earphone Conditions

Subject	# Correct: Rt. Ear Standard	# Correct: Left Ear Standard	Errors: Standard	# Correct: Right Ear Reversed	# Correct: Left Ear Reversed	Errors: Reversed	# Correct: Right Ear Total	# Correct: Left Ear Total	Errors: Total
KC	19	13	28	19	11	30	38	24	58
VT	21	18	21	23	14	23	44	32	44
RBG	20	15	25	22	16	22	42	31	47
SA	22	20	18	26	19	15	48	39	33
TL	18	15	27	17	14	29	35	29	56
GH	29	19	12	20	22	18	49	41	30
FW	26	23	11	25	23	12	51	46	23
BC	20	23	17	20	14	26	40	37	43
JS	22	20	18	21	20	19	43	40	37
DG	21	21	18	23	20	17	44	41	35
HS	19	24	17	25	20	15	44	44	32
DS	22	22	16	22	24	14	44	46	30
TS	19	21	20	17	17	26	36	38	46
CD	22	23	15	21	24	15	43	47	30
MM	17	18	25	12	15	33	29	33	58
DA	19	21	20	18	22	20	37	43	40
LV	23	25	12	20	26	14	43	51	26
MA	23	22	15	16	25	19	39	47	34
MT	15	21	24	14	20	26	29	41	50
KS	15	29	16	17	31	28	32	60	28

TABLE D

Control Group Dichotic Raw Scores in Standard and Reversed Earphone Conditions

Subject	# Correct: Right Ear Standard	# Correct: Left Ear Standard	Errors: Standard	# Correct: Right Ear Reversed	# Correct: Left Ear Reversed	Errors: Reversed	# Correct: Right Ear Total	# Correct: Left Ear Total	Errors: Total
AH	24	12	24	31	14	15	55	26	39
AB	26	19	15	39	12	9	65	31	24
JB	27	13	20	29	14	17	56	27	37
HL	26	15	19	28	13	19	54	28	38
LM	28	16	16	31	16	13	59	32	29
JR	27	17	16	26	18	16	53	35	32
CBD	27	20	13	25	15	18	52	35	31
LK	24	18	18	24	18	18	48	36	36
MG	19	14	27	22	17	21	41	31	48
MBB	26	18	16	25	21	14	51	39	30
SD	22	17	21	26	21	13	48	38	34
KBC	26	22	12	29	22	9	55	44	21
DE	22	15	23	17	17	26	39	32	49
MB	29	20	11	25	25	10	54	45	21
LG	26	22	12	22	20	17	48	43	29
LBM	22	18	20	22	22	16	44	40	36
DP	23	21	16	24	22	14	47	43	30
RG	25	21	14	17	19	24	42	40	38
SH	18	17	25	16	18	26	34	35	51
RZ	16	25	19	17	21	22	33	46	41

TABLE E

Handedness Raw Scores: Experimental Group

Subject	Harris Rt.	Harris Lf.	Pegs Rt.	Pegs Lf.	Tapping Rt.	Tapping Lf.	Cards Rt.	Cards Lf.	Scissors Rt.	Scissors Lf.	Grip Rt.	Grip Lf.
KC	9	1	29	32	138	121	12	9	15	50	20.5	20.0
VT	10	0	33	27	140	123	20	12	19	80	23.0	21.5
RBG	10	0	26	24	124	97	17	13	10	10	27.5	23.5
SA	9	1	36	24	124	103	17	10	23	49	29.0	24.5
TL	9	1	30	21	107	94	8	3	18	53	19.0	19.0
GH	9	1	31	31	111	100	14	9	12	35	25.0	22.0
FW	10	0	28	24	102	107	9	6	14	60	16.5	15.5
BC	10	0	30	26	123	97	9	9	16	30	14.5	12.5
JS	9	1	31	24	118	87	14	5	18	57	18.5	15.5
DG	7	3	31	25	104	122	11	7	17	44	19.0	19.0
HS	10	0	32	31	140	117	12	10	18	40	19.5	19.5
DS	10	0	34	33	114	98	9	13	12	50	24.0	22.5
TS	8	2	29	26	141	114	17	10	10	17	39.5	33.5
CD	9	1	28	31	97	88	7	7	17	21	35.0	30.5
MM	8	2	22	22	121	102	5	7	27	67	27.0	23.0
DA	10	0	15	20	115	83	3	3	9	40	20.5	17.5
LV	10	0	27	32	130	107	13	12	22	56	17.5	12.0
MA	10	0	31	31	120	119	9	11	21	35	26.0	21.0
MT	9	1	34	29	124	118	9	15	17	28	24.5	22.0
KS	8	2	37	34	130	112	9	17	12	60	24.0	23.0

TABLE F

Handedness Raw Scores: Control Group

Subject	Harris Rt.	Harris Lf.	Pegs Rt.	Pegs Lf.	Tapping Rt.	Tapping Lf.	Cards Rt.	Cards Lf.	Scissors Rt.	Scissors Lf.	Grip Rt.	Grip Lf.
AH	10	0	33	31	144	133	9	11	17	42	34.0	32.5
AB	10	0	34	23	140	123	12	8	7	23	27.5	27.5
JB	10	0	35	35	140	128	11	10	11	40	23.0	22.5
HL	8	2	38	31	136	113	15	9	33	43	22.0	22.0
LM	10	0	33	25	131	81	7	9	12	32	20.5	18.5
JR	10	0	39	44	146	141	10	11	20	60	25.0	25.5
CBD	10	0	33	25	114	91	9	8	17	75	33.5	24.5
LK	10	0	30	25	134	107	10	9	14	50	20.0	17.5
MG	9	1	34	30	147	133	19	10	16	28	21.5	19.5
MBB	10	0	36	32	134	132	13	14	29	35	30.0	26.5
SD	10	0	31	27	127	110	9	14	15	63	14.0	19.5
KBC	10	0	46	36	125	89	9	10	7	18	31.0	26.5
DE	9	1	33	28	149	143	3	2	24	46	35.5	29.0
MB	10	0	28	29	122	125	10	14	22	58	18.0	19.5
LG	8	2	35	31	137	112	15	9	25	102	25.5	23.0
LBM	10	0	35	33	145	132	11	15	11	48	28.5	25.5
DP	8	2	31	36	138	132	9	10	17	26	26.0	22.5
RG	10	0	29	27	120	114	11	6	13	53	29.0	29.0
SH	9	1	31	27	114	97	15	9	19	29	36.5	31.0
RZ	10	0	29	26	135	119	6	4	21	42	19.5	13.0

TABLE G

Raw Scores: Subparts and Total Score of Complexity Measure of Expressive Language
(See Pages 154 - 158 for key)

	ID	1	2	3	4	6	7	8	9	10	11	13	15	16	17	18	19	20	21	22	23	24
KC	1	63	28.0	52	3.5	25	10.5	22	27.5	51	40.8	10.5	0.0	10.0	3.5	1	8	0.0	1.3	0.0	0.0	0
VT	2	84	35.5	53	3.5	21	6.0	22	35.0	69	43.2	13.5	2.4	0.0	3.5	0	2	0.0	0.0	0.0	0.0	0
RBG	3	82	19.0	59	3.5	29	15.0	14	27.5	64	39.8	4.5	0.0	0.0	11.0	2	8	2.4	0.0	0.0	0.0	0
SA	4	91	46.5	74	7.0	49	7.5	10	2.5	89	45.6	6.0	0.0	0.0	7.5	4	18	3.0	2.6	0.0	0.0	0
TL	5	98	23.0	61	11.0	14	0.0	20	10.0	73	38.4	7.5	0.0	2.5	6.0	23	1	4.8	0.0	1.4	0.0	0
GH	6	66	29.0	53	0.0	20	13.5	14	10.0	42	39.6	0.0	2.4	7.5	5.0	7	7	0.0	2.6	0.0	0.0	0
FW	7	73	23.0	61	7.0	21	30.0	15	15.0	44	58.8	7.5	2.4	2.5	40.0	9	0	0.0	0.0	0.0	0.0	0
BC	8	63	28.0	56	2.5	27	18.0	4	22.5	55	24.0	6.0	0.0	0.0	7.0	3	8	6.0	1.3	0.0	0.0	0
JS	9	65	30.0	49	3.0	21	4.5	30	25.0	59	21.6	1.5	0.0	2.5	0.5	0	2	2.4	3.9	1.4	0.0	0
DG	10	83	32.0	66	7.0	13	39.0	14	35.0	63	34.6	13.5	0.0	0.0	8.0	3	1	2.4	1.3	1.4	0.0	0
HS	11	67	45.5	64	52.5	12	10.5	16	90.0	67	32.4	4.5	0.0	0.0	3.5	1	0	0.0	2.6	2.8	0.0	0
LV	12	87	23.5	55	4.0	16	16.0	32	20.0	64	32.4	9.0	0.0	2.5	4.5	3	1	1.2	0.0	2.8	0.0	1
DS	13	87	41.0	76	6.5	27	10.5	16	60.0	88	33.6	4.5	2.4	5.0	9.5	2	0	0.0	10.1	2.8	0.0	0
TS	14	78	27.0	57	7.0	31	16.5	12	20.0	68	43.2	10.5	0.0	0.0	0.5	7	0	0.0	0.0	5.2	0.0	0
CD	15	78	34.5	62	4.5	15	13.5	16	72.5	70	39.6	21.0	0.0	0.0	6.5	0	1	0.0	0.0	0.0	0.0	0
MM	16	78	10.5	55	4.0	17	33.0	10	10.0	52	34.8	3.0	0.0	5.0	8.5	5	3	0.0	1.3	0.0	0.0	1
DA	17	55	32.0	52	1.5	24	5.0	19	7.5	57	22.8	1.5	0.0	0.0	7.5	2	9	2.4	5.2	4.2	0.0	0
MA	18	94	49.5	6	11.0	22	3.0	50	2.5	82	50.4	7.5	0.0	0.0	6.5	2	7	0.0	7.8	1.4	0.0	0
MT	19	110	45.5	77	13.5	26	13.5	44	35.0	110	50.4	13.5	0.0	0.0	10.0	1	8	0.0	3.9	5.6	0.0	0
KS	20	102	39.0	67	9.0	11	31.5	24	25.0	73	68.4	9.0	0.0	5.0	13.5	6	0	0.0	0.0	2.8	0.0	1
AH	21	106	54.5	88	25.0	14	9.0	26	130.0	88	39.6	12.0	0.0	0.0	6.0	0	0	0.0	0.0	0.0	0.0	0
AB	22	91	41.5	61	3.5	15	4.5	22	80.0	73	44.4	9.0	0.0	0.0	1.5	4	2	4.8	1.3	0.0	0.0	0
JB	23	143	80.0	107	21.0	28	21.0	68	57.5	132	84.0	24.0	0.0	10.0	7.0	2	0	8.4	7.8	2.8	0.0	20
HL	24	99	33.0	69	10.0	20	7.5	48	47.5	89	39.6	12.0	0.0	7.5	3.5	1	3	0.0	2.6	5.6	0.0	0
LM	25	97	31.0	71	7.5	36	4.5	22	35.0	81	49.2	10.5	0.0	0.0	6.5	6	4	9.6	3.9	1.4	0.0	0
JR	26	130	32.0	90	16.5	28	36.0	32	25.0	114	74.4	18.0	0.0	7.5	16.5	9	0	2.4	6.5	5.6	0.0	0
CBD	27	104	53.0	81	17.0	24	15.0	60	50.0	76	60.0	13.5	0.0	2.5	8.0	2	0	1.2	1.3	2.8	0.0	0
LK	28	96	37.0	73	7.0	39	18.0	18	22.5	93	37.2	0.0	0.0	0.0	3.5	6	4	3.6	20.8	0.0	0.0	0
MG	29	71	24.5	60	1.0	24	45.0	20	40.0	59	31.2	6.0	0.0	0.0	6.0	4	1	1.2	2.6	1.4	0.0	0
MBB	30	122	55.5	82	9.5	38	6.0	30	32.5	102	61.2	22.5	0.0	2.5	11.0	2	5	3.6	6.5	4.2	0.0	10
SD	31	107	43.5	78	11.5	20	24.0	36	62.5	95	48.0	27.0	0.0	5.0	6.0	0	1	0.0	3.9	0.0	0.0	0
KBC	32	100	36.0	71	9.0	32	0.0	40	22.5	88	43.2	13.5	2.4	0.0	9.0	3	3	4.8	7.8	2.8	2.8	0
DE	33	152	64.0	112	21.5	34	33.0	38	45.0	113	87.6	15.0	0.0	7.5	11.0	12	3	2.4	2.6	8.4	3.6	5
MB	34	98	28.5	65	8.0	22	10.5	30	22.5	61	67.2	15.0	0.0	10.0	9.0	10	4	1.2	1.3	1.4	1.2	0
LG	35	128	47.0	85	14.0	27	21.0	28	40.0	98	81.6	15.0	0.0	2.5	16.5	4	4	1.2	1.3	8.4	0.0	0
LBM	36	103	69.0	83	20.5	8	15.0	36	110.0	78	87.6	22.5	0.0	5.0	3.5	3	1	0.0	1.3	1.4	0.0	5
DP	37	151	56.0	104	18.5	23	30.0	40	110.0	118	90.0	18.0	0.0	10.0	9.0	1	2	3.6	1.3	1.4	2.6	5
RG	38	154	45.5	109	23.0	32	27.0	40	52.5	126	64.8	7.5	0.0	12.5	15.0	10	3	4.8	2.6	2.8	0.0	0
SH	39	82	45.0	61	2.0	21	10.5	24	30.0	75	36.0	9.0	0.0	0.0	5.0	3	0	1.2	2.6	0.0	0.0	0
RZ	40	119	24.5	74	10.5	12	7.5	34	57.5	89	58.8	6.0	0.0	0.0	9.0	2	1	1.2	2.6	0.0	0.0	0

TABLE G (cont'd.)

Raw Scores: Subparts and Total Score of Complexity Measure of Expressive Language
(See Page 154 - 158 for key)

	ID	25	26	27	28	29	30	32	33	34	35	36	37	39	40	41	44	46	47	48	49	50
KC	1	1	0	0	0.0	0.0	0.0	0.0	3	0	0.0	0.0	6	3	0	0	0	-0.4	0.0	-1.2	0.0	0.0
VT	2	0	0	0	0.0	0.0	0.0	0.0	0	0	5.0	0.0	8	0	0	0	3	-1.6	-0.2	-0.6	-0.2	0.0
RBG	3	2	5	0	0.0	0.0	0.0	0.0	0	25	0.5	0.0	12	0	0	0	0	-0.2	-0.1	0.0	0.0	0.0
SA	4	2	0	2	0.0	0.0	0.0	0.0	0	20	6.5	0.0	8	0	0	0	0	0.0	-0.6	0.0	-0.2	0.0
TL	5	3	10	0	0,0	0.0	0.0	0.0	6	40	1.0	0.0	2	0	0	0	0	-0.2	0.0	-0.2	0.0	0.0
GH	6	1	0	0	0.0	0.0	0.0	0.0	3	10	5.0	0.0	2	0	0	0	0	-1.2	0.0	-0.6	0.0	0.0
FW	7	0	1	1	0.0	0.0	1.2	0.0	6	0	0.0	0.0	8	0	0	0	18	-0.8	0.0	-1.2	0.0	0.0
BC	8	0	0	1	0.0	0.0	0.0	0.0	3	40	0.0	0.0	4	0	0	0	0	-1.4	0.0	-0.6	0.0	0.0
JS	9	6	0	0	0.0	0.0	0.0	0.0	9	10	0.0	0.0	4	0	0	0	0	0.0	-0.2	-0.8	0.0	0.0
DG	10	0	0	0	0.0	0.0	0.0	0.0	3	0	5.0	0.0	2	0	0	0	0	-2.2	-0.2	0.0	0.0	0.0
HS	11	0	0	0	0.0	0.0	0.0	0.0	0	5	0.0	1.5	8	0	0	0	0	-0.6	-0.2	0.0	0.0	0.0
LV	12	3	0	2	0.0	0.0	0.0	0.0	9	40	1.0	2.0	4	0	0	0	0	-0.4	0.0	-1.8	0.0	0.0
DS	13	3	15	0	0.0	0.0	0.0	0.0	5	0	0.0	0.0	2	0	0	0	0	0.0	0.0	-0.8	0.0	0.0
TS	14	0	0	0	1.1	0.0	0.0	0.0	15	15	0.0	0.0	10	0	4	0	0	-1.2	0.0	-2.6	-0.4	-0.4
CD	15	0	0	0	0.0	0.0	0.0	0.0	0	0	1.5	0.0	8	0	0	2	0	-0.2	0.0	-0.2	0.0	0.0
MM	16	0	0	0	0.0	0.0	0.0	0.0	0	0	5.0	0.0	4	0	0	0	3	0.0	-0.2	-2.4	0.0	0.0
DA	17	4	10	0	0.0	0.0	0.0	0.0	6	20	0.0	0.0	4	0	0	0	0	0.0	0.0	-0.2	0.0	0.0
MA	18	2	5	0	0.0	0.0	0.0	0.0	0	15	0.0	0.0	0	0	0	0	0	-0.2	0.0	-0.6	-0.2	0.0
MT	19	2	0	0	0.0	0.0	2.6	0.0	0	0	2.5	3.0	12	6	0	0	0	-0.6	0.0	-0.8	0.0	-0.2
KS	20	0	0	0	0.0	0.0	0.0	0.0	0	5	0.5	0.0	4	0	0	0	6	0.0	-0.2	0.0	0.0	0.0
AH	21	0	0	6	0.0	0.0	0.0	0.0	0	10	1.0	0.0	8	0	0	0	0	-0.2	0.0	-0.4	0.0	0.0
AB	22	0	10	0	0.0	0.0	0.0	0.0	0	15	1.0	0.0	2	0	0	0	3	-0.4	0.0	0.0	0.0	0.0
JB	23	0	0	0	0.0	0.0	0.0	0.0	0	0	1.0	0.0	10	0	0	0	0	0.0	-0.2	0.0	0.0	0.0
HL	24	3	5	0	0.0	0.0	0.0	0.0	0	5	0.0	0.0	12	3	0	0	0	0.0	0.0	-0.4	0.0	0.0
LM	25	7	20	1	0.0	0.0	0.0	0.0	0	30	1.5	0.0	10	6	0	0	3	-0.4	0.0	0.0	0.0	0.0
JR	26	0	0	0	0.0	0.0	0.0	0.0	0	10	1.5	1.5	14	0	0	0	9	0.0	0.0	0.0	0.0	0.0
CBD	27	0	5	0	0.0	0.0	0.0	0.0	0	0	1.5	1.5	2	0	0	0	0	0.0	0.0	0.0	0.0	0.0
LK	28	6	15	0	0.0	0.0	0.0	0.0	0	25	1.5	0.0	22	0	0	0	0	-0.2	-0.2	-0.6	-0.2	0.0
MG	29	2	40	0	0.0	0.0	0.0	0.0	0	0	1.0	0.0	22	0	0	0	0	0.0	0.0	0.0	0.0	0.0
MBB	30	6	10	0	0.0	1.2	1.3	0.0	0	5	2.5	0.0	14	0	0	0	0	-0.2	0.0	0.0	0.0	0.0
SD	31	0	0	0	0.0	0.0	0.0	0.0	0	0	5.0	1.5	20	0	3	0	0	0.0	0.0	0.0	0.0	0.0
KBC	32	3	15	0	0.0	0.0	0.0	0.0	0	5	0.0	0.0	12	0	0	0	0	0.0	-0.6	0.0	0.0	0.0
DE	33	1	20	0	0.0	0.0	0.0	0.0	3	5	5.0	1.5	16	0	0	0	3	-0.6	0.0	0.0	0.0	-0.2
MB	34	1	20	0	0.0	0.0	0.0	0.0	0	0	1.0	0.0	12	0	0	0	0	0.0	0.0	0.0	0.0	0.0
LG	35	2	0	0	0.0	0.0	0.0	0.0	0	5	1.0	4.5	16	0	0	0	3	0.0	0.0	0.0	0.0	0.0
LBM	36	1	0	0	0.0	0.0	0.0	0.0	0	0	6.0	0.0	2	0	0	0	6	-0.2	0.0	0.0	0.0	0.0
DP	37	2	0	0	0.0	0.0	0.0	0.0	0	5	0.0	0.0	6	0	0	0	12	0.0	-0.2	0.0	0.0	0.0
RG	38	6	0	0	0.0	0.0	0.0	0.0	9	10	1.5	1.5	14	3	0	0	3	0.0	-0.4	-0.6	0.0	-0.2
SH	39	5	0	0	0.0	0.0	0.0	0.0	0	5	2.0	1.5	16	0	0	0	3	-0.2	0.0	-1.2	0.0	0.0
RZ	40	0	10	0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	8	0	0	0	6	-1.4	0.0	-0.4	-0.2	0.0

TABLE G (cont'd.)

Raw Scores: Subparts and Total Score of Complexity Measure of Expressive Language
(See Pages 154 - 158 for key)

	ID	51	52	53	54	55	TOTALS
KC	1	0.0	0.0	0.0	-0.1	-1.0	365.9
VT	2	0.0	-0.2	0.0	-0.1	-3.4	408.3
RBG	3	0.0	0.0	0.0	0.0	0.0	420.3
SA	4	0.0	0.0	0.0	-0.1	0.0	504.0
TL	5	0.0	0.0	0.0	0.0	-0.4	456.8
GH	6	0.0	0.0	0.0	0.0	0.0	338.3
FW	7	0.0	0.0	-0.3	0.0	-0.4	402.7
BC	8	0.0	0.0	0.0	0.0	-0.2	365.1
JS	9	0.0	0.0	0.0	0.0	-0.4	350.9
DG	10	0.0	-0.2	0.0	-0.3	0.0	424.3
HS	11	0.0	0.0	0.0	0.0	-2.0	442.5
LV	12	0.0	0.0	0.0	-0.2	0.0	436.6
DS	13	0.0	-0.1	0.0	0.0	0.0	494.0
TS	14	0.0	0.0	0.0	-0.4	-0.8	408.7
CD	15	0.0	0.0	-0.1	0.0	0.0	445.1
MM	16	-0.4	0.0	0.0	0.0	0.0	333.8
DA	17	-0.2	0.0	-0.2	0.0	-0.4	353.7
MA	18	0.0	0.0	0.0	0.0	0.0	477.9
MT	19	0.0	0.0	0.0	-0.1	-0.6	588.5
KS	20	0.0	0.0	-0.2	0.0	0.0	502.4
AH	21	0.0	0.0	0.0	0.0	0.0	622.5
AB	22	0.0	0.0	0.0	0.0	0.0	489.3
JB	23	0.0	0.0	-0.1	0.0	0.0	820.3
HL	24	0.0	-0.2	0.0	0.0	0.0	522.2
LM	25	0.0	0.0	0.0	0.0	0.0	550.7
JR	26	0.0	0.0	-0.1	0.0	0.0	716.8
CBD	27	0.0	0.0	0.0	0.0	0.0	581.9
LK	28	0.0	0.0	0.0	0.0	0.0	546.9
MG	29	0.0	0.0	0.0	0.0	0.0	422.1
MBB	30	0.0	0.0	0.0	-0.1	0.0	644.4
SD	31	0.0	0.0	0.0	0.0	0.0	524.2
KBC	32	0.0	0.0	0.0	0.0	0.0	593.7
DE	33	0.0	0.0	-0.1	0.0	-0.2	797.5
MB	34	0.0	0.0	0.0	0.0	0.0	499.8
LG	35	0.0	0.0	0.0	0.0	-0.2	653.8
LBM	36	0.0	0.0	0.0	-0.1	0.0	667.5
DP	37	0.0	0.0	-0.1	0.0	0.0	819.1
RG	38	0.0	-0.2	-0.1	0.0	-0.2	775.3
SH	39	0.0	0.0	-0.1	-0.1	0.0	442.5
RZ	40	0.0	0.0	-0.2	-0.2	-0.1	524.2

TABLE H

Simple Correlation Matrix: Experimental Group

	Age	SOL-ST	MDS	DLCT	CMEL	AS	VMI	PIQ	GIQ	REA	Har-ris	Pegs	Tap-ping	Card	Scis-sors	Grip	AEA
Sex	.25	-.13	.27	-.21	.19	-.05	-.32	-.35	-.03	.11	.11	.18	.27	.06	.26	-.18	.17
Age		-.04	.42	-.03	.27	.14	.04	.07	-.15	-.36	-.07	-.43	.00	-.54	.07	-.14	.31
SOLST			-.24	-.32	-.39	.17	-.09	-.08	-.25	-.01	-.34	.05	-.15	-.10	.10	.02	-.12
MDS				.06	.38	-.02	.31	.02	.46	-.08	-.13	.01	-.06	-.19	-.45	-.02	.31
DLCT					.46	-.30	.32	.59	.04	-.02	-.25	.34	-.65	.13	-.01	-.36	.05
CMEL						-.53	.41	.30	.28	-.44	.00	.29	-.30	-.40	-.20	-.15	.28
AS							-.13	-.21	-.23	.40	-.20	-.22	.02	.16	.14	-.10	.12
VMI								.39	.22	-.50	-.12	.07	-.29	-.37	-.19	.10	-.16
PIQ									.33	-.33	-.14	.10	.56	-.17	.16	-.40	.11
GIQ										.06	.12	.17	-.07	-.09	.44	.31	-.13
REA											.21	.26	.02	.71	-.05	-.19	-.15
Harris												-.26	.33	-.04	-.02	.21	-.13
Pegs													-.21	.47	-.02	-.31	-.01
Tapping														.07	-.02	.36	-.01
Cards															.05	-.04	-.31
Scissors																-.35	.17
Grip																	-.09

TABLE I

Simple Correlation Matrix: Control Group

	Age	MDS	DLCT	CMEL	VMI	PIQ	GIQ	REA	Harris	Pegs	Tapping	Card	Scissors	Grip	AEA
Sex	-.26	-.41	-.23	-.06	-.43	-.58	.23	.07	-.07	.11	.32	.05	.42	-.17	-.08
Age		.67	.36	.45	.42	.11	.17	.16	-.06	-.26	-.17	-.11	-.12	.03	-.09
MDS			.46	.24	.30	.15	-.03	.26	.00	-.27	-.41	-.04	-.34	-.02	.18
DLCT				-.09	.40	.25	.09	.10	.12	.00	-.12	-.29	.01	.13	.08
CMEL					.42	.32	.29	.02	-.09	-.54	-.38	-.14	.17	.03	-.10
VMI						.20	.27	.20	.06	-.13	-.18	-.26	.10	.21	.24
PIQ							.20	-.27	.26	-.38	.52	-.29	.40	-.28	-.29
GIQ								.09	-.55	-.18	-.29	-.09	-.04	-.06	-.25
REA									.12	.26	.19	-.17	.11	-.29	.84
Harris										.15	-.04	-.45	.47	-.05	.23
Pegs											.63	.27	.10	.16	.31
Tapping												-.05	.18	.18	.22
Cards													-.23	.29	-.07
Scissors														-.17	.03
Grip															-.03

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